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An Analysis of the Evolution of Tourism Destinations from the Point of View of the Economic Growth Theory

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An Analysis of the Evolution of Tourism Destinations from the Point of View of the Economic Growth Theory

Summary

In this paper we try to build a bridge between the traditional analysis of the evolution of tourism destinations and economic growth theory. With such an aim we develop an environmental growth model for an economy specialized in tourism and we derive the pattern of tourism development with numerical calculations. The results of our simulations do not contradict the general pattern of evolution implied in the Tourism Area Life Cycle Hypothesis, being environmental deterioration and public goods congestion the main reasons for the stagnation of the tourism destination. We also show the importance of the quality of private tourism services in the evolution of the tourism destination.

Keywords: Tourism, Economic growth, Tourism lifecycle

JEL Classification: L83, Q26, O41

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1. Introduction

The analysis of the development of tourism destinations is one of the main topics in tourism research. The literature on this topic has been structured around the concept of Tourism Area Life Cycle (TALC) that Butler (1980) put forward. As it is well known, according to the TALC hypothesis a tourism destination experiences several stages of tourism development that end up in the stagnation of the tourism destination. These stages are differentiated by several factors such as the number of visitors, tourists' motivations, the perception of the tourism phenomenon by the residents or the degree of environmental damage. As this last factor is usually stressed as one of the main reasons for the final stagnation of the tourism destination, this literature is closely linked to the concepts of sustainability and carrying capacity.

Most of the literature is aimed to test the adequacy of the TALC hypothesis for specific tourism destinations (for instance, Cooper and Jackson, 1989; Agarwal, 1997, 2002). The methodology is mainly descriptive, without a formal base. An important shortcoming of this literature is that there have been little attempts to base the analysis of the evolution of tourism destinations on sound economic principles. Specifically, it is quite disappointing the disconnection of this literature from the economic growth theory.

In the field of economic growth analysis the so called environmental growth models have been developed as an appropriate tool to consider the role of environmental constraints on economic development (Barbier, 1999; Hettich, 1998; Schou, 2000; Stockey, 1998; Beltratti, 1996 are just some examples). These models have several characteristics that make them useful tools for the analysis of the development of tourism destinations. First their dynamic nature allows for the consideration of the intertemporal effects of resource allocation. Second they are based on optimisation behaviour and therefore allow for an analysis of the impact on welfare of different policies and institutional settings. Third they consider the interdependence among different markets in a general equilibrium framework. Fourth, they explicitly consider the relationship between economic activity and environmental and natural resources. Finally, they allow for a consideration of the different market failures associated with the use of natural and environmental resources.

In this paper we build an environmental growth model for an economy specialized in tourism and analyze the pattern of tourism development that stems from the model. Despite the simplifying assumptions of the model, it gives interesting insights about the dynamics of tourists' inflows, tourism revenues, environmental quality, congestion of public goods and residents' welfare.

The approach we adopt is quite innovative regarding the determinants of the evolution of a tourism destination. In the few papers on the TALC hypothesis that have a formal base it is usually assumed that the evolution of tourists inflows is demand driven (see for example

Lundtorp y Wanhill, 2001) and it is derived from a model of information diffusion that results in a logistic function for the number of tourists. It is therefore assumed that supply will respond adequately to the increase in demand. In our model the incentives to build tourism facilities (due to high returns to investment) are the driving force and we assume that occupation of accommodation capacity is guaranteed. The role of the demand side is to determine the price paid for tourism services and, therefore, the returns to investment in the tourism sector and the building of tourism facilities. The willingness to pay will depend on the characteristics of the tourism destination.

The rest of the paper is organized as follows. Section 2 describes the assumptions of the model and finds the equilibrium. Section 3 shows the pattern of evolution of a tourism destination for different levels of accommodation quality. Finally, section 4 concludes.

2. The model

2.1. International tourism market

We consider an economy that supplies tourism services in an international tourism market where there are a large number of suppliers. Specifically, we assume that in this market several economies or tourism regions participate. In each of these economies there are different firms that supply tourism accommodation. On the other hand, in this market there also are a large number of heterogeneous tourists differentiated by their tastes and their income. In these circumstances, and given the hedonic price theory (Rosen, 1974) there exist an hedonic price function where the equilibrium price depends on the quality of the tourism product. Firms in this market compete in the characteristics space and the large number of suppliers implies zero profits.

