

Land, Environmental Externalities and Tourism Development

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Summary

In a two sectors dynamic model we analyze the process of tourism development based on the accumulation of capital (building of tourism facilities) and the reallocation of land from traditional activities to the tourism sector. The model incorporates the conflict between occupation of the territory by the tourism facilities, other productive activities and availability of cultural, natural and environmental assets that are valued by residents and visitors. We characterize the process of tourism development in two settings: the socially optimal solution and a situation where the costs of tourism expansion are external to the decision makers, where externalities on residents as well as intraindustry externalities are considered. Regarding the optimal solution, we show that it is optimal to limit tourism expansion before it reaches its maximum capacity even in a context where the economic attractiveness of tourism relative to other productive sectors rise continuously. However, in this context and when all the costs of tourism development are externalities the only limit to tourism quantitative expansion is its maximum capacity determined by the availability of land. Finally, we show that excessive environmental degradation from the future generations' point of view is not a problem of discounting the future but rather a problem of externalities that affects negatively the current and future generations.

Keywords: Intertemporal land allocation, Structural economic change, Tourism industry

JEL Classification: O41, Q24

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1. INTRODUCTION

Nowadays there exists a widely accepted consensus that there are limits to a tourism development based on quantitative growth. Obviously, the availability of a fixed amount of land in a tourism resort puts an ultimate limit to its carrying capacity. However, it is reasonable to assume that before the full occupation of land by tourism facilities other limiting factors will operate. Thus, the continuous growth in the number of tourists and the associated urban development, specially in small tourism destinations, can give place to costs in the form of congestion of public goods and loss of cultural, natural and environmental resources. These costs are not only suffered by the residents but they may also cause a negative impact on the tourism attractiveness of the destination, an adverse effect on the willingness to pay for tourism services provided in the tourism resort and therefore a fall in the returns to investment in the tourism sector.

In this paper we develop a two sector dynamic general equilibrium model of a small open economy where tourism development is characterized as a process of reallocation of land in fixed supply from low productivity activities (agriculture, forestry...) to its use in the building of tourism facilities. This change in the use of land goes along with investment aimed to the building of lodging and recreational tourism facilities. Land in the traditional sector, besides being a direct production factor in this sector, contains the cultural, natural and environmental resources of the economy. These resources are not only valued by the residents but also have a positive effect on the tourism attractiveness of the resort and on the willingness to pay for visiting the tourism destination. We therefore make explicit one of the characteristics of tourism development, viz. the urbanization of land. The model allows for the discussion about the limits of the quantitative tourism development in terms of three relevant factors: dependence of tourism with respect to cultural, natural and environmental assets available in fixed supply, the positive valuation of these assets by the residents and relative productivity of tourism with respect to other alternative sectors.

Despite the costs of tourism expansion, in the model tourism development is associated with improvements in the standard of living for the residents that are ultimately determined by two factors: sectoral change and investment opportunities associated to the tourism sector on the one hand and improvements in the price of tourism relative to manufactures on the other hand. While the latter has already been put forward by Lanza and Pigliaru (1994) this is to our knowledge the first paper that considers in a dynamic general equilibrium setting the reallocation of factors from low productivity sectors to the tourism sector as a possible explanation for the fast growth of the economies that specialize in tourism.

The rest of the paper is organized as follows. Section 2 discusses the model. Section 3 shows the optimal solution. In section 4 we obtain the behavior of the economy when the cost of tourism development are external to the decision makers. Section 5 compares the optimal and decentralized solution with the green golden rule in order to discuss several issues regarding long-term environmental degradation. Section 6 consider the case when the price of tourism relative to manufactures grows exogenously driven by international factors and compares the dynamics of land allocation in the optimal and decentralized solution. Finally, section 7 concludes.

2. THE MODEL

2.1. Production

We consider a region with a limited space that we normalize to one. Land has two alternative productive uses. On the one hand, it can be used in a traditional sector (agriculture, farming, forestry). On the other hand, land can be combined with physical capital to obtain tourism facilities for lodging and recreational purposes. We denote the first type of land L_T and the second L_{NT} .

In the economy there are three sectors. Firstly, production in the traditional sector depends on land devoted to this purpose, with decreasing returns and the following production function:

$$Y_{NT} = f(L_{NT})$$

or, given that L_T is the complementary of L_{NT} :

$$Y_{NT} = f(L_T) \tag{1}$$

where $f(L_T)$ and df/dL_T are continuous functions in the interval $L_T \in [0,1]$ with the following properties:

$$Y_{NT} = 0 \text{ when } L_T = 1$$

$$dY_{NT}/dL_{NT} > 0, d^2Y_{NT}/dL_{NT}^2 < 0, \lim_{L_{NT} \rightarrow 0^+} dY_{NT}/dL_{NT} = \infty$$

$$dY_{NT}/dL_T < 0, d^2Y_{NT}/dL_T^2 < 0, \lim_{L_T \rightarrow 1^-} dY_{NT}/dL_T = -\infty$$

Secondly, a construction sector builds tourism facilities for accommodation and recreational purposes using land and investment in physical capital. For simplicity, we consider that both production factors

are combined in fixed proportions to obtain units of accommodation capacity according to the following expression:

$$\dot{T} = \min\left(\eta \dot{L}_T, \varphi I\right) \quad (2)$$

Where $\dot{T}$ are new units of accommodation capacity that are built in each moment of time. $\dot{L}_T$ and I are the amount of land and investment needed for providing the tourism facilities associated to those units of accommodation capacity, while η and φ are fixed parameters.

Given (2), efficiency requires that:

$$\dot{T} = \eta \dot{L}_T = \varphi I$$

and therefore:

$$\dot{L}_T = \frac{\varphi}{\eta} I \quad (3)$$

$$T(\tau) = \int_0^{\tau} \dot{T}(t) dt = \int_0^{\tau} \eta \dot{L}_T(t) dt = \eta L_T(\tau) \quad (4)$$

where in (4) we have assumed that $T(t=0)=L_T(t=0)=0$.

Expression (3) shows the relationship between investment and land in the provision of tourism facilities, where η/φ measures the investment per unit of land. According to expression (4), accommodation capacity is proportional to the land devoted to tourism facilities.

Finally, a tourism sector supplies accommodation and recreational services using tourism facilities. Output of the tourism sector is measured by the number of night stays per unit of time. Assuming that night stays is a fixed multiple $\mathcal{G}$ of the accommodation capacity, output of the tourism sector is a linear function of the land occupied by tourism facilities:

$$Y_T = AL_T, A = \mathcal{G}\eta \quad (5)$$

Notice that A is the upper limit to the output of the tourism sector, that is, if $L_T=1$ then $Y_T=A$. Therefore, this parameter can be interpreted as a measure of physical carrying capacity. The number of the night stays is a fraction of this carrying capacity determined by the fraction of the space devoted to tourism facilities.

2.2. Trade flows

We are interested in a situation where tourism services are provided to foreigners. We assume that the economy sells the whole production of both sectors in exchange for an homogeneous good, manufactures, that is produced abroad. This imported good is used for consumption and investment and it is the numeraire. Moreover, for simplicity we assume that the economy cannot lend or borrow from abroad. Given these assumptions, goods markets clearing condition implies:

$$\begin{aligned} TR+NTR &= C+I \\ TR &= P_T Y_T \\ NTR &= P_{NT} Y_{NT} \end{aligned} \tag{6}$$

where TR and NTR stand for tourism and non-tourism revenues and P_T and P_{NT} are the prices of tourism and non tourism production relative to manufactures, while C is aggregate consumption.

2.3. Hypothesis about prices of final goods and tourism revenues function

We assume that P_{NT} is fixed, that is the economy is small in the international market of this product. Without loss of generality we normalize this price to one.

Regarding the price of the tourism services, our crucial assumption is that the price of the night stay depends on the satisfaction of the tourists that visit the resort. The satisfaction of a visitor depends on many variables, some are specific to the tourism firm that provides for lodging and recreational services and some are common to the whole tourism resort. The model includes two of the first kind of characteristics that could be determinants of the satisfaction of visitors, namely capital and land per unit of accommodation capacity. However, these ratios are considered exogenous and therefore they play a secondary role in the model. Our interest lays on those characteristics that are common to the tourism resort and, specifically, on landscape and cultural and environmental assets. Regarding this, we assume two hypothesis. Firstly, loss of landscape and cultural and environmental assets reduces the satisfaction of the tourists that visit the resort. Secondly, these intangibles can be approximated by the allocation of

land between its alternative uses. Basically we are assuming that the economy is endowed with natural and cultural assets with tourism attractiveness and these assets are intrinsically linked with that fraction of land devoted to traditional activities.

