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ENDOGENOUS GROWTH AND SUSTAINABLE TOURISM

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Endogenous Growth and Sustainable Tourism*

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Abstract

I build a dynamic general equilibrium model of a small economy specialized in tourism where visitors are attracted by the stock of existing environmental assets, and the stock of tourism and leisure facilities. Residents, at any date, choose the level of consumption, the number of visitors, and the quantity of resources to be devoted to abatement of pollution, the latter being generated by the existing stock of tourism facilities and by the flow of tourists. I analyze the balanced growth path properties of this economy, and focus on the sensitiveness of its qualitative dynamic behaviour, according to different subsets in the parameters' space. The model is able to perform both endogenous growth and sustainability of the environmental resource. We analyse the condition for this result to hold and we find that when tourists' preferences are greener (i.e. they care for environmental quality and they are crowding-adverse), the economy generally grows faster. Finally, we develop the transitional dynamics analysis in the case of constant environmental quality in the long-run. Given its generality and flexibility, we believe our model may serve as a workhorse model suitable to be used as an instrument to perform for many relevant policy exercises.

Key words: Growth, Tourism Specialization, Tourism Facilities, Environmental Assets, Pollution Abatement, Transitional Dynamics
JEL Classifications: O41, Q56, L83.

1 Introduction

Is it possible, for a small economy specialized in tourism based on environmental resources, to perform long-run endogenous growth and environmental sustainability? And, if this is the case, what are the endogenous determinants of the growth rate of the tourism economy? These questions are at the heart of an international debate which goes beyond the purely academic world. In the recent years, as a result of the ever-increasing international demand for tourism goods, many developing countries endowed with environmental and cultural amenities are facing the choice between addressing their economic efforts towards the development of an attractive tourist sector or investing resources in more traditional industrial sectors, characterized by higher technological-intensity and

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then - at first sight - more suitable to contribute for the growth of the whole economy. The implications of such choice will not only affect the long-term economic performance of the countries which are the actor of the choice itself, but will also shape the social and environmental context of vast areas like the Mediterranean see, the Indian Ocean, the Caribbean sea, etc., where other more industrialized countries operate and will therefore be affected by this decision.

Despite their relevance and importance, to our knowledge, no scientific works so far - empirical or theoretical whatsoever - have offered a clear answer to our previous questions. One of the first paper dealing with the issue of the growth potential of a small tourism economy based on natural resources is Lanza and Pigliaru (1994), then followed by Lanza and Pigliaru (1999). In these works, the authors propose an international trade model based on Lucas (1988) where the country specializing in tourism performs long-run growth thanks to ever-increasing terms of trade gains (caused by the limited substitutability of the tourism good) and the growth experienced by the foreign countries. However, in this case, growth can hardly be considered *endogenous* as it depends on economic decisions which are taken outside the tourism economy and it relies on foreign economic growth. Moreover, these works do not explicitly analyze the role and the long-run dynamic behavior of the natural resources which the tourism sector is based on and, therefore, no sustainability issue is dealt with. The joint possibility of endogenous growth and sustainable tourism is not even clearly addressed by the works belonging to a recent literature strand analyzing the dynamic evolution of an economy specialized in tourism based on natural resources. Among these works we remind Lozano et al. (2008), which builds a dynamic general equilibrium model where investments in accommodation capacity and public goods are taken into account; Giannoni and Maupertuis (2007) and Candela and Cellini (2006) who adopt the point of view of a representative tourism firm aiming to maximize its lifetime profit; Rey-Maquieira et al. (2005) who analyze the dynamic consequences of the conflict between agricultural and tourism sector for the use of land; Cerina (2007) and Cerina (2008) which introduce several kind of abatement policies and provide the respective analyzes of the transitional dynamics of the economy, and finally Hernandez and Leon (2007) who present a model of tourist lifecycle highlighting the interactions between natural resources and physical capital. None of these papers face the issue of the conditions for an endogenous, sustained and sustainable growth in an economy specialized in tourism based on natural resources, which is the issue we deal with. An exception is represented by Cerina and Giannoni (2010) where such conditions are analyzed in a theoretical model but where the environmental variable is treated as a flow and where the supply-side of the economy is represented in a very stylized way.

Our paper can be thought as an extension and generalization of Cerina and Giannoni (2010). It shares the same objectives of the latter (finding the condition for endogenous growth and sustainable tourism and analyzing the determinants of long-run growth), but it pursues them by means of a more detailed and richer description of the whole economy. Accordingly, we build a dynamic general equilibrium model of a small economy specialized in tourism where visitors are attracted by the stock of existing environmental assets, and by the stock of tourism and leisure facilities. Residents, at any date, have to choose the level of consumption, the number of visitors, and the quantity of resources to be devoted to abatement of pollution, the latter being positively affected by the existing stock of tourism facilities and by the flow of tourists. The model is then able to study the several characteristics of the trade-off between economic growth and environmental sustainability[1] in the context of an economy specialized in tourism.