We will consider a bounded set of characteristics that are valued by tourists and therefore determine the price of the tourism product:

First, the quality of accommodation services, represented in the model as the amount of capital per unit of accommodation, K_{ij}/T_{ij} , where K_{ij} is total amount of capital of firm i in destination j and T_{ij} is the number of units of accommodation (let us say beds) of the firm.

Second, public goods provided by the government, G_j . We assume that these public goods experience congestion (they are therefore rival but non-excludable) so that their impact on the hedonic price function is given by G_j/T_j , where T_j is the total number of beds in destination j .

Finally, environmental quality of tourism destinations. We represent environmental quality with a single variable, N_j .

Given these assumptions, the hedonic price function is:

$$P_{ij} = P\left(\frac{K_{ij}}{T_{ij}}, \frac{G_j}{T_j}, N_j\right)$$

or, considering a Cobb-Douglas:

$$P_{ij} = \left(\frac{K_{ij}}{T_{ij}}\right)^\alpha \left(\frac{G_j}{T_j}\right)^\beta N_j^\mu \quad (1)$$

We will assume that $0 < \alpha, \beta < 1$; $\mu > 0$; $\alpha + \beta < 1$

Given (1), the tourism revenue function for a firm i in a tourism destination j is:

$$TR_{ij} = T_{ij}^{1-\alpha} K_{ij}^\alpha \left(\frac{G_j}{T_j}\right)^\beta N_j^\mu \quad (2)$$

Whereas the aggregate tourism revenue function for the whole economy is:

$$TR = T^{1-\alpha-\beta} K^\alpha G^\beta N^\mu \quad (2')$$

Therefore, tourism revenues may rise due to increases in accommodation capacity or because of improvements in the attractiveness of the tourism destination thanks to higher quality of private tourism services, higher public expenditure or better environmental quality.

2.2. Public sector

We assume that the government finances the provision of public goods with an *ad-valorem* tax levied on tourism revenues, τ_{TR} , $0 \leq \tau_{TR} < 1$. Public budget is always in equilibrium, that is:

$$\tau_{TR} TR = G \quad (3)$$

2.3. Firm's behaviour

Tourism firms maximize profits choosing the amount of capital and the number of accommodation units. Both decisions determine the quality of services provided by the firm, K_i/T_i . Firms take as given the amount of goods and services provided by the public sector, environmental quality and aggregate accommodation capacity of the economy. Notice that the model allows for two kind of investment. Investment in quality takes place when the firm increases its capital without modifying its accommodation capacity. However, when accommodation capacity is raised in the same proportion as capital we can speak of investment in capacity.

In this paper we simplify firms' decision considering that there is a minimum of capital per unit of accommodation, κ , to which all the firms adjust optimally. This minimum could be justified as a characteristic of tourism preferences. In this case we would assume that

there is a minimum threshold for accommodation quality below which tourist are not willing to visit the tourism destination. Alternatively, we could consider that this minimum is set by the public sector as tool for tourism quality management. In any case, this assumption will allow to compare the evolution of tourism destinations for different alternatives regarding the quality of accommodation facilities.

Given these assumptions, the optimal behavior of the firm is determined by the following expressions:

$$T_i = \frac{K_i}{\kappa}$$

$$(1 - \tau_{TR}) \frac{TR_i}{K_i} = R$$

Where R is the return to capital. Or, in the aggregate:

$$T = \frac{K}{\kappa}$$

$$(1 - \tau_{TR}) \frac{TR}{K} = R \quad (4)$$

2.4. Residents' behaviour

We consider that the economy is populated by a single representative agent that maximizes the following intertemporal utility function:

$$\omega_0 = \int_0^{\infty} e^{-\rho t} \frac{(C_t N_t^v)^{1-\theta}}{1-\theta} dt \quad v, \rho, \theta > 0$$

Where the arguments of the utility function are consumption, C , and environmental quality, N . It is assumed a constant elasticity of intertemporal substitution and a unitary intratemporal elasticity between consumption and environmental quality. We also assume that marginal utility of each argument is positive and decreasing. The parameter ρ is a discount factor while v measures the relative weight of environmental quality on residents' preferences.

Residents own capital. Returns to capital net of depreciation and taxes are r . Income is used for consumption and saving (investment in capital). Therefore, the budget constraint for residents is:

$$\dot{K} = rK - C \quad (7)$$

Applying the usual optimal control conditions we derive the following expressions that, beside the budget constraint, describe the residents' behaviour:

$$\frac{\dot{C}}{C} = \frac{1}{\theta} \left[r - \rho + v(1 - \theta) \frac{\dot{N}}{N} \right] \quad (8)$$

$$\lim_{t \rightarrow \infty} \lambda_t K_t = 0 \quad (9)$$

Where λ_t is a costate variable and r is the returns to capital net of depreciation.