Formally our reasoning runs as follows. We define a utility function that measures the satisfaction per night stay of a tourist that visits the resort:

$$U_T^i = U_T(\omega^i, \Omega)$$

Where U_T^i is satisfaction of a tourist that receives services from firm i , ω^i is a vector of those characteristics specific to that tourism firm and Ω measures characteristics that are common to the whole tourism resort (landscape, cultural and environmental assets, congestion). Given the restrictions imposed to the production sector, all the tourism firms are identical and therefore we can drop the index i . Let us now define P_U as the price a tourist is willing to pay for a unit of satisfaction obtained in the resort. We consider that this price is exogenously determined in the international market and it is a price relative to manufactures. Given this, we can obtain an expression for the price for tourism services in the resort:

$$P_T = P_U U_T(\omega, \Omega)$$

Where P_T is the price paid per night stay. This function could be interpreted in the following way. In the international economy there is a continuum of tourism markets differentiated by their quality and the price paid for the tourism services. In each of them the suppliers are price-takers but they can move along the quality ladder either due to their own decisions or due to changes in the characteristics of the tourism resort where they are located. If we consider that the allocation of land is a good approximation of Ω then:

$$P_T = P(L_{NT}), P'(L_{NT}) > 0$$

Or, alternatively¹

$$P_T = P(L_T), P'(L_T) < 0$$

¹ Given that the number of visits to the tourism resort is proportional to L_T , the allocation of land could also be a good approximation of the degree of congestion. This would reinforce the negative effect of L_T on tourists' satisfaction.

where we have dropped the vector ω since it is constant through time and we have normalized P_U to one.

In the literature we can find several works that justify that the tourism price depends on the allocation of land. Firstly, applying the contingent valuation methodology, works as Drake (1992), Pruckner (1995) or Drake (1999) show that the willingness to pay for the landscape associated to agricultural land can be large. On this base, López *et alt.* (1994) and Brunstad *et alt.* (1999) consider the hypothesis that this willingness to pay is a function of the amount of land devoted to agricultural activities. Secondly, in the tourism field Fleischer and Tsur (2000), applying the travel cost method, show that tourists give a positive valuation to agricultural landscape that is of a large magnitude in comparison with the agricultural production value. Huybers and Bennet (2000) also measure the willingness to pay of tourists for better environmental conditions and lower congestion in the tourism resorts they visit.

Given (5) and the function for the price of a night stay, tourism revenues are:

$$TR = AL_T P(L_T)$$

We consider that this function is continuous and twice differentiable in the interval $L_T \in [0,1]$.

The occupation of the land by tourism facilities has two opposite effects on tourism revenues. On the one hand, a positive quantity effect given the positive relationship between night stays and land occupied by tourism facilities and, on the other hand, a negative effect on price due to the loss of intangible assets with tourism attractiveness. The relative strength of both effects determines the behavior of tourism revenues along a process of tourism development. Regarding this, we can consider two interesting scenarios.

In the first one, the quantity effect dominates the price effect, that is:

$$dTR/dL_T > 0 \quad \forall L_T \in [0,1]$$

This is the case if the elasticity of the price with respect to L_T is below one $\forall L_T \in [0,1]$

In a second interesting scenario the elasticity of the tourism price is increasing with L_T in such a way that:

$$dTR/dL_T > 0 \text{ if } L_T \in [0, \hat{L}_T)$$

$$dTR/dL_T < 0 \text{ if } L_T \in (\hat{L}_T, 1]$$

$$\hat{L}_T \in (0, 1)$$

where $\hat{L}_T$ is a tourism development threshold beyond which tourism expansion leads to a fall in tourism revenues. This will be the case if the elasticity of the price is lower than one when L_T is below that threshold and higher than one when L_T is above it.²

In both scenarios we consider that:

$$d^2TR/dL_T^2 < 0$$

$$TR(L_T) > 0 \quad \forall L_T \in (0, 1]$$

The second condition implies that the intangible assets linked to land used in traditional activities are not essential for the resort to have tourism attractiveness since the tourism price is positive even in the case when all the land is occupied by tourism facilities.

2.4. Resident's preferences

We consider that the economy is populated by a single representative agent that gives positive value to consumption and those cultural and natural assets that are contained in land devoted to traditional activities. His/her instantaneous utility function is:

$$U = U(C, L_{NT}) \quad U_C > 0, U_{CC} < 0, U_{LNT} > 0, U_{LNTLNT} < 0$$

3. OPTIMAL SOLUTION

Optimal solution results from solving the following problem:

² Tisdell (1987) considers a similar relationship between willingness to pay of tourists and the number of visits on the grounds of a combination of bandwagon and congestion effects, where the former would dominate in situations of low number of visitors and the later when the number of tourists is high enough.

$$MAX \int_0^{\infty} e^{-\rho t} U(C, L_{NT}) dt$$

subject to:

$$\dot{L}_T = \frac{\varphi}{\eta} [TR(L_T) + NTR(L_T) - C] \quad (7)$$

$$C \geq 0$$

$$0 \leq L_T \leq 1$$

$$L_{NT} = 1 - L_T$$

where (3) and (6) have been considered and ρ is the rate of time preference.

The first order conditions of the maximum principle are:

$$U_C = \lambda \frac{\varphi}{\eta} \quad (9)$$

$$-U_{L_{NT}} + \lambda \frac{\varphi}{\eta} [TR'(L_T) + NTR'(L_T)] = \rho\lambda - \dot{\lambda} \quad (10)$$

and the transversality condition is:

$$\lim_{t \rightarrow \infty} e^{-\rho t} \lambda(t) L_T(t) = 0$$

From (9) and (10) results:

$$TR'(L_T) = \frac{\eta}{\varphi} \left[\rho + \theta \frac{\dot{C}}{C} + \frac{U_{CL_{NT}}}{U_C} \frac{\dot{L}_T}{L_T} \right] - NTR'(L_T) + \frac{U_{L_{NT}}}{U_C} \quad (11)$$

where $\theta = -U_{CC}C/U_C$ is the elasticity of the marginal utility of consumption which is assumed constant.

Expression (11) is the Keynes-Ramsey rule that equates marginal returns to L_T (left-hand side) and the loss in utility and revenues from the traditional sector that arises from a marginal development of land aimed to accommodate tourism facilities (right-hand side). In equilibrium, marginal returns to L_T have to be larger the larger is the rate of time preference, since the occupation of land by tourism facilities requires an investment effort and therefore a delay in consumption. The second and third terms in the right hand side measure the proportional change of the marginal utility of consumption, $-\dot{U}_C/U_C$. If,

for instance, marginal utility of consumption falls through time,³ the faster is its fall, the lower is the value of an increase in consumption capacity due to the expansion of tourism and, therefore, the higher the marginal return of L_T should be. The fourth term is the loss of revenues from the traditional sector due to a marginal transfer of land from that sector to the tourism sector. Finally, tourism expansion results in environmental, landscape and cultural losses whose value in terms of consumption is U_{LNT}/U_C , that is, the last term of the right-hand side.

In the steady state all the variables remain constant. Therefore, and given (7) and (11) in the steady state the following conditions must be satisfied:

$$C_I = \frac{1}{v\theta} \left\{ (1-L_T) \left[TR'(L_T) + NTR'(L_T) - \frac{\eta}{\phi} \rho \right] - v(1-\theta)[TR(L_T) + NTR(L_T)] \right\} \quad (12)$$

$$C_{II} = TR(L_T) + NTR(L_T) \quad (13)$$

$$C_I = C_{II}$$

Where we have considered the following utility function for the resident:

$$U = \frac{(CL_{NT}^v)^{1-\theta}}{1-\theta} \quad (14)$$

Proposition 1. *In the optimal solution there is a unique steady state where the tourism sector is present if and only if the following condition is satisfied:*

$$TR'(0) > vNTR(0) - NTR'(0) + \frac{\eta}{\phi} \rho \quad (15)$$

If (15) is satisfied, in the steady state $C > 0$ and $L_T \in (0, 1)$.