Our paper can also be viewed in the light of the debate on the trade-off between environmental quality and growth in an endogenous growth framework. The existence of a clear evidence on this trade-off is an intensively debated and still controversial social question (see, for example, Copeland and Taylor, 2004 and Xepapadeas 2005). As clearly summarized in Smulders (2000), sustainability does not necessarily require "greeness", when consumption and the environment are good substitutes. In this case, a balanced growth path where all economic variables grow at a constant (positive) rate, can be achieved, even though all environmental variables remain constant over time. The problem is that when we want to integrate the environmental sector into a standard endogenous growth framework, we need to carefully characterize the way natural resources affect productivity. In this view, we are interested in exploring whether the presence of tourism services based on natural resources might serve as a key determinant to foster long-run economic growth. Although a recurrent criticism of conventional endogenous growth theory is concerned with the needed strong assumption of constant returns to scale in the production function, a strand of literature reconciles the presence of increasing returns with an upper bound on per capita growth rate, when the environment enters as an input the production function (see, for example, Smulders, 1995; and Groth and Schou, 2002). The endogenous growth framework set out in this paper follows the steps of this literature. A balanced growth path equilibrium is achieved when either the environment or the tourism services are introduced, even though no assumption of increasing returns to scale in the production function is assumed. The challenge is then to implement an economy where environmental quality joint with tourism services may act in the right direction in order to achieve a sustainable development.

We analyze the balanced growth path properties of this economy, and deeply focus on the sensitiveness of its qualitative dynamic behavior, according to different subsets in the parameters' space. The economy we model is able to perform both endogenous growth - defined as positive and sustained long-run growth rate of the economy as a result of an optimization problem, and sustainability of the environmental resource - defined as a non-negative growth rate of the environmental assets. We analyze the conditions for this situation to occur and we find that endogenous growth and sustainability are not generally strictly related. In other words, there are subsets of parameters values such that endogenous growth and sustainability may or may not occur simultaneously. We also analyze the determinants of the growth rate of the economy and we interestingly find that when tourists' preferences are greener (i.e. when they care for environmental quality and they are crowding-adverse), the economy generally grows faster. These findings might have an appeal for policy-makers as they show that devoting resources to the development of an environment-friendly kind of tourism, opposed to mass-tourism, do not necessarily reduce the long-term

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[1] Such general issues are dealt with in the so-called environmental and growth' literature (Tahvonen and Kuuluvainen, 1991; Gradus and Smulders, 1993; Smulders and Gradus, 1996; Stokey, 1998, etc – see Smulders, 2000; Brock and Taylor, 2005; and Xepapadeas, 2005, for some comprehensive surveys).

economic performance of the economy. Basically, our paper shows the exact opposite: addressing towards a more greener kind of tourism will actually *boost* economic growth. Finally, we also develop the transitional dynamics analysis in the case of constant environmental quality along the balanced growth-path, and we provide a complete characterization of the dynamic properties of the equilibrium. In particular, we provide the conditions for the steady-state to be saddle-point stable.

Given its generality and flexibility, we believe our model may serve as a workhorse model suitable to perform many relevant policy exercises. The paper will proceed as follows: section 2 presents the analytical framework; section 3 analyzes the conditions for the existence of a balanced growth path and investigates some of its properties; section 4 provides the condition for the optimal growth rate as result of an hypothetical central planner decision and analyses its determinants; section 5 provides the analysis of the transitional dynamics when the environmental assets is bound to be constant along the balanced growth path. Finally, section 6 draws some conclusions.

2 The analytical framework

2.1 Tourists' preferences and the international tourism market

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

$$p_t = \gamma p \left(E_t, k_t, T_t \right)$$

hence the price tourists are willing to pay to visit the destination depends on three variables: environmental quality E ($\frac{\partial p}{\partial E} > 0$), the stock of facilities k ($\frac{\partial p}{\partial k} > 0$) and the number of visitors (or nightstays) T per unit of time ($\frac{\partial p}{\partial T} > 0$ if tourists are crowding-lover or $\frac{\partial p}{\partial T} < 0$ if they are crowding adverse). γ is a positive time-invariant scale parameter.

In order for a balanced growth path to be feasible we have to assume a Cobb-douglas functional form

$$p_t = \gamma E_t^{\phi} k_t^{\psi} T_t^{-\beta} \tag{1}$$

with $\phi, \psi > 0$ and $\beta > 0$ or < 0 according to whether tourists are respectively crowding-averse or lower. In any case, in order for tourism revenues to be increasing in the number of tourists, we assume $\beta < 1$.