2.6. The environment

We interpret environmental quality as a renewable resource. The quality of the environment accumulates due to the regenerative capacity of nature that depends on the level of environmental quality. We consider that tourism activity has damaging effects on the environment. Davies and Cahill [12] give an account of the environmental impacts of tourism such as energy consumption, water consumption, wastes, impacts on water and air quality, ecosystems alteration and fragmentation, impacts on wildlife and on aesthetic and cultural environment. The intensity of those impacts are closely related to the number of visitors and the building of facilities for their lodging and recreational activities.

We assume that environmental quality evolves over time according to the following function:

$$\dot{N} = \zeta(\bar{N} - N) - zT \quad (10)$$

For simplicity we have considered a linear regeneration function. \bar{N} is the maximum level of environmental quality, ζ is the rate of recovery of the environment due to natural regeneration and z measures the environmental impact associated with a unit of accommodation capacity. Given this specification, investment in capacity has a negative impact on the environment but investment in quality (higher capital for a given capacity of accommodation) has not. We do not differentiate the environmental impact of different types of tourism. For instance, the differences in habits and behavior of tourists with different socio-economic characteristics may imply differences in their environmental impact. Therefore, a change from mass tourism to “quality” tourism would not only affect the environment through the amount of tourists (assumedly in a positive way) but also from a change in z . A constant z is therefore a simplification only justified by our lack of evidence about the magnitude and even the sign of the change in z when the composition of visitors changes.

2.7. Equilibrium

Given our previous assumptions, the revenue function for the whole tourism destination is:

$$TR = \kappa^{\frac{\alpha+\beta-1}{1-\beta}} \tau_{TR}^{\frac{\beta}{1-\beta}} KN^{\frac{\mu}{1-\beta}} \quad (2'')$$

where the public budget constraint has been considered.

The dynamic behaviour of the economy is defined by equations (2''), (7), (9), (10) and the following one that results from the combination of (4) and (8):

$$\frac{\dot{C}}{C} = \frac{1}{\theta} \left[(1 - \tau_{TR}) \frac{IT}{K} - \delta - \rho + \nu(1 - \theta) \frac{\dot{N}}{N} \right] \quad (12)$$

The steady state is defined by the following expressions¹:

$$N = \left[\kappa^{1-\alpha-\beta} (\delta + \rho)^{1-\beta} \left(\frac{1}{1 - \tau_{TR}} \right)^{1-\beta} \left(\frac{1}{\tau_{TR}} \right)^{\beta} \right]^{\frac{1}{\mu}} \quad (13)$$

$$T = \frac{\zeta(\bar{N} - N)}{z} \quad (14)$$

$$K = \kappa T \quad (15)$$

$$IT = \frac{\delta + \rho}{(1 - \tau_{TR})} K \quad (16)$$

$$C = (1 - \tau_{TR})IT - \delta K \quad (17)$$

3. Dynamics of tourism development

In this section we show the pattern of tourism development that follows from our model. With such an aim, we calibrate the model and perform numerical calculations of the dynamic of the relevant variables considering an initial situation of low tourism development².

Before presenting the assumptions of this exercise and its results we explain the working forces of the model dynamics. The evolution of the tourism destination is determined by the interplay of demand and supply factors. The demand factors, through the hedonic price function, determine the price of the tourism services supplied in the economy. This price is a main determinant of the returns to the tourism firms and therefore the accommodation capacity of the tourism destination. Under the assumption of full occupation of capacity, the evolution of this capacity determines how the number of visitors changes. As the model is set up, the economy converges to a steady state or, in TALC terminology, reaches the stagnation stage.

An analysis of expression 2'' helps to understand the reasons for the final stagnation. They are not the usual assumptions of neoclassical growth models about decreasing returns to

¹ See appendix A for a discussion of the stability of the steady state.

² Simulations have been done using the solver CONOPT2 of the program GAMS 2.0. For numerical calculations the version of the model in discrete time is used. See appendix B.

investment since returns to capital are constant once it is considered that investment is in capacity (κ is assumed to be constant) and congestion of public goods is compensated by a higher provision thanks to increases in tourism revenues. The only limitative factor to continuous growth is the negative impact of the increase in capacity on environmental quality and its effect on the price of tourism services and eventually on the return to investment in the tourism business.