Proof: appendix I

Let us assume that the economy is initially specialized in the traditional sector and condition (15) is satisfied. As it is shown in figure 1, there is an initial consumption level, C_0 , that puts the economy in a path that converges to the steady state.⁴ This path is characterized by a process of tourism development where capital accumulates, land is progressively occupied by tourism facilities and consumption and

³ This is what happens when consumption grows and, if marginal utility of consumption is increasing with L_T , when the tourism sector expands. As it is shown below, this is what happens in the transitional dynamics of the model.

⁴ In the appendix I it is shown that the steady state is saddle-path stable.

tourism revenues grow. This process of tourism expansion stops before reaching the physical carrying capacity due to three factors: the negative effect of congestion and loss of intangible assets on resident's and tourists' utility and the increase in marginal returns to land in the traditional sector.

The expression (15) can be interpreted as a necessary condition for a process of tourism development to be socially optimal. That is, for the resident to be interested in the expansion of the tourism sector revenues from the initial development of this sector, net of the revenue losses in the traditional sector, that is, $TR'(0)+NTR'(0)$, should be high enough; total revenues from the traditional sector when the economy is fully specialized in this sector, that is, $NTR(0)$, should be low enough; moreover, the weight on resident's utility of the intangible assets that are linked to land used in the traditional sector, v , as well as the rate of time preference, ρ , and investment per unit of land required for the building of tourism facilities, η/ϕ should be low enough. Figure 2 shows a case when condition (15) is not satisfied.

Regarding initial consumption, $C(t=0)>C^*$ is not possible, since it implies $\dot{L}_T(t=0)<0$ and therefore a negative value of L_T . Any value of $C(t=0)<C^*$ would set the economy in a path where $C(t)<C^* \forall t$, which is inferior to an alternative feasible path where $C(t)=C^* \forall t$. Therefore, the optimal solution is $C(t)=C^*, L_T(t)=0 \forall t$, that is, society is not interested in the tourism development.

4. SOLUTION WITH EXTERNALITIES

In a decentralized economy some of the costs associated to the tourism expansion are not considered in the decisions about allocation of factors. For instance, lack of well defined property rights on natural, environmental and landscape assets implies that, without public intervention, the tourism sector do not compensate to the residents for the degradation of those assets linked to the tourism expansion. It is true that some of the costs of the tourism development fall on the tourism sector in the form of lower tourism attractiveness of the resort and a lower tourism price. However, the tourism price depends on the characteristics of the whole tourism resort regarding congestion and quality and abundance of intangible assets and therefore, except for the case of perfect coordination in the tourism sector (for instance, in the case of a monopoly), the decisions of any of the tourism firms will cause negative externalities to the rest of the sector.

In this section the behavior of the model is explored in a case where the costs associated to the tourism expansion are purely external. That is, the agents that take the decisions about the allocation of factors do not take into account the negative effects of congestion and the loss of intangible assets neither on the resident (externalities on residents) nor on the tourism price (intrasector externalities).

Applying the maximum principle to this version of the model we obtain:

$$U_c = \lambda \frac{\varphi}{\eta} \quad (16)$$

$$\lambda \frac{\varphi}{\eta} [AP(L_T) + NTR'(L_T)] = \rho \lambda - \dot{\lambda} \quad (17)$$

and the transversality condition is:

$$\lim_{t \rightarrow \infty} e^{-\rho t} \lambda(t) L_T(t) = 0$$

Condition (17) is different from (10) since in the former we assume that the effects of a change in the use of land on resident's utility and on the price of a night stay are not considered in the decisions of allocation of factors.

The behavior of the economy is determined by the transversality condition and the following dynamic system:

$$\frac{\dot{C}}{C} = \frac{1}{\theta} \frac{\varphi}{\eta} \left[AP(L_T) + NTR'(L_T) - v(1 - \theta) \frac{1}{1 - L_T} [TR(L_T) + NTR(L_T) - C] - \frac{\eta}{\varphi} \rho \right] \quad (18)$$

$$\dot{L}_T = \frac{\varphi}{\eta} [TR(L_T) + NTR(L_T) - C] \quad (7)$$

where (14), (16) and (17) have been considered. The steady state satisfies the following conditions:

$$C_I = -\frac{(1 - L_T)}{v(1 - \theta)} \left[AP(L_T) + NTR'(L_T) - \frac{\eta}{\varphi} \rho \right] + TR(L_T) + NTR(L_T) \quad (19)$$

$$C_{II} = TR(L_T) + NTR(L_T) \quad (20)$$

$$C_I = C_{II}$$

Proposition 2. *In the solution with externalities there is a unique interior steady state if and only if the following condition is satisfied:*

$$AP(0) + NTR'(0) - \frac{\eta}{\varphi} \rho > 0 \quad (21)$$

If (21) is satisfied, in the interior steady state $C > 0$, $L_T \in (0, 1)$.

Proof: appendix II

As it is shown in appendix II, the interior steady state is saddle-path stable and satisfies the transversality condition. Depending on the functional form of the tourism revenues function, there could exist a second steady state where $L_T=1$. However, this steady state does not satisfy the transversality condition.

As it happens in the optimal solution, if the economy is initially specialized in traditional activities and condition (21) is satisfied the economy will follow a path of tourism expansion characterized by the progressive occupation of land by the tourism facilities, accumulation of capital and growth in consumption and tourism revenues. The condition that ensures that this process of tourism development stops before the whole land is occupied by tourism facilities is the assumption that marginal returns to land in the traditional sector goes to infinity when L_{NT} tends to zero. Figure 3 shows the steady state and the transitional path for the solution with externalities.

It is easy to show that in the solution with externalities tourism expansion is excessive from the social point of view. On the one hand, in the solution with externalities land occupied by tourism facilities when the steady state is reached can be worked out from the following expression:

$$AP(L_T) + NTR'(L_T) = \frac{\eta}{\phi} \rho \quad (22)$$

where (19) and (20) have been considered.

On the other hand, from (12) and (13) it follows that in the optimal solution:

$$AP(L_T) + NTR'(L_T) = \frac{v}{1-L_T} [TR(L_T) + NTR(L_T)] - AL_T P'(L_T) + \frac{\eta}{\phi} \rho$$

Given that $(v/(1-L_T))[TR(L_T) + NTR(L_T)] - AL_T P'(L_T) > 0 \quad \forall L_T \in (0,1)$ and that the left hand side of both expressions is decreasing with L_T it follows that when the economic system do not consider the negative external effects of the tourism sector the proportion of land occupied by the tourism facilities as well as the accommodation capacity of the tourism resort are excessive from the social welfare point of view.

What is more, when the costs of the tourism expansion are not internalized it could happen that a process of tourism development would take place being it socially suboptimal. This is what happens in the model when (21) is satisfied but (15) is not. Figure 4 shows a case of this sort.

5. ENVIRONMENTAL DEGRADATION, DISCOUNTING AND EXTERNALITIES

Many times environmental degradation has been explained by intergenerational conflict. That is, present generations, seeking for a high own welfare and disregarding the welfare of future generations overexploit natural resources leaving a bequest of degraded environment and low welfare. According to this explanation, a high discount factor is to blame for unsustainable development paths.

We address this question in the context of our model. What we show is that a higher discount factor implies higher (not lower) cultural, natural and environmental assets in the long run. This is not to say that the economy cannot end up with an excessive degradation of these assets but this will be due to the presence of externalities in the process of tourism development.