It is important to highlight an alternative interpretation for (1). The latter can also be written as

$$p_t = \gamma E_t^{\phi} k_t^{\psi} T_t^{-\beta} = \gamma q \left(E_t, k_t \right) T_t^{-\beta}$$

so that, expressing it in terms of T_t

$$T_t = \left(\gamma q \left(E_t, k_t \right) \right)^{\frac{1}{\beta}} \left(p_t \right)^{-\frac{1}{\beta}}$$

can be viewed as the demand function for tourism services (nightstays), $\left|\frac{1}{\beta}\right|$ being the demand elasticity with respect to price (as in Candela and Cellini (2006)). If we draw the associated demand curve in the (T, p) axis, we can notice that it can shifts upwards or backwards according to whether $q(E_t, k_t)$ increases or decreases. In particular, more visitors are attracted for a given price, when the destination increases tourism and leisure facilities k and the environmental quality E. Also notice that, in this case, crowding-lover tourists will lead to a positive-sloped demand function $(-\frac{1}{\beta} > 0)$ which is clearly not supported by the data nor by commonsense. For this reason, we stick on the assumption according to which tourists are crowding-averse and $\beta > 0$. Finally, note that an higher value of β means a lower value of the demand elasticity with respect to price, meaning that the destination is considered to be less easily repleceable and then to have a larger market power in the international market of tourism destinations.

As for the latter, we assume our economy supplies tourism services in an international tourism market where a large number of small tourism economies participate. Even here, we can have a double interpretation of its structure.

On the one hand, if T_t enters as an argument in the willingness to pay function of tourists, we can assume 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 - E_t - and/or by a higher stock of tourism facilities k_t - and or/or by less crowd of tourists T_t) than other countries'. In other words, the international market consists of 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. We can also 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. So the market clears all the time and the quantity of T_t exchanged is totally determined by the supply side.

On the other hand, if (1) is interpreted as an inverse demand function and $\frac{1}{\beta}$ is the elasticity of demand with respect to price, then we are dealing with an oligopolistic tourism market where destinations offering a tourism product belonging to the same quality ladder (i.e for a given k and E) face a negative-sloped international demand function. As a consequence, the amount of visitors in equilibrium is a result of the interaction between demand function (1) and the supply function which - as we will see now - is a result of residents' utility maximization.

These two different interpretation leads to the same formal results.

2.2 Tourism revenues and residents' behavior

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 T_t. The supply side of the economy is made up of a large number of identical "households-firms" which we normalize to 1. For the sake of simplicity, we assume that the country provides tourism services without any labour 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, and by the accumulated stock of facilities which is a result of residents' savings.

Aggregate tourism revenues correspond to aggregate profits obtained by the households-firms and is represented by the value of the economy's output

$$y = \gamma q \left(E_t, k_t, T_t\right) T_t = \gamma E_t^{\phi} k_t^{\psi} T_t^{1-\beta} \tag{2}$$

Formally, this is not different from a "production function"of tourism services (a daily tourism experience) where T_t, E_t and k_t enter as input factors.

Resident's behaviour 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 c_t purchased from abroad at a unitary price [2]. Their lifetime utility is given by an infinite discounted sum of CES instantaneous utility

$$U_t = \int_t^{\infty} u\left(c_t\right) e^{-\rho t} dt = \int_t^{\infty} \frac{c_t^{1-\sigma} - 1}{1-\sigma} e^{-\rho t} dt. \tag{3}$$

Residents use tourism revenues for three purposes: 1) they buy the consumption good from abroad; 2) they save to invest in tourism facilities k (thus facing the usual intertemporal trade-off between consumption today and consumption tomorrow); 3) they finance a flow of pollution abatement activities A_t in order to reduce the flow of pollution. The accumulation equation for tourism facilities is then

$$\dot{k} = y_t - c_t - A_t \tag{4}$$

2.3 The dynamics 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

$$\dot{E}_t = f\left(E_t\right) - P_t \tag{5}$$

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 increases as the current stock of environment grows. By choosing to model environmental quality this way, we are implicitly renouncing to assume an upper bound to environmental quality. The literature which introduces such an upper bound (extensively described in Smulders 2001) is highly related to a merely "physical" interpretation of 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. Since our interpretation of E_t is much broader (including social and cultural resources), we think our assumption fits better with tourism-related issues.

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[2] Assuming that residents' utility is also positively affected by E_t would not change results significantly.

What are the determinants of the pollution flow P in an economy specialized in tourism?[3]. Pollution is considered as a by-product of the tourism industry which uses k and T as "production factors". 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 behavior of the pollution flow may take the following form

$$P_t = P\left(k_t, T_t, A_t\right) \tag{6}$$

where $A_t \leq y_t$ is an absolute measure of the abatement effort and represents the part of national income devoted to abate the flow of pollution brought by tourists. Formalizing the previous intuition, we assume that $P_k > 0$, $P_T > 0$ and $P_A < 0$.

In order for a Balanced Growth Path (BGP) to be feasible and closed-form, we need to introduce some explicit functional forms for $f(\cdot)$ and $P(\cdot)$

$$\begin{aligned} f(E) &= \theta E \\ P\left(k_t, T_t, A_t\right) &= z k_t^{\varphi} T_t^{\nu} A_t^{-\eta} \end{aligned}$$

where θ, φ, v, $\eta \geq 0$ respectively measure 1) the regeneration rate of the environment; 2) the elasticity of pollution with respect to physical capital; 3) the elasticity of pollution with respect to tourists; 4) the elasticity of pollution with respect to abatement expenditures.