After these general comments we show the results of our numerical calculations. Specifically, we show the evolution of the number of visitors, tourism revenues, environmental quality, public expenditure per tourist and instantaneous utility of residents. For all simulations the model is calibrated using the following parameter values:

δ	ρ	α	β	μ	V	ζ	\bar{N}	z	θ	τ_{TR}
0.05	0.05	0.6	0.3	0.5	1	1	1	1	0.9	0.3

Given that we are only interested in the general dynamic patterns and not in precise quantitative results, these values are hypothetical and have been chosen according to the following criteria. The value of δ implies a slow depreciation due to the importance of buildings in total capital stock of tourism. We have assumed that net returns to capital in steady state are 5% ($\rho=0.05$). We assume that the elasticity of tourism revenues with respect to the quality of accommodation (α) is higher than the elasticity with respect to public goods (β) and with respect to environmental quality (μ). It is plausibly assumed that residents give a higher value to the environment than visitors ($v>\mu$). The regenerative capacity of the environment is considered to be high ($\zeta=1$) The highest level of environmental quality and the relationship between tourism flows and environmental damage are normalized to one ($\bar{N}=1$ and $z=1$). As it is usual in the literature, the intertemporal elasticity of substitution is set to a value close to one ($\theta=0.9$). Finally, the tax levied on tourism revenues is at its efficient value equal to the elasticity of tourism revenues with respect to public expenditure.

Obviously, different parameter values would imply different values for the endogenous variables. However, our aim is not to get exact values but to show general patterns of evolution. For different parameter values the shape of the curves will be the same as far as the stability condition is satisfied.

We perform different simulations considering different levels of capital per unit of accommodation. Since this variable is taken as an indicator of accommodation quality, this allows to consider the consequences of specializing in different market segments. As a point

of reference we take the steady state level of capital per unit of accommodation in the central planner solution of the model. Specifically, simulations are done for values of capital per unit of accommodation of 1%, 10%, 30%, 50% y 100% of that value.

As we want to show the complete evolution of the tourism destination, the initial values of the state variables are chosen as to represent a situation of low tourism development. Specifically, we assume that initially environmental quality is at its highest value ($N_0 = \bar{N}$) and tourism capital is very low ($K=0.01$)³.

3.1. Tourism flows

Figure 2 shows the evolution of the annual number of tourists that visit the destination for different levels of accommodation quality. For every case the shape of the curve reproduces the pattern of evolution described by Butler (1980). Therefore, after a first stage when the number of visitors grows slowly the inflows accelerate but sooner or later the number of visitors stagnates at its steady state level. This result is quite interesting since we have not imposed a logistic function to the inflows of tourists as, for instance, in Lundtorp and Wanhill (2001).

Figure 1 also shows that when accommodation quality is higher it takes a longer time to reach the stagnation stage and the number of visitors in the steady state is lower. This last characteristic can also be verified in figure 2.

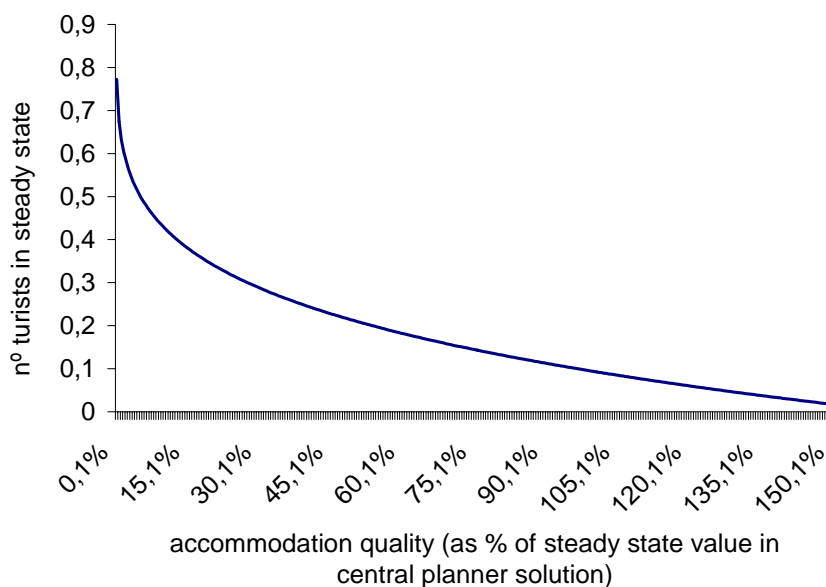


Figure 1. Relationship between number of tourists and accommodation quality in the steady state

³ This is 0.15% of the steady state level of capital in the central planner solution.