To show this, let us firstly calculate the “green” golden rule level. In the context of this model, the green golden rule level is the allocation of land that maximizes utility in the long-run (steady state). In words of Heal (1998), this is the maximum level of sustainable welfare and it could be interpreted as the long-run situation of an economy that would only care for long-term welfare. The green golden rule comes from the following problem:

$$\begin{aligned} \underset{C, L_T}{MAX} U &= \frac{[C(1-L_T)^v]^{1-\theta}}{1-\theta} \\ \text{subject to} \\ C &= TR(L_T) + NTR(L_T) \end{aligned}$$

that gives the following condition:

$$\Phi(L_T) = \frac{(1-L_T)}{v} [TR'(L_T) + NTR'(L_T)] - [TR(L_T) + NTR(L_T)] = 0 \quad (23)$$

The optimal solution and the green golden rule only differ in that in the former the welfare during the transition to the steady state is also considered in the economic decisions and, moreover, the future is discounted. In the optimal solution the economy ends up with a lower level of L_T than the green golden rule level. This can be shown if we combine (12) and (13) to get:

$$\Phi(L_T) = \frac{(1-L_T)}{v} [TR'(L_T) + NTR'(L_T)] - [TR(L_T) + NTR(L_T)] = \frac{(1-L_T)}{v} \frac{\eta}{\phi} \rho \quad (24)$$

Given that the right hand of (24) is positive when it is evaluated at the steady state of the optimal solution and that $\Phi'(L_T) < 0$ for the relevant range of values for L_T , we can conclude that in the optimal solution the economy ends up with a level of L_T that is lower than the green golden rule. That is, in this model it is not true that environmental degradation is a consequence of disregarding of future generations' welfare since if society would only be worried by long-term welfare it would opt for a larger tourism expansion and lower long-term cultural, natural and environmental assets. This is due to the fact that tourism expansion and environmental degradation are linked to investment in the provision of tourism facilities. Precisely because in the optimal solution the future is discounted, current generations are not disposed to make the necessary sacrifices in terms of current consumption that are needed to reach the green golden rule. Figure 5 compares the steady state of the optimal solution with the green golden rule.

Contrary to the case of the optimal solution, when the environmental and cultural costs of tourism expansion are external to the decision makers the economy can end up in the log-run with a more degraded environment than what would follow from the maximization of long-run welfare. This is what happens if:

$$\frac{\eta}{\phi} \rho < \frac{v}{1-L_T} [TR(L_T) + NTR(L_T)] - AL_T P'(L_T)$$

Condition that results from the combination of (22) and (23) and where the right hand side is evaluated at the green golden rule level.⁵ This condition is satisfied for low values of the rate of time preference and investment requirements per unit of land. In this situation the solution with externalities is dynamically inefficient, that is to say, there are paths that imply higher welfare levels not only in the steady state but also during the transitional path and therefore long-term environmental degradation is not a symptom of intergenerational conflict but of inefficiencies due to the presence of external costs. Figure 6 represents a case where the solution with externalities implies excessive environmental degradation from the long-term welfare point of view.

6. CONTINUOUS GROWTH AND ENVIRONMENTAL DEGRADATION

As it is set up, the model does not allow for long-run growth based on endogenous factors. On the one hand, consistent with a large body of the literature that stresses the existence of a carrying capacity in

⁵ From (23) it follows that in the the green golden rule $AP(L_T) + ITN'(L_T) = (v/(1-L_T)) [IT(L_T) + INT(L_T)] - AL_T P'(L_T)$. Moreover, $AP'(L_T) + ITN''(L_T) < 0$.

the tourism resorts (see for instance Butler, 1980), quantitative growth based on the increase in accommodation capacity and the number of visitors is not possible given a limited amount of space⁶ and cultural and environmental assets. On the other hand, the model is constructed in a way that qualitative growth, for instance through the increase in capital per unit of accommodation, is not possible.⁷ Therefore, if we want to analyze the effects of continuous growth in the allocation of land we have to rely on exogenous forces. A good candidate is the price of tourism relative to manufactures. Thus, in this section we explore the behavior of the model in a situation in which factors exogenous to the economy rise this relative price.

This assumption seems reasonable given several facts observed during the last decades. Specifically, since the 50's international tourism expenditures have experience faster growth than world GDP. At the micro level tourism expenditure has increased its share in households' expenditure in most developed countries. This behavior can be related to a broader phenomenon consistent on a shift of expenditure shares from manufactures to services. As it is commented by Rowthorn and Ramaswamy (1997), this can be mainly explained by a rise in the price of services relative to manufactures since in real terms the change of expenditure shares in manufactures and services is quite small. The increase in this relative price can be explained by the combination of two factors. On the one hand, Clark (1957) considers the hypothesis that income effects could increase relative demand for services after a threshold of economic development has been passed. On the other hand, the higher productivity growth that the manufacturing sector has experienced tends to lower the price of manufactures relative to services. Figure 7 shows the effects of both explanations for the case of the price of tourism relative to manufactures. On the vertical axis there is the international relative price per night stay for a given perceived quality. *RD* is international relative demand tourism/manufactures that shifts to the right due to income effects⁸ or possible changes in preferences. *RS* is relative supply tourism/manufactures that shifts to the left due to higher productivity growth in the manufacturing sector. The combined effect is an increase in the relative price of tourism for a given perceived quality of the tourism product and an increase of the share of tourism expenditure in total expenditures.

Lanza and Pligiaru (1994) set up a model where the international price of tourism relative to manufactures rises continuously due to a lower productivity growth in the former sector. In their model this relative price is endogenous since the economy specialized in tourism is large in the international markets (in fact, it is the sole supplier of tourism). In contrast, in our model the economy is small in the sense that variations in its supply of accommodation capacity has a negligible effect on world tourism supply. Therefore, what we assume is that the rise in the international tourism price relative to

⁶ As it is shown in the previous sections, growth stops before reaching the maximum capacity of the resort.

⁷ See Gómez, Lozano and Rey-Maqueira (2003) for a model where qualitative growth is allowed.

⁸ Crouch (1995, 1996) reports high income elasticity of tourism demand.

manufactures is exogenous from the point of view of the economy. Regarding the price of the output of the traditional sector relative to manufactures we continue to assume that it remains constant through time.

Therefore, let us consider the following:

$$P_T = \tau P(L_T)$$

$$\frac{\dot{\tau}}{\tau} = g, \quad \tau(t=0) > 0, \quad g > 0$$

where τ is a parameter whose growth reflects upward pressure on relative price of tourism for any perceived quality of tourism services, that is, for any level of L_T .

Therefore, we identify two determinants of the relative price of tourism supplied by the economy. On the one hand, several factors that push upwards the price of tourism relative to manufactures and affect all the tourism destinations and all the market segments. On the other hand, those factors specific to the tourism destination, that is, congestion, landscape and natural and environmental assets that determine the satisfaction of a tourist visiting the resort and his/her willingness to pay for tourism services given a level of τ .

In the following we analyze the effect on the allocation of land of the assumption that τ grows continuously. Specifically, we would like to answer two questions:

- i. is it socially optimal to limit the quantitative growth of the tourism sector?
- ii. when the costs of tourism expansion are external to the decision makers, is there any limit to the quantitative growth of the tourism sector?

With such an aim, we calculate the asymptotic steady state value of L_T in the optimal solution and in the solution with externalities when τ grows continuously.

6.1. *Optimal solution*

Considering (12) and (13) and inserting the parameter τ , the following condition is satisfied in the steady state of the optimal solution:

$$v[\tau TR(L_T) + NTR(L_T)] = (1 - L_T) \left[TR'(L_T) + NTR'(L_T) - \frac{\eta}{\varphi} \rho \right] \quad (25)$$

or:

$$\tau = \frac{(1-L_T) \left[NTR'(L_T) - \frac{\eta}{\phi} \rho \right] - vNTR(L_T)}{vTR(L_T) - (1-L_T)TR'(L_T)} \quad (26)$$

The asymptotic value of L_T consistent with a τ that tends to infinite is that value that makes the denominator of the previous expression equal to zero,⁹ that is:

$$TR'(L_T)(1-L_T) = vTR(L_T) \quad (27)$$

From this reasoning we can derive the following proposition:

Proposition 3. *When the international relative tourism price grows continuously the steady state value of L_T tends asymptotically to a value $\bar{L}_T \in (0,1)$.*

Prof.: appendix III

The proposition 3 implies that even when the relative price of tourism and therefore the attractiveness of tourism relative to other productive sectors grow continuously, it is socially optimal to limit the quantitative expansion of the tourism sector before it reaches its maximum capacity.

To show the dynamics of tourism development with the new assumption, let us consider expression (15) again where we have now inserted parameter τ .

$$\tau TR'(0) > vNTR(0) - NTR'(0) + \frac{\eta}{\phi} \rho \quad (15')$$

Remember that this expression is a necessary condition for a process of tourism development to be optimal. Therefore, there is a threshold of τ under which it is not socially optimal to develop the tourism sector. If τ grows continuously that condition will be satisfied soon or later and from then on the economy will experience a non balanced growth path characterized by an expansion of the tourism sector at the expense of the traditional sector. Consumption and accommodation capacity grow but

⁹ There is no value of $L_T \in [0,1]$ for which the numerator is infinite.

while the former grows continuously the later tends asymptotically to a level below the maximum capacity. Therefore, we identify two sources of growth in the economy: sectoral change fueled by the reallocation of resources from other sectors to the tourism sector and exogenous improvements in the terms of trade of the economy. However, in the long-term the former vanishes and the later remains alone. Figure 8 shows the behavior of the economy when τ grows continuously.