The two motion equations are then

$$\dot{k}_t = \gamma E_t^{\phi} k_t^{\psi} T_t^{1-\beta} - c_t - A_t \tag{7}$$

$$\dot{E}_t = \theta E_t - z k_t^{\varphi} T_t^{\nu} A_t^{-\eta} \tag{8}$$

3 Endogenous and sustainable growth

We are now interested in finding the conditions for the existence of a *Balanced Growth Path with Sustainable Tourism and Endogenous Growth.* The latter situation is defined by the following

Definition 1 *A* ***Balanced Growth Path with Sustainable Tourism and Endogenous Growth*** *is a dynamic equilibrium in which capital, income (tourism revenues), and consumption all grow at a constant positive rate, and environmental quality grows at a constant non-negative rate.*

Along the BGP, the motion equation for k can be written as

$$g_k = \gamma E^{\phi} k^{\psi-1} T^{1-\beta} - \frac{c}{k} - \frac{A}{k}$$

where $g_k = \frac{\dot{k}}{k}$ is the constant growth rate of capital along the BGP[4].

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[3] Davies and Cahill (2000) 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.

[4] By g_j we identify the growth rate of variable j along the balanced growth path.

Hence, in order for g_k to be positive, we need

$$\gamma E^{\phi} k^{\psi-1} T^{1-\beta} - \frac{c}{k} - \frac{A}{k} > 0$$

while, in order for g_k to be constant, we need: 1) $\frac{c}{k}$ constant; 2) $\frac{A}{k}$ constant and 3) $\gamma E^{\phi} k^{\psi-1} T^{1+\beta} = \frac{y}{k}$ constant. As a consequence, a simple application of the Uzawa-theorem requires

$$g_c = g_k = g_A = g_y = g \tag{9}$$

By differentiating $\frac{y}{k}$ along the BGP, we find that

$$\phi g_E + (\psi - 1)\, g + (1 - \beta)\, g_T = 0 \tag{10}$$

This condition should always be true along the BGP and it gives us a first relation between g, g_E and g_T along the balanced growth path.

Along the BGP, the motion equation for E can be written as

$$g_E = \theta - \frac{z k_t^{\varphi} T_t^{\nu} A_t^{-\eta}}{E} \tag{11}$$

The constancy of this growth rate requires that $\frac{z k^{\varphi} T^{\nu} A^{-\eta}}{E}$ is constant along the BGP. Moreover, sustainability ($g_E \geq 0$) requires $\theta \geq \frac{z k^{\varphi} T^{\nu} A^{-\eta}}{E}$.

By differentiating $\frac{z k^{\varphi} T^{\nu} A^{-\eta}}{E}$ along the BGP - and using (9) , we find that

$$(\varphi - \eta)\, g + v g_T - g_E = 0 \tag{12}$$

and by means of (10) and (12) we are able to express g_E and g_T as direct functions of g

$$g_E = \frac{(1-\beta)(\varphi - \eta) + v(1-\psi)}{1 - \beta + \phi v} g \tag{13}$$

$$g_T = \frac{(1-\psi) - \phi(\varphi - \eta)}{1 - \beta + \phi v} g \tag{14}$$

which, together with the optimality conditions, give us the expressions of the growth rate of each variable along the BGP as functions of the parameters only.

As we can notice, both g_E and g_T take non-zero values if and only if g is positive: i.e., when the growth rate of k along the BGP is zero, also the number of visitors and the environmental quality grow at the same rate

$$g = 0 \Rightarrow (g_T = 0) \cap (g_E = 0)$$

The opposite is not necessarily true: both g_T and g_E can be zero even when g, as we require, is positive. In particular, when $g \neq 0$, we find that

$$(1-\beta)(\varphi - \eta) + v(1-\psi) = 0 \Rightarrow g_E = 0 \tag{15}$$

$$(1-\psi) - \phi(\varphi - \eta) = 0 \Rightarrow g_T = 0 \tag{16}$$

$$(\psi = 1) \cap (\varphi = \eta) \Rightarrow (g_T = 0) \cap (g_E = 0) \tag{17}$$

These important knife-edge conditions deserve some comments.

Condition (15) reveals us a first way to look at sustainable tourism: from a policy maker viewpoint, it might be reasonable to study the conditions in order for a constant environmental quality ($g_E = 0$) to be compatible with a growing tourism economy ($g > 0$). Condition (15) gives an answer to this question. In particular, it tells us that when capital is very productive ($\psi > 1$), then capital should not pollute too much relatively to the intensity of the abatement technology ($\varphi < \eta$). This condition is quite intuitive: an highly productive capital leads to large investments and fast accumulation of capital; this accumulation leads to more pollution and has a negative effect on the environmental quality. Such negative effect should be counterbalanced by a relatively high productivity of the abatement technology. By contrast, when capital is not too productive ($\psi < 1$), then a relatively low η ($\eta < \varphi$) is what we need in order to keep the environmental quality constant along the BGP: if this is not the case, environmental quality will grow forever.