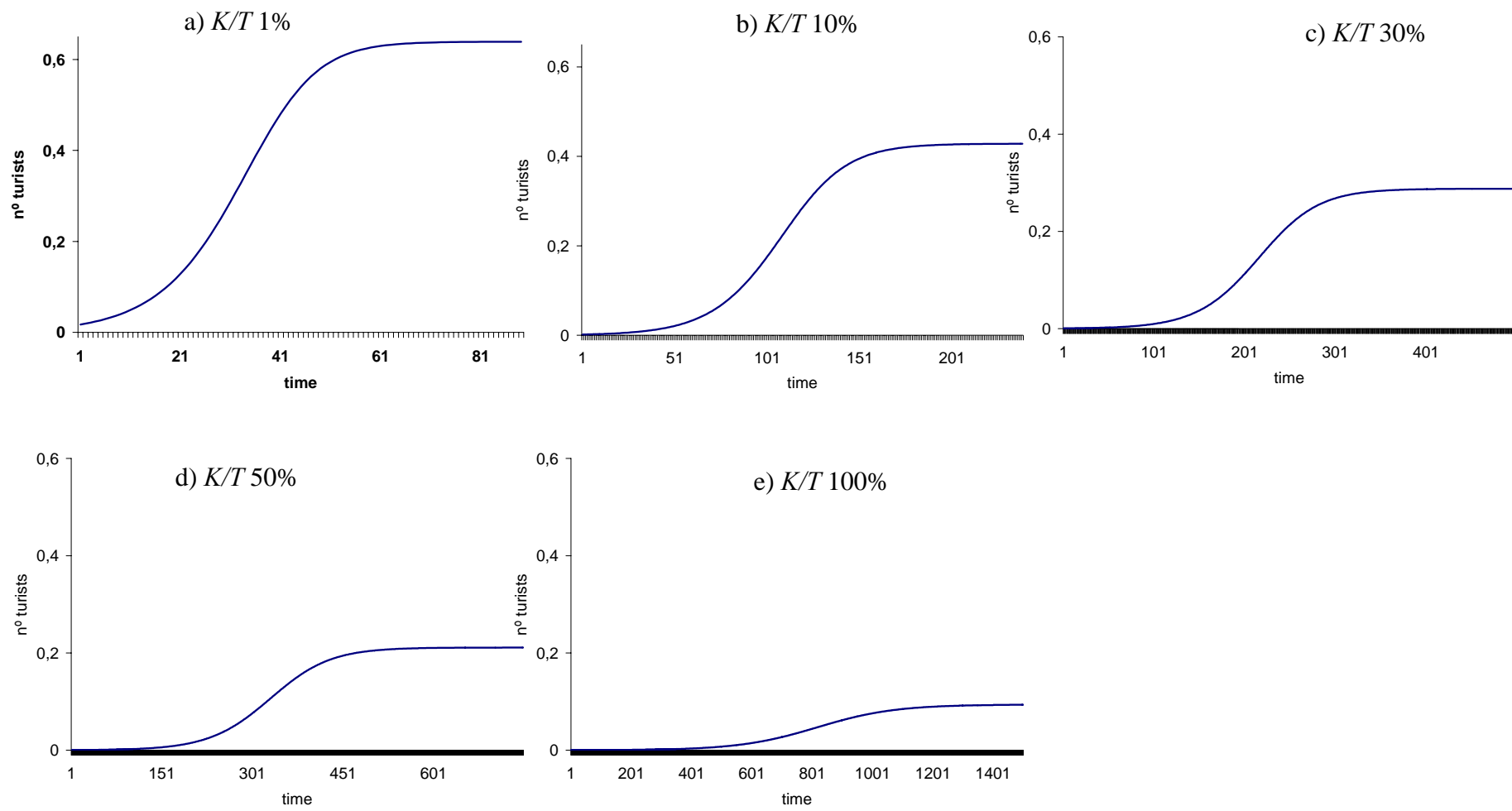


Figure 2. Evolution of tourists inflows for different levels of accommodation quality

3.2. Tourism revenues

Figure 4 shows the dynamics of tourism revenues for different levels of accommodation quality. Again, the pattern of evolutions fits to a logistic and it takes longer to reach the steady state for higher levels of accommodation quality. However, as it is shown in figure 3, the relationship accommodation quality and steady state tourism revenues is not monotonous. When accommodation quality is low, an increase in the quality of private tourism facilities would imply higher long term tourism revenues. However, above a critical threshold higher quality of accommodation means lower long term tourism revenues. This characteristic of the model can be explained in the following way. On the one hand, low accommodation quality is associated in the long term with high tourists' inflows, a very degraded natural environment, high congestion of public goods (as shown below) and therefore a low tourism price. On the other hand, to provide for higher quality private services a larger investment per unit of accommodation is needed and this investment effort may not be compensated by the positive effect on price of a better environment and lower congestion.