Notice that in the determination of $\bar{L}_T$ (expression 27), the traditional sector is absent. This is so because although this sector do not disappear (the asymptotic value of L_{NT} is positive) its share in the production value of the economy tends to zero as τ grows. Condition (27) has an interesting economic interpretation if we transform that expression into the following:

$$\tau TR'(L_T) \left[C^{-\theta} (1 - L_T)^{v(1-\theta)} \right] = v C^{(1-\theta)} (1 - L_T)^{v(1-\theta)-1} \quad (27')$$

where $(1-L_T)$ has gone to the right, we have multiplied both sides by $\tau C^{-\theta} (1-L_T)^{v(1-\theta)}$ and we have considered that, when τ grows the asymptotic value of consumption is equal to the asymptotic level of tourism revenues since investment tends asymptotically to zero and the revenues from the traditional sector tend to a constant value.

The left hand side of (27') represents the contribution to resident's utility of an additional unit of consumption that comes from a marginal transfer of land to the tourism sector disregarding the loss in the output of the traditional sector. The right hand side is the negative impact on resident's utility due to the loss of intangible assets associated to that marginal transfer of land. Expression (27') therefore equates marginal costs and marginal benefits of an increase in the accommodation capacity of the resort disregarding the effects on the traditional sector. In summary, even in a context where the economic attractiveness of tourism relative to the traditional sector increases continuously, full specialization in tourism is not socially optimal, but the preservation of the traditional sector is not based on its direct productive contribution but on its role in the preservation of cultural, environmental and natural assets that are valued by the residents and are a source of tourism revenues.

6.2. *Solution with externalities*

From (19) and (20) and inserting the parameter τ , the following condition is satisfied in the steady state of the solution with externalities.

$$\frac{(1-L_T)}{v(1-\theta)} \left[\tau AP(L_T) + NTR'(L_T) - \frac{\eta}{\phi} \rho \right] = 0$$

which, for the interior steady state, implies:

$$\left[\tau AP(L_T) + NTR'(L_T) - \frac{\eta}{\phi} \rho \right] = 0$$

or

$$\tau = \frac{-NTR'(L_T) + \frac{\eta}{\phi} \rho}{AP(L_T)} \quad (28)$$

Proposition 4. *The value of L_T in the interior steady state of the solution with externalities tends asymptotically to its maximum value, unity, when the relative tourism price grows continuously.*

Proof: we know that $\lim_{L_T \rightarrow 1^-} NTR'(L_T) = -\infty$ and $\lim_{L_T \rightarrow 1^-} P(L_T) > 0$, a finite value. Therefore, in (28)

$\lim_{L_T \rightarrow 1^-} \tau = \infty$. Moreover, in (28) τ is a monotonous function of L_T for $L_T \in [0, 1]$ since $NTR''(L_T) < 0$ and $P'(L_T) < 0$. We then conclude that $\lim_{\tau \rightarrow \infty} L_T = 1$.

Proposition 4 implies that if the costs of tourism development are not considered by the decision makers, a continuous increase in the economic attractiveness of tourism relative to other sectors would generate incentives to expand tourism capacity with the only limit of the total availability of land. The tourism sector fully crowds-out other productive sectors even if full specialization in tourism is not socially optimal and society prefers to preserve part of the land from its occupation by tourism facilities not only as a source of amenities for the residents but also as a source of tourism revenues. Figure 9 shows the behavior of the economy with externalities when τ grows continuously.

7. CONCLUSIONS

In this paper we have constructed a dynamic general equilibrium model of tourism development based on the reallocation of land from a low productivity traditional sector to its use in the building of tourism

facilities, where that reallocation is associated to investment efforts to provide for those facilities. Tourism expansion allows for increases in consumption capabilities but also implies a loss of cultural, natural and environmental assets linked to land used in the traditional sector that are positively valued not only by the residents but also by the tourists.

In this framework, the social optimal solution is obtained. We identify a condition for the tourism development to be socially desirable. If this condition is met, the optimal solution implies convergence to a steady state where land is only partially occupied by tourism facilities. During the transition to the steady state the economy experiences economic growth based on the sectoral change. Tourism development stops before reaching its maximum capacity due to the positive valuation of cultural, natural and environmental assets by the residents, the negative effect on tourism revenues of the loss of those assets and decreasing returns to land in the traditional sector.

It has also been shown that when the costs of tourism expansion are external to the decision makers, tourism development is excessive from the point of view of the residents' welfare. It could even happen that a process of tourism development would take place without it being socially desirable. It is also possible to end up in the long-term with an environmental degradation that is not compensated with high enough consumption. However, in case this is so, the reason is not a problem of intergenerational conflict, since a lower tourism development would increase welfare not only in the steady state but also during the transitional path, but rather the fact that the costs of tourism development are not fully internalized.

Finally, we consider an exogenous growth factor, that is, the increase in the price of tourism relative to manufactures in the international markets. In this context, the economic attractiveness of tourism relative to the traditional sector grows continuously but the society is interested in preserving the latter not because it makes a significant contribution to income but because land used in this sector contains the cultural, natural and environmental assets that are valued by the residents and have a positive influence on tourism revenues. However, if the costs of tourism expansion are not considered in the decisions of factors allocation the traditional sector and those intangible assets that are linked to this sector tend to disappear asymptotically.

APPENDIX I. Steady state and stability in the optimal solution

The steady state of the optimal solution satisfies the following conditions:

$$C_I = \frac{1}{v}(1 - L_T) \left[TR'(L_T) + NTR'(L_T) - \frac{\eta}{\phi} \rho \right] \quad (I.1)$$

$$C_{II} = TR(L_T) + NTR(L_T) \quad (I.2)$$

$$C_I = C_{II}$$

where (I.1) comes from the combination of (12) and (13) and (I.2) is the same as (13)

First of all we show that if (15) is satisfied, there exists at least one steady state where $C > 0$, $0 < L_T < 1$. To prove existence, given continuity in $L_T \in [0, 1]$ of all functions, the following is enough:

- a) $C_{II} > 0 \quad \forall L_T \in [0, 1]$.
- b) If (15) is satisfied, then $C_I > C_{II}$ for $L_T = 0$.
- c) There is an $L_T = L_T^* \in (0, 1)$ for which $C_I = 0$. Given (I.1), L_T^* satisfies:

$$\Omega(L_T) = TR'(L_T) + NTR'(L_T) - \frac{\eta}{\phi} \rho = 0$$

There is only one level of L_T that satisfies this condition since: (i) $\Omega(0) > 0$ if (15) is satisfied; (ii) $\Omega(1) < 0$ given the properties of the traditional sector production function; (iii) $\Omega'(L_T) < 0$ in the unit interval given the assumption about the second derivatives of the tourism revenues function and the traditional sector production function. Therefore, C_I and C_{II} intersect at least once in the interval $L_T \in (0, 1)$.

Secondly, it can be proved that the steady state is unique in the interval $L_T \in [0, 1]$. On the one hand, if (15) is satisfied then $L_T \neq 0$ in the steady state. Moreover, given that in the steady state:

$$\frac{1}{v} \left[TR'(L_T) + NTR'(L_T) - \frac{\eta}{\phi} \rho \right] = \frac{TR(L_T) + NTR(L_T)}{1 - L_T}$$

then $L_T \neq 1$ in the steady state since when $L_T = 1$ the left hand side is minus infinite and the right hand side is plus infinite.

On the other hand, given that $C_{II} > 0 \quad \forall L_T \in (0, 1)$, $C_I > 0 \quad \forall L_T \in (0, L_T^*)$ and $C_I < 0 \quad \forall L_T \in (L_T^*, 1)$, then $L_T \in (0, L_T^*)$ in the steady state. For this interval, C_I is always decreasing in L_T and therefore, the steady state is unique if C_{II} is increasing in L_T for $L_T \in (0, L_T^*)$. Notice that C_{II} has a single maximum in the interval $L_T \in [0, 1]$ since $dC_{II}/dL_T > 0$ when $L_T = 0$ if (15) is satisfied, $dC_{II}/dL_T < 0$ when $L_T = 1$ given the

properties of the traditional sector production function and finally $d^2C_H/dL_T^2 < 0$. C_H is maximum when $TR'(L_T) + NTR'(L_T) = 0$ while L_T^* satisfies the condition $TR'(L_T) + NTR'(L_T) = \eta\rho/\phi$. Since $d^2C_H/dL_T^2 < 0$, the value of L_T that maximizes C_H is larger than L_T^* and therefore C_H is increasing in L_T in the interval $L_T \in (0, L_T^*)$.