It is important to highlight that a growing and sustainable tourism economy ($g > 0$ and $g_E = 0$) is perfectly compatible with a constantly decreasing number of visitors overtime ($g_T < 0$). To see this, apply the sustainability condition (15) in (14) to obtain

$$g_T = \frac{\eta - \varphi}{v} g$$

so that, being g positive by assumption, we have a growing and sustainable economy with ever-decreasing number of visitors ($g_T < 0$) if $\varphi > \eta$, provided that ψ is sufficiently larger than 1 in order for g_E to be zero. In words, when tourists care very much for capital, buildings and leisure facilities (i.e. capital is very productive) *and* the abatement technology is not very efficient, then the economy grows with a constant environmental quality if and only if the number of tourists is decreasing along the BGP. On the other hand, when $\eta > \varphi$ - provided that ψ is sufficiently lower than 1 for g_E to be zero - then a growing and sustainable economy is possible if and only if the number of tourists constantly grows along the BGP. The intuition is straightforward: the number of visitors is allowed to grow overtime provided that the abatement technology is productive enough and provided that visitors are not too much willing to pay for an additional unit of tourism facilities.

Of course, as condition (17) clearly states, a constant number of tourists ($g_T = 0$) is also compatible with a constant environmental quality ($g_E = 0$). In this case we need two different knife-edge conditions: ψ should be exactly equal to 1 and the elasticity of pollution with respect to capital and abatement should be equal in absolute value. However, albeit this possibility is allowed, it can be shown that this raises some indeterminacy problems on the steady state solution either, as pointed out in section 5.

Finally, focusing on condition (16), we see that constant number of tourists ($g_T = 0$) is compatible with both an ever-increasing or an ever-decreasing environmental quality. To see this use (16) into (13) to obtain

$$g_E = (\varphi - \eta)\, g$$

So that we have $g_T = 0$ *and* $g_E > 0$ or $g_E < 0$ according to whether φ is bigger or smaller than η. In the first case, in order for $g_T = 0$, we also need $\psi < 1$ which in fact leads to $g_E > 0$. While, in the second case, $\psi > 1$ is needed to keep T constant overtime and this implies $g_E < 0$.

4 Steady state analysis and optimal growth

In this section we analyze the problem of a hypothetical central planner. His/her objective is to choose the dynamic path of consumption levels c_t, the number of visitors T_t, and the level of abatement expenditures A_t in order to maximize the discounted sum of instantaneous utilities given by (3) and subject to equations (7), (8), given two transversality conditions respectively on the state variables k and E. Formally, the central planner solves the following optimization problem

$$\begin{aligned} & \max_{c_t, T_t, A_t} \int_t^{\infty} \frac{c_t^{1-\sigma}-1}{1-\sigma} e^{-\rho t} dt \\ s.t. \quad : \quad & \dot{k}_t = \gamma E_t^{\phi} k_t^{\psi} T_t^{1-\beta} - c_t - A_t \\ & \dot{E}_t = \theta E_t - z k_t^{\varphi} T_t^{\nu} A_t^{-\eta} \\ & \lim_{t \to \infty} \lambda_t k_t e^{-\rho t} = 0 \\ & \lim_{t \to \infty} \mu_t E_t e^{-\rho t} = 0 \end{aligned}$$

Where λ_t and μ_t are the values at time t of the Lagrange multiplier associated, respectively, to k and E.

It is important to highlight that the two transversality conditions together imply

$$v(1-\psi) + (1-\beta)(\varphi - \eta) < v \frac{c_t}{y_t}.$$

Since $v \frac{c_t}{y_t}$ is strictly positive, there is a range of parameters such that the sustainability condition according to which $v(1-\psi) + (1-\beta)(\varphi - \eta) = 0$ is always satisfied.

If we introduce a state-like variable (x) and a control-like variable (m), defined as[5]

$$\begin{aligned} x &= \frac{c}{k} \\ m &= \frac{y}{k} = \gamma E^{\phi} k^{\psi - 1} T^{1-\beta} \end{aligned}$$

then we can reduce the dimension of the system-space by simply focusing on the evolution of these two variables.

After applying the first-order condition, the optimal equilibrium dynamic system governing the economy appears as follows

$$\frac{\dot{x}}{x} = x - m \frac{\Psi + \Omega(\sigma - 1)}{v\sigma} - \frac{\rho}{\sigma} \tag{18}$$

$$\frac{\dot{m}}{m} = x \frac{1-\beta-\Psi}{1-\beta-\Omega} - m \frac{\Psi}{v} - \theta \frac{1-\beta+v\phi}{1-\beta-\Omega} \tag{19}$$

where

$$\begin{aligned} \Psi &= (1-\beta)(\varphi - \eta) + v(1-\psi) \\ \Omega &= v - (1-\beta)\eta \end{aligned}$$

Notice that from (15) we should have $\Psi \geq 0$ in order to have $g_E \geq 0$ with $g > 0$

As for Ω we'll soon demonstrate it is positive too.

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[5] We can get rid of the time subscript for notational simplicity.