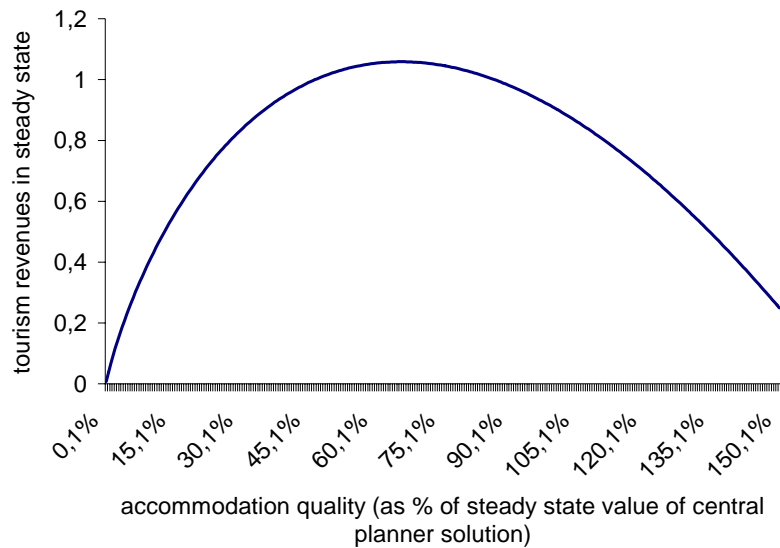


Figure 3. Relationship between tourism revenues and accommodation quality in the steady state.

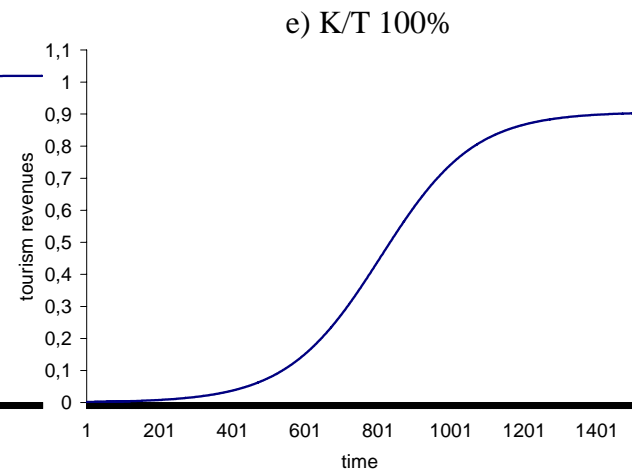
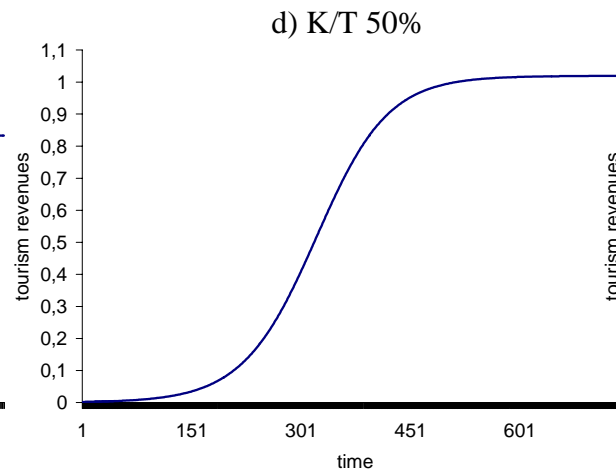
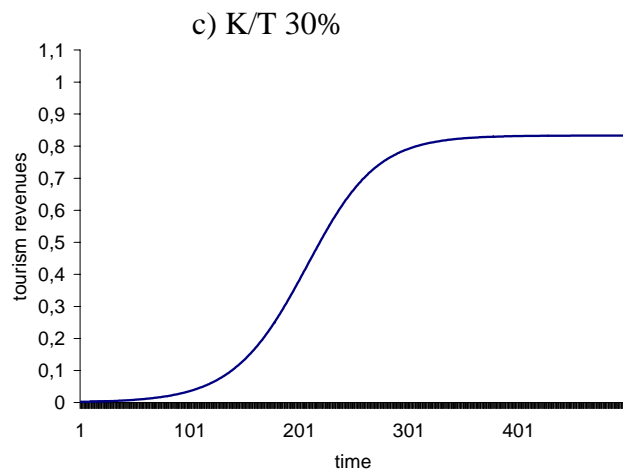
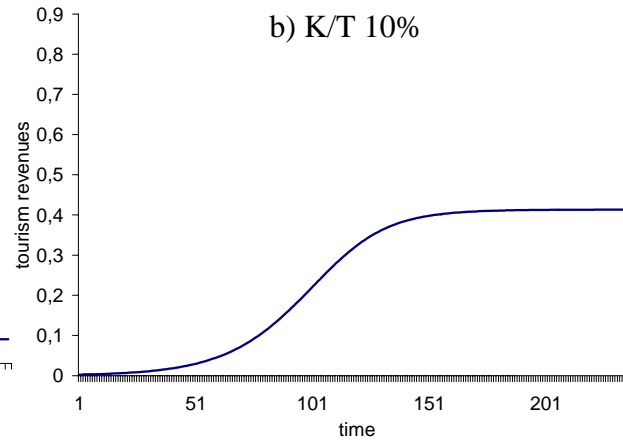
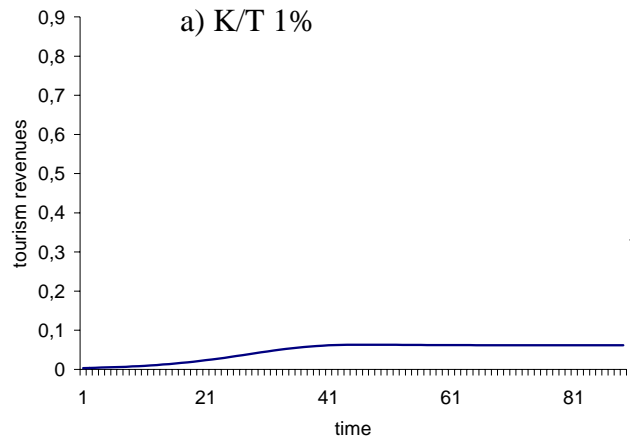