Regarding stability, let us consider the system (7), (11) where in (11) it is assumed that the utility function of the resident is (14). Linearization around the steady state results in a linear system whose Jacobian is:

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$$

and

$$a_{11} = v \frac{\bar{C}}{1 - \bar{L}_T} + \frac{\eta}{\phi} \rho$$

$$a_{12} = -\frac{\phi}{\eta}$$

$$a_{21} = \frac{\bar{C}}{\theta} \frac{\phi}{\eta} \left\{ IT''(\bar{L}_T) + INT''(\bar{L}_T) - [v^2(1 - \theta) + v] \frac{\bar{C}}{(1 - \bar{L}_T)^2} - v(1 - \theta) \frac{\eta}{\phi} \rho \right\}$$

$$a_{22} = -v \frac{\phi}{\eta} \frac{\bar{C}}{1 - \bar{L}_T}$$

where $\bar{C}$ and $\bar{L}_T$ are steady state values.

It is clear that $a_{11} > 0$, $a_{12} < 0$, $a_{22} < 0$. If $\theta \leq 1$ then $a_{21} < 0$. In this case, $\text{Det}(A) < 0$ and therefore the eigenvalues are real and of opposite signs so the steady state is saddle-path.

Notice that $\theta \leq 1$ is a sufficient but not necessary condition for the steady state to be saddle-path. This assumption implies that marginal utility of consumption is increasing in L_{NT} .

APPENDIX II. Steady state and stability in the solution with externalities

Conditions (19) and (20) imply:

$$\frac{(1-L_T)}{\nu(1-\theta)} \left[AP(L_T) + NTR'(L_T) - \frac{\eta}{\varphi} \rho \right] = 0 \quad (\text{II.1})$$

Leaving aside the case when $L_T=1$ for the moment, (II.1) is satisfied if there is a value of $L_T \in [0,1)$ for which:

$$\psi(L_T) = AP(L_T) + NTR'(L_T) - \frac{\eta}{\varphi} \rho = 0$$

Given that:

i) $\psi'(L_T) < 0 \ \forall L_T \in (0,1)$, since $P'(L_T) < 0, NTR''(L_T) < 0$

ii) $\psi(1) < 0$, since $AP(1) > 0, NTR'(1) = -\infty$

there is a single value of $L_T \in [0,1)$ for which $\psi(L_T)=0$ if:

$$\psi(0) = AP(0) + NTR'(0) - \frac{\eta}{\varphi} \rho \geq 0$$

In this steady state consumption is positive since $C_H > 0 \ \forall \in [0,1)$. Moreover, this value of L_T is different from zero if the previous condition is satisfied as an strict inequality (condition 21).

Regarding the transversality condition, this can be expressed in the following way:

$$\lim_{t \rightarrow \infty} L_T(t) \lambda(t=0) e^{\left[\frac{\dot{\lambda}(t)}{\lambda(t)} - \rho \right] t} = 0$$

L_T tends to a constant value since it belongs to the unit range. Moreover, $\lambda(t=0) < \infty$, since $\lambda = \eta U_C / \varphi$, $0 < U_C < \infty \ \forall L_T \in [0,1)$. Regarding the growth rate of the shadow price, from (17) this can be expressed:

$$\frac{\dot{\lambda}}{\lambda} = \frac{\varphi}{\eta} [-AP'(L_T) - NTR'(L_T)] + \rho$$

In the path that converges to the interior steady state the previous expression converges to zero since in the interior steady state the following condition is satisfied:

$$AP(L_T) + NTR'(L_T) = \frac{\eta}{\varphi} \rho > 0$$

Therefore, the transversality condition is satisfied.

In the case a second steady state would exist where $L_T=1$, the path that converges to this steady state do not satisfies the transversality condition. In this path $NTR'(L_T)$ goes to minus infinite and therefore the growth rate of the shadow price tends to infinite.

Regarding stability, the elements of the Jacobian in the solution with externalities are:

$$a_{11} = \frac{\varphi}{\eta} [TR'(L_T) + NTR'(L_T)]$$

$$a_{12} = -\frac{\varphi}{\eta}$$

$$a_{21} = \frac{C}{\theta} \frac{\varphi}{\eta} \left\{ AP'(L_T) + NTR''(L_T) - v(1-\theta) \frac{1}{1-L_T} [TR'(L_T) + NTR'(L_T)] \right\}$$

$$a_{22} = v \frac{1-\theta}{\theta} \frac{\varphi}{\eta} \frac{C}{1-L_T}$$

Therefore, the determinant is:

$$Det = -\frac{C}{\theta} \left(\frac{\varphi}{\eta} \right)^2 [AP'(L_T) + NTR''(L_T)] < 0$$

From which it can be concluded that the interior steady state is a saddle-path.

APPENDIX III. Proof of proposition 3

To prove proposition 3 we have firstly to show that there is a single value of $L_T \in (0,1)$ that satisfies (27). This proof requires a different treatment depending on the hypothesis regarding the behavior of the tourism revenues function that have been considered in section 2.3.

In the case where $TR'(L_T) > 0 \forall L_T \in [0,1]$, the following is sufficient to prove that a single value of $L_T \in (0,1)$ satisfies (27):

- a) when $L_T=0$ left hand side is larger than right hand side;

- b) when $L_T=1$ left hand side is smaller than right hand side;
- c) left hand side is decreasing in L_T since $TR''(L_T)<0$ and right hand side is increasing in L_T for any $L_T \in [0,1]$.

In the alternative case when tourism revenues reach a maximum before reaching maximum tourism capacity, we can prove that a single value of $L_T \in (0,1)$ satisfies (27) in the following way. Condition (27) can be expressed as:

$$1 - L_T = v \frac{TR(L_T)}{TR'(L_T)} \quad (\text{III.1})$$

The right hand side of (III.1) is zero when $L_T=0$, infinite if L_T takes the value that maximizes tourism revenues, negative if L_T is larger than that value and increasing in L_T if this variable is below that value. Therefore, the level of L_T that satisfies (III.1) and (27) is unique and it is strictly between zero and one.

We know that if L_T tends to the value that satisfies (27), the value of τ in expression (26) goes to infinite. The opposite is true, that is, if τ tends to infinite then the steady state level of L_T tends to the value that satisfies (27) if (26) is monotonically increasing. To show this, we have to prove that $d\tau/dL_T > 0$. To prove this, we differentiate the steady state condition (25), which is equivalent to (26), with respect to τ and L_T to obtain:

$$\frac{d\tau}{dL_T} = \frac{(v+1)[\tau TR'(L_T) + NTR'(L_T)] - (1-L_T)[\tau TR''(L_T) + NTR''(L_T)] - \frac{\eta}{\phi} \rho}{(1-L_T)TR'(L_T) - vTR(L_T)}$$

where L_T takes its steady state value. This expression is always positive since:

- a) the denominator is positive since when steady state condition (25) is satisfied then:

$$(1-L_T)TR'(L_T) - vTR(L_T) = \frac{NTR(L_T) - (1-L_T)[NTR'(L_T) - \eta\rho/\phi]}{\tau} > 0$$

- b) $\tau TR'(L_T) + NTR'(L_T) > 0$, since L_T in the steady state of the optimal solution is always below the golden rule.
- c) $\tau TR''(L_T) + NTR''(L_T) < 0$

d) $\tau TR'(L_T) + NTR'(L_T) > \eta\rho/\varphi$, since in appendix I it is shown that L_T in the steady state of the optimal solution is below L_T^* , where $\tau TR'(L_T^*) + NTR'(L_T^*) = \eta\rho/\varphi$ and moreover $TR''(L_T) < 0$ and $NTR''(L_T) < 0$.