4.1 Balanced growth path analysis

We are now interested in finding an expression for the growth rate of the economy along the BGP. From (4), the growth rate of physical capital can be written as

$$\frac{\dot{k}}{k} = \frac{y}{k} - \frac{A}{k} - \frac{c}{k} = m - \frac{A}{k} - x$$

First-order conditions lead to

$$\frac{(1-\beta)\,\eta}{v} m = \frac{A}{k} \tag{20a}$$

so that

$$\frac{(1-\beta)\,\eta}{v} = \frac{A}{y} = \tau_A < 1 \tag{21}$$

where τ_A can be considered as the optimal "abatement tax" which is always constant even when the economy is not on its balanced-growth path. As we can easily see, the abatement tax is a negative function of β, so that the tax will be lower in destinations addressing to more crowding-adverse tourism. Unsurprisingly, the abatement tax is also a negative function of v so that it will be lower when the tourists impact on pollution is small. The result that τ_A is also increasing in η (a measure of the productivity of the abatement technology) can be explained by the fact the that the it is optimal for the economy to allocate more resources in relatively more productive technologies. Finally, in order to have a meaningful tax $\tau_A < 1$, we know we must have $\Omega > 0$.

By using (20a) we obtain

$$\frac{\dot{k}}{k} = m\frac{\Omega}{v} - x$$

Hence, in steady state we have

$$g = m_{ss}\frac{\Omega}{v} - x_{ss} \tag{22}$$

where m_{ss} and x_{ss} are the steady state values of m and x. Since c, y and k grow at the same rate along the BGP, we know that m_{ss} and x_{ss} are constant and are equal to[6]

$$\begin{aligned} x_{ss} &= \frac{\theta\,(1-\beta+v\phi)\,(\Psi+\Omega\,(\sigma-1)) - \rho\Psi\,(1-\beta-\Omega)}{((1-\beta)\,(\sigma-1)+\Psi)\,(\Omega-\Psi)} \\ m_{ss} &= v\frac{\theta\sigma\,(1-\beta+v\phi) - \rho\,(1-\beta-\Psi)}{((1-\beta)\,(\sigma-1)+\Psi)\,(\Omega-\Psi)} \end{aligned}$$

so that the growth rate g in steady state can be written as

$$g = \frac{(1-\beta)\,(\theta-\rho)+v\phi\theta}{(1-\beta)\,(\sigma-1)+\Psi} \tag{23}$$

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[6] This implies that $\frac{c}{y} = \frac{\Psi+\Omega(\sigma-1)+v\rho}{v\sigma}$ so that the transversality condition can be written as

$$(\Psi-\Omega)\,(\sigma-1) < v\rho$$

which, using the expression for Ψ, can also be written as

$$g = \frac{(1-\beta)(\theta-\rho) + v\phi\theta}{(1-\beta)(\sigma - 1 + \varphi - \eta) + v(1-\psi)} \tag{24}$$

As a consequence, from (13) and (14) we find that

$$\begin{aligned} g_E &= \frac{\Psi}{\phi v + (1-\beta)} \frac{(1-\beta)(\theta-\rho) + v\phi\theta}{(1-\beta)(\sigma-1) + \Psi} && (25) \\ g_T &= \frac{(1-\psi) - \phi(\varphi-\eta)}{\phi v + (1-\beta)} \frac{(1-\beta)(\theta-\rho) + v\phi\theta}{(1-\beta)(\sigma-1) + \Psi} && (26) \end{aligned}$$

We are now ready to perform some comparative statics exercises. These exercises are very important because many parameters can be thought to be affected by policy makers.

4.2 The determinants of growth

Under which conditions we have a positive and sustained growth in our Small Tourism Economy? Which parameters may affect the growth rate of the economy? How can a policy-maker fasten the growth rate of the economy? We are now ready to answer these questions.

First, we find the conditions under which $g > 0$. In turns out that growth is positive in two very different scenarios, let's call them a *green* scenario and a *grey* scenario. The two scenarios are summarized by these conditions

$$g > 0 \Leftrightarrow \left\{ \begin{array}{l} \left[\frac{\theta}{\rho} > \frac{(1-\beta)}{(1-\beta+v\phi)}\right] \cap \left[\psi < \frac{(1-\beta)(\sigma+\varphi-1)}{v} + 1 - \tau_A\right] \\ \left[\frac{\theta}{\rho} < \frac{(1-\beta)}{(1-\beta+v\phi)}\right] \cap \left[\psi > \frac{(1-\beta)(\sigma+\varphi-1)}{v} + 1 - \tau_A\right] \end{array} \right. \tag{27}$$

The first group of conditions identifies the green scenario: in this case, a positive growth rate of the tourist economy is reach through relatively *high* regeneration rate of the environment θ together with a relatively *low* preference of tourists for capital (leisure facilities, etc.) ψ. The second group, by contrast, indentifies the grey scenario as it describes a situation in which the natural rate of regeneration is relatively low and tourists are capital-lovers. Notice that both scenario are *environmentally sustainable* meaning that the growth rate of environmental quality is non-negative as $\Psi \geq 0$. However, needless to say, such growth rate is lower in the grey scenario.