Figure 4. Evolution of tourism revenues for different levels of accommodation quality.

3.3. Environmental quality

Figure 6 shows how environmental quality evolves in the process of tourism development. For every case, environmental quality evolves following three stages that are consistent with the evolution of tourism inflows. In the first stage environmental deterioration is low. This stage is shorter the lower is the quality of accommodation supply. Afterwards, environmental degradation accelerates and eventually environmental quality reaches its steady state value. As can be seen in figure 5, higher accommodation quality is associated with a better environment in the long term.

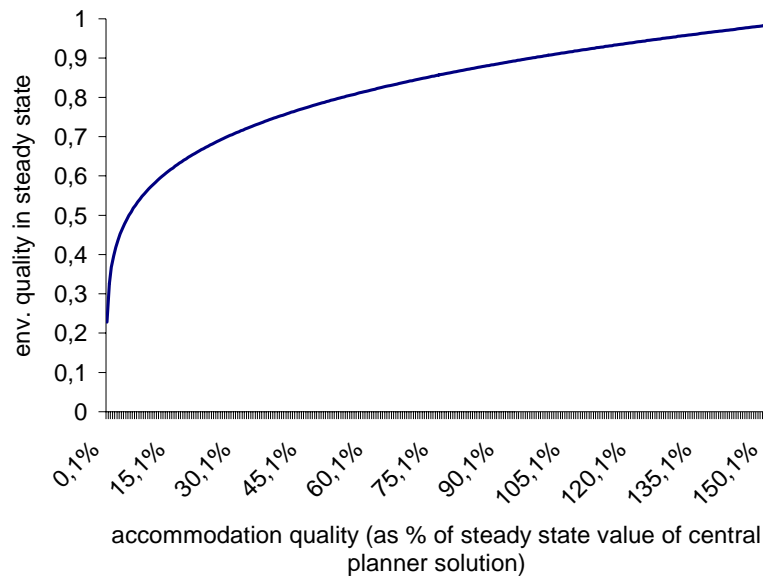


Figure 5. Relationship between environmental quality and accommodation quality in the steady state