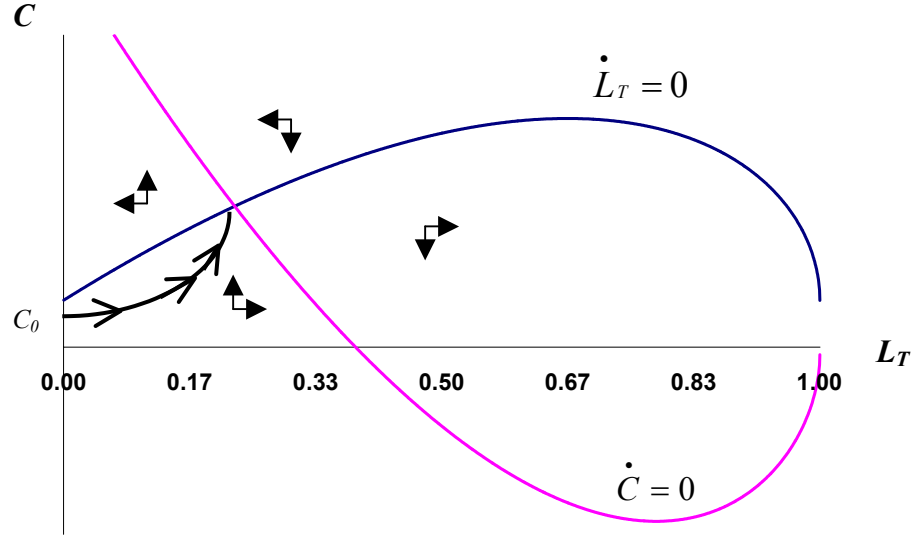
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FIGURE 1

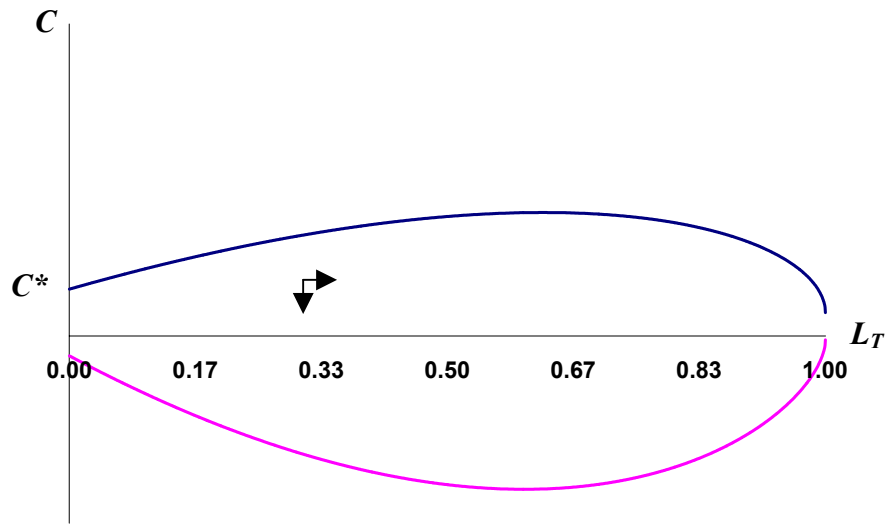
Steady state and path of tourism development in the optimal solution¹⁰



¹⁰ The following functional forms and parameter values have been used: $Y_{NT} = B(L_{NT})^\beta$, $P_T = P_U[(L_{NT})^\alpha + j]$, $IT = AL_T P_T$, $B = 300000$, $A = 3000000$, $\alpha = 0.5$, $\beta = 0.9$, $\eta = 100000$, $\varphi = 0.035$, $\theta = 0.8$, $\rho = 0.05$, $v = 0.5$, $j = 0.1$, $P_U = 1$

FIGURE 2

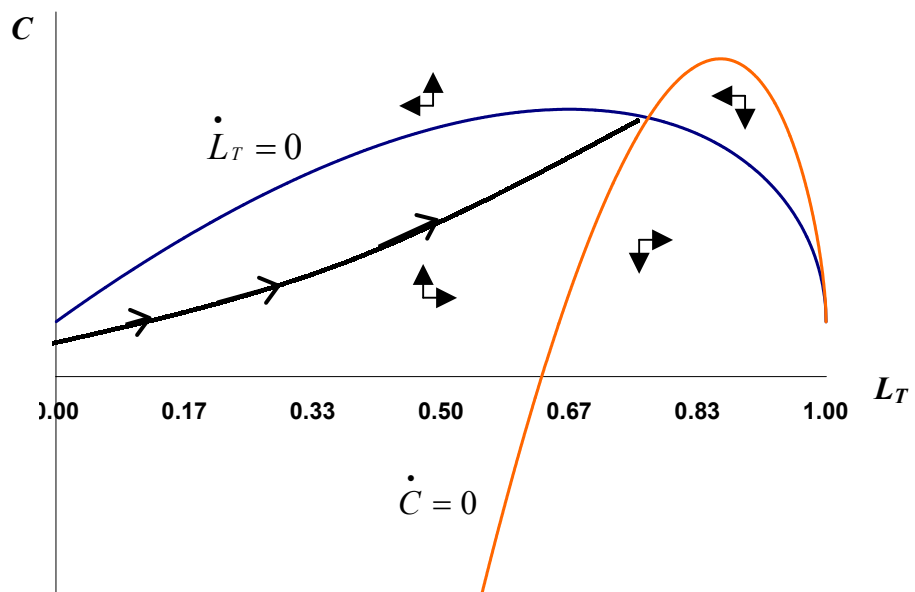
A case where the expansion of the tourism sector is not socially optimal¹¹



¹¹ Same functional forms and parameter values as in figure 1 except for P_U . Here $P_U=0.5$

FIGURE 3

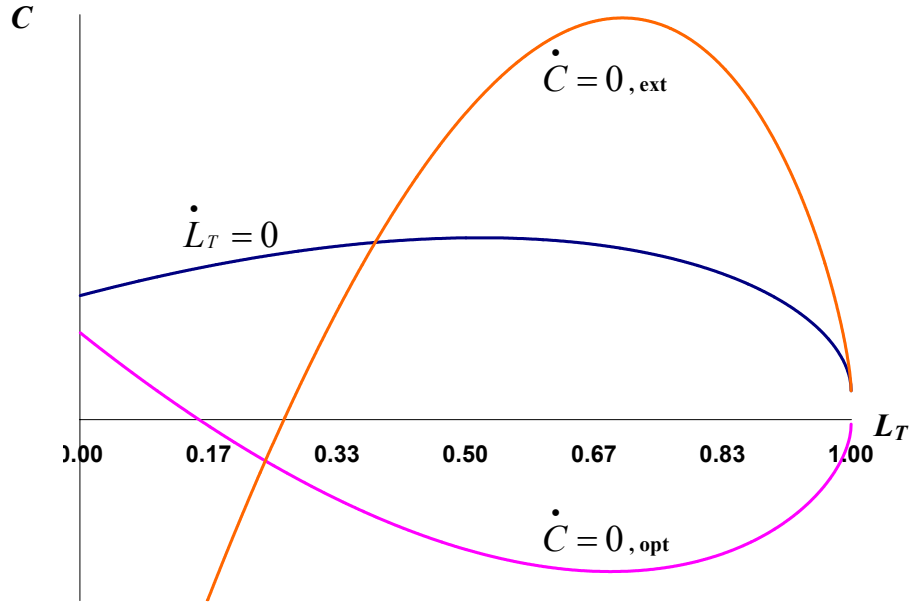
Steady state and path of tourism development in the solution with externalities¹²



¹² Same functional forms and parameter values as in figure 1.

FIGURE 4

A case where tourism expansion takes place despite it being suboptimal¹³



¹³ Same functional forms and parameter values as in figure 1 except for the productivity parameter of the traditional sector.