As for the determinants of growth, we differentiate (24) with respect to all the parameters in order to see how they affect the growth of the tourist economy. Results are summarized by the following table:

	σ	ϕ	θ	φ	η	ψ	β	ρ	v
g	$-$	$+$	$+$	$-$	$+$	$+$	$-/+$	$-$	$+/-$

Notice that, as expected, an higher natural regeneration rate θ and a stronger preference for enviromental quality by tourists ϕ both contribute to boost economic growth. These parameters have positive effect on the stock of environmental quality which is also an argument of the tourism revenue function. In other words, the environment is worth being protected because tourists demand it and therefore it has an important economic value.

For similar reasons, even tourists' preference for capital ψ have a positive effect on economic growth. In this case, even if capital is a source of pollution (and then it negatively affects environmental quality), its direct positive effect on tourism revenues always offsets its negative effect on the environment.

Not surprisingly, the elasticity of pollution with respect to capital φ is detrimental to growth while, by contrast, the effectiveness of abatement η affects growth positively.

As for crowding aversion β (or the inverse of the demand elasticity to price), the effect is ambiguous. It turns out that

$$sign\left(\frac{\partial g}{\partial \beta}\right) = sign\left[\phi\theta\left(\sigma - 1 + \varphi - \eta\right) - \left(1 - \psi\right)\left(\theta - \rho\right)\right] \tag{28}$$

Both members of the right hand side of (28) have an ambiguous sign even though some combinations of parameters values are excluded by (27) and (15). A good way to interpret (28) is to express it in terms of ψ. By assuming $(\sigma - 1 + \varphi - \eta) > 0$ and $(\theta - \rho) > 0$ (which implies a green scenario, which looks more realistic than a grey one), we have that

$$\frac{\partial g}{\partial \beta} > 0 \Leftrightarrow \psi > 1 - \frac{\phi\theta\left(\sigma - 1 + \varphi - \eta\right)}{\left(\theta - \rho\right)}$$

This condition tells us that - under a green scenario - an increase in tourists' crowding aversion is good for growth if and only if such increase is compensated by a strong tourists' preference for leisure facilities.

Alternatively, we can find that, under the same assumptions

$$\frac{\partial g}{\partial \beta} > 0 \Leftrightarrow \phi > \frac{\left(\theta - \rho\right)\left(1 - \psi\right)}{\theta\left(\sigma - 1 + \varphi - \eta\right)} \tag{29}$$

which means that a stronger aversion to crowding might accelerate growth if and only if the tourists' preference for the environmental quality is large enough. In other words, as a larger β will reduce the level and/or the growth rate of tourists in equilibrium, our economy can afford it only if visitors' willingness to pay is very elastic to environmental quality whose level and/or growth rate in equilibrium will be increased thanks to the reduction of visitors.

These results can be particularly interesting from the policy perspective. We can think that large ϕ and large β are associated to a "green" kind of tourism while small ϕ and positive and large β may represent a "mass-tourism", not very interested on the environmental resources. Since the destination can hypothetically choose which kind of visitors address its supply to, we can consider ϕ and β as policy instruments. From this perspective, as $\frac{\partial g}{\partial \phi}$ is unambiguosly positive, our model predicts that policy measures which gives an incentive to the development of a green-tourism are more favorable to growth than policies which give an incentive to mass-tourism. This result is streghten by the results according to which even $\frac{\partial g}{\partial \beta}$ is positive when ϕ is sufficiently high - i.e. the economy is already "green".

5 A "not-too-special" case: constant environmental quality along the BGP

In this section we will study in details the properties of the balanced growth path, and the transitional dynamics of system (19) and (18) when we assume environmental quality E to be constant along the BGP, i.e., $g_E = 0$. As we have already seen, this is a particular, though interesting, way to look at sustainable tourism. A policy maker would be reasonably interested in an equilibrium situation in which a growing tourism economy is compatible with a constant environmental quality. We know that $g_E = 0$ when $\Psi = 0$. In this case the dynamic system governing the economy can be written in growth rate terms as

$$\frac{\dot{m}}{m} = x\frac{1-\beta}{1-\beta-\Omega} - \theta\frac{1-\beta+v\phi}{1-\beta-\Omega} \tag{30}$$

$$\frac{\dot{x}}{x} = x - m\frac{\Omega(\sigma-1)}{v\sigma} - \frac{\rho}{\sigma} \tag{31}$$

The steady state values of m and x are consequently given by

$$x_{ss} = \theta\frac{1-\beta+v\phi}{1-\beta} \tag{32}$$

$$m_{ss} = v\frac{\theta\sigma(1-\beta+v\phi) - \rho(1-\beta)}{\Omega(1-\beta)(\sigma-1)} \tag{33}$$

and the three growth rates we are interested in, g, g_E and g_T, can be expressed then in terms of parameters only, as follows

$$g = \frac{(1-\beta)(\theta-\rho) + v\phi\theta}{(1-\beta)(\sigma-1)} \tag{34}$$

$$g_E = 0 \tag{35}$$

$$g_T = \frac{(1-\psi) - \phi(\varphi-\eta)}{\phi v + (1-\beta)}\frac{(1-\beta)(\theta-\rho) + v\phi\theta}{(1-\beta)(\sigma-1)} \tag{36}$$