FIGURE 5

Optimal solution's steady state and green golden rule

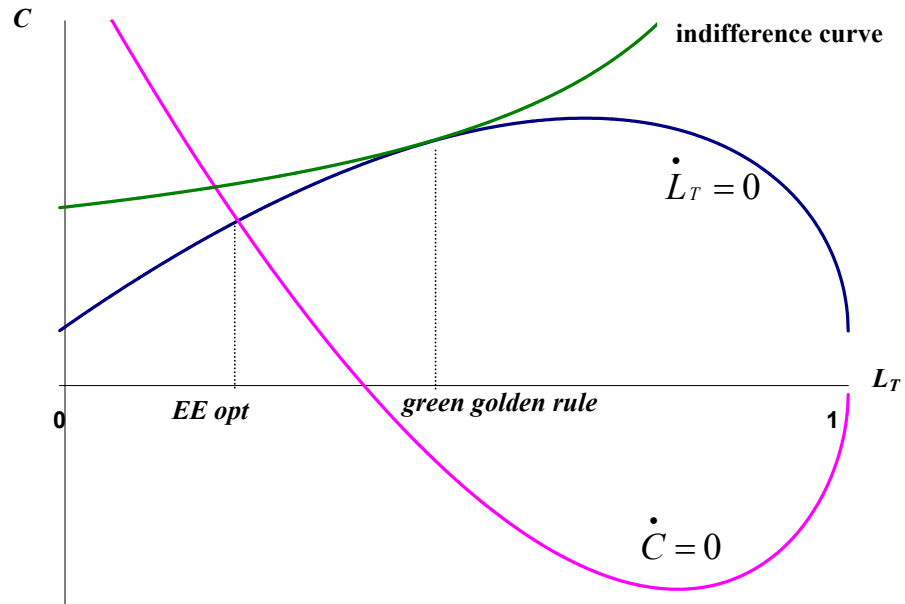


FIGURE 6

Steady state in the solution with externalities and green golden rule: a case of dynamic inefficiency

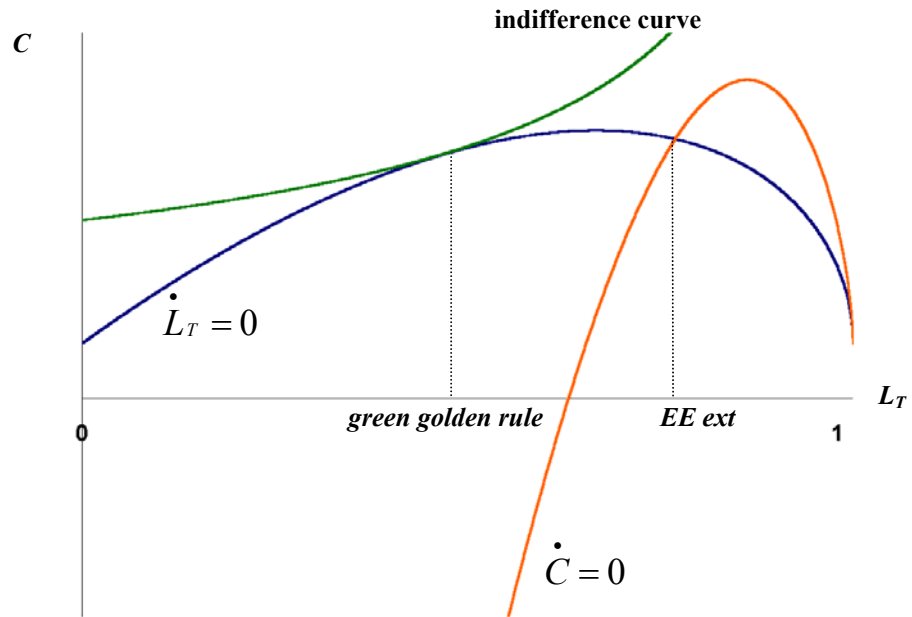


FIGURE 7

Effects of shifts in relative demand and supply tourism/manufactures on relative price of tourism

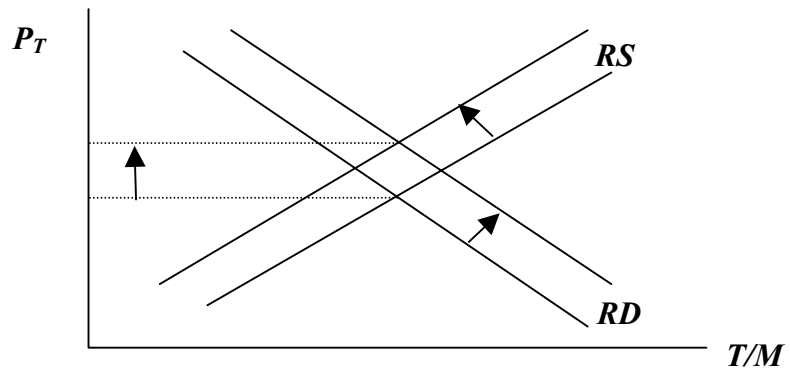
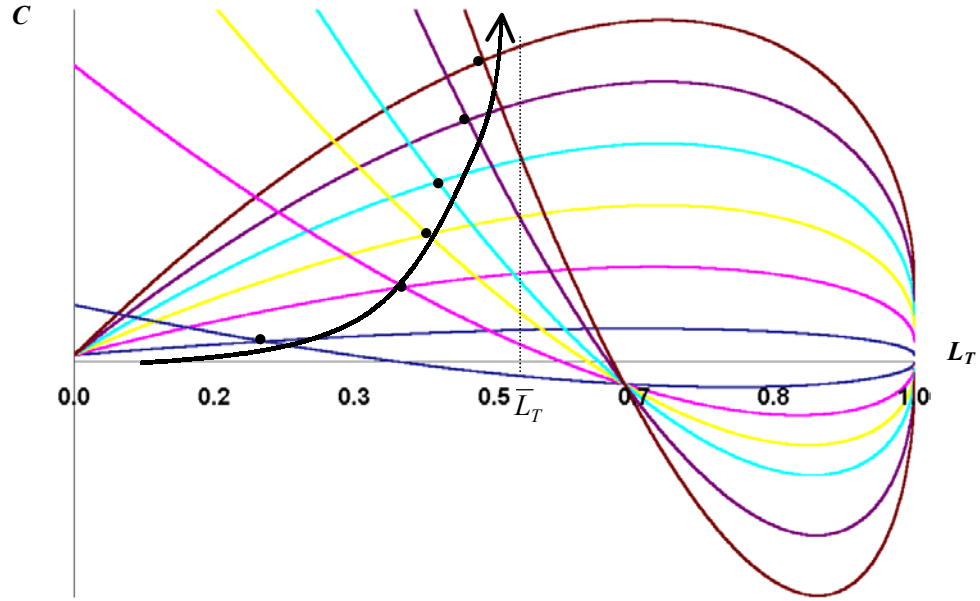


FIGURE 8

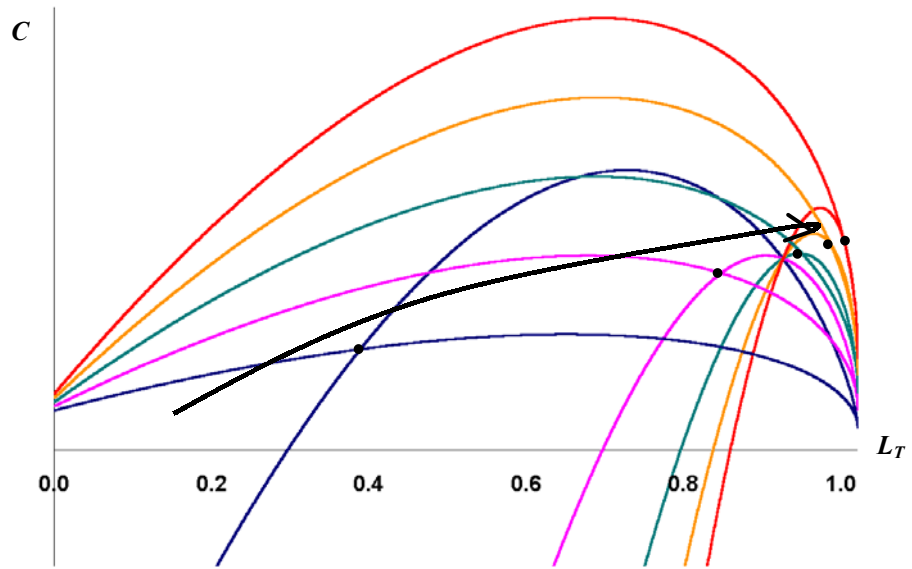
Steady state in the optimal solution when τ grows continuously.¹⁴



¹⁴ Same functional forms and parameter values as in figure 1.

FIGURE 9

Steady state in the solution with externalities when τ grows continuously.¹⁵



¹⁵ Same functional forms and parameter values as in figure 1.

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- (lix) This paper was presented at the ENGIME Workshop on “Mapping Diversity”, Leuven, May 16-17, 2002
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