The way growth is affected by the parameters is not so different when $\Psi = 0$, except that now g is unaffected by φ, η and ψ. The following table summarizes the way g is affected by the several parameters:

	σ	ϕ	θ	φ	η	ψ	β	v
g	$-$	$+$	$+$	$=$	$=$	$=$	$-/+$	$+$

What is interesting here is the way now growth depends on crowding aversion. We have

$$\frac{\partial g}{\partial \beta} > 0 \Leftrightarrow \sigma > 1 \tag{37}$$

so that the way β affects growth only depends on the inverse of the intertemporal elasticity of substitution. More precisely, when $\sigma > 1$ then the positive effect of β (i.e. the smaller pollution flow and the positive effect on environmental quality) more than compensates the negative effect of β (i.e. the reduction in tourism entries). The opposite happens when $\sigma < 1$.

5.1 Transitional dynamics when $\Psi = 0$

When the environmental quality is bound to be constant in steady state, analyzing the transitional dynamics of the system becomes an easier task. This is the aim of the present section. After linearization, the system (30),(31) can be written, in matrix form, as

$$\begin{bmatrix} \dot{x} \\ \dot{m} \end{bmatrix} = J^* \begin{bmatrix} x - x_{ss} \\ m - m_{ss} \end{bmatrix}$$

where the Jacobian matrix, J^*, is given by

$$J^* = \begin{bmatrix} x_{ss} & -x_{ss}\frac{\Omega(\sigma-1)}{v\sigma} \\ m_{ss}\frac{(1-\beta)}{1-\beta-\Omega} & 0 \end{bmatrix}$$

Studying the behavior of this economy in the balanced growth path towards the steady state needs particular attention, especially if we want to control for the presence of some undesired outcomes due to the rise of instability problems. To this end, we need to check for the sign of the determinant ($DetJ^*$) associated to J^*, since the trace is always constrained to be positive ($trJ^* = x_{ss} > 0$).

More specifically, the determinant can be explicitly derived as

$$\det J = \frac{\Omega\left(\sigma - 1\right)\left(1 - \beta\right)}{v\sigma\left(1 - \beta - \Omega\right)} x_{ss} m_{ss}$$

whose sign is decided by the factor $\frac{\Omega(\sigma-1)}{(1-\beta-\Omega)}$ so that two cases may appear to let $\det J < 0$:

$$\det J < 0 \Leftrightarrow \left[(\sigma > 1) \cap (\Omega > 1 - \beta)\right] \text{ or } \left[(\sigma < 1) \cap (\Omega < 1 - \beta)\right]$$

which can also be written as

$$\det J < 0 \Leftrightarrow \left[(\sigma > 1) \cap \left(\beta < \frac{1 + \eta - v}{1 + \eta}\right)\right] \text{ or } \left[(\sigma < 1) \cap \left(\beta > \frac{1 + \eta - v}{1 + \eta}\right)\right]$$

If this is the case, the two eigenvalues have opposite sign and then the equilibrium is a saddle.

It is possible to show that, in a bidimensional plane (m, x), the saddle path has positive inclination when $\left[(\sigma < 1) \cap \left(\beta < \frac{1+\eta-v}{1+\eta}\right)\right]$ and negative inclination when $\left[(\sigma > 1) \cap \left(\beta < \frac{1+\eta-v}{1+\eta}\right)\right]$. In the first case, consumption c and tourism revenues y are positively correlated and increase or decrease together according to whether the economy starts below or above the equilibrium values of $\frac{c}{k}$ and $\frac{y}{k}$. By contrast, in the second case, consumption and income go in opposite directions. The first case appears to be more significant and realistic. For this to happen, then, we need the inverse of the elasticity of substitution to be smaller than 1 and tourists' crowding aversion to be large enough.

6 Conclusions

We have proposed a dynamic general equilibrium model of a small economy specialized on tourism based on environmental resources. The model is able to study the several characteristics of the trade-off between economic growth and environmental sustainability in the context of an economy specialized in tourism. We analyze the balanced growth path properties of this economy, and deeply focus on the sensitiveness of its qualitative dynamic behavior, according to different subsets in the parameters' space. The economy we model is able to perform both endogenous growth - defined as positive and sustained long-run growth rate of the economy as a result of an optimization problem, and sustainability of the environmental resource - defined as a non-negative growth rate of the environmental assets. We analyze the conditions for this situation to occur and we find that endogenous growth and sustainability are not generally strictly related. In other words, there are subsets of parameters values such that endogenous growth and sustainability may or may not occur simultaneously. We also analyze the determinants of the growth rate of the economy and we interestingly find that when tourists' preferences are greener (i.e. when they care for environmental quality and they are crowding-adverse), the economy generally grows faster. These findings might have an appeal for policy-makers as they show that devoting resources towards the development of an environment-friendly kind of tourism, opposed to mass-tourism, do not necessarily reduce the long-term economic performance of the economy. Finally, we also develop the transitional dynamics analysis in the case of constant environmental quality along the balanced growth-path and we provide a complete characterization of the dynamic properties of the equilibrium. In particular, we provide the conditions for the steady-state to be saddle-point stable.

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