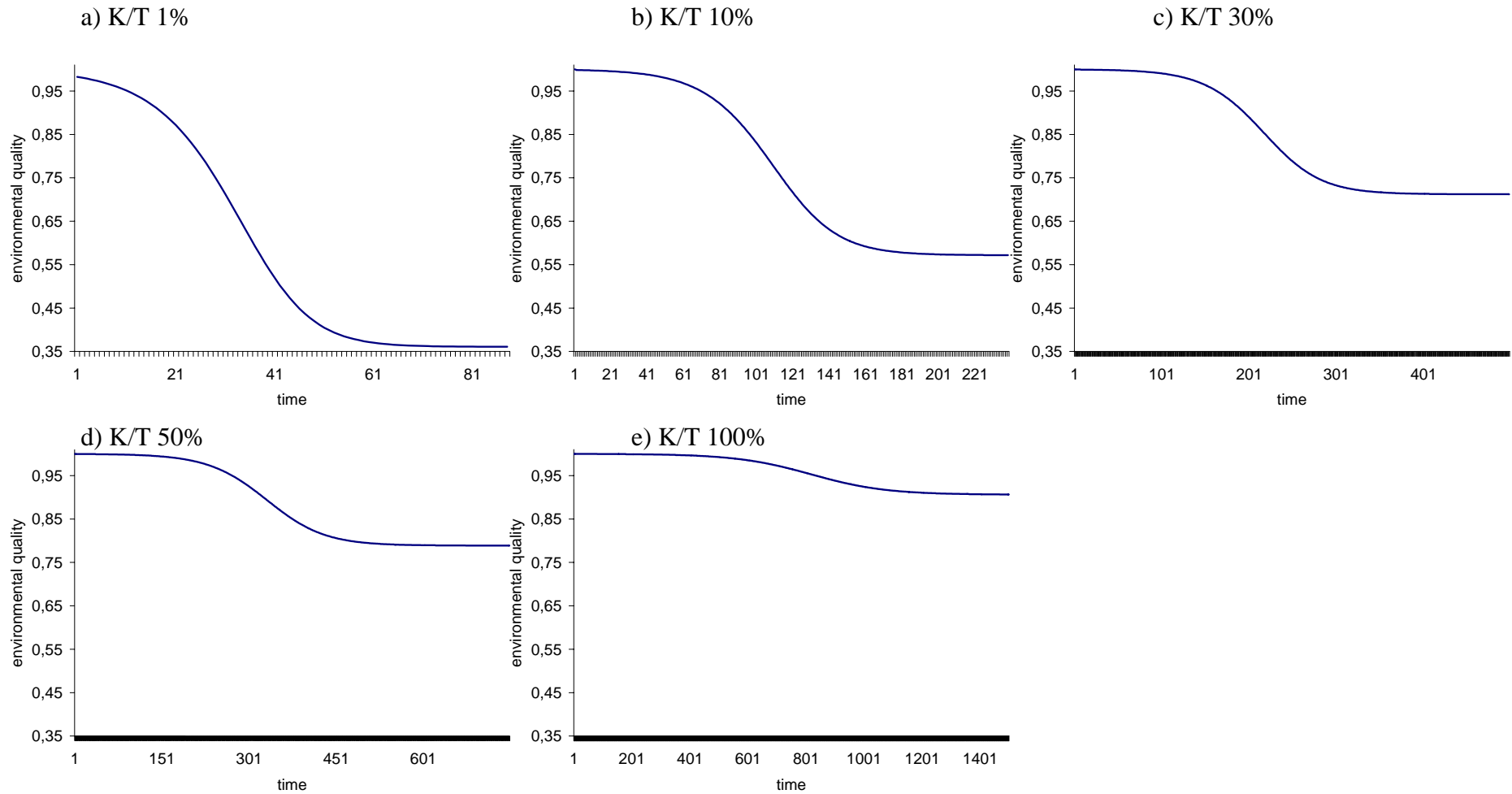


Figure 6. Evolution of environmental quality for different levels of accommodation quality.

3.4. Congestion of public goods

Figure 8 shows that, given a constant tax rate, tourism development implies an increase in public goods congestion. This factor contributes to the final stagnation of the tourism destination. The increase in congestion can be attributed to the faster growth of tourists inflows compared to the growth in revenues due to the fall in the price of tourism services associated to environmental degradation.

Another interesting characteristic is that the increase in congestion is slower and less pronounced when accommodation quality is higher. As can be seen in figure 7, an economy that supplies private tourism services of higher quality can also finance a higher level of public goods per tourist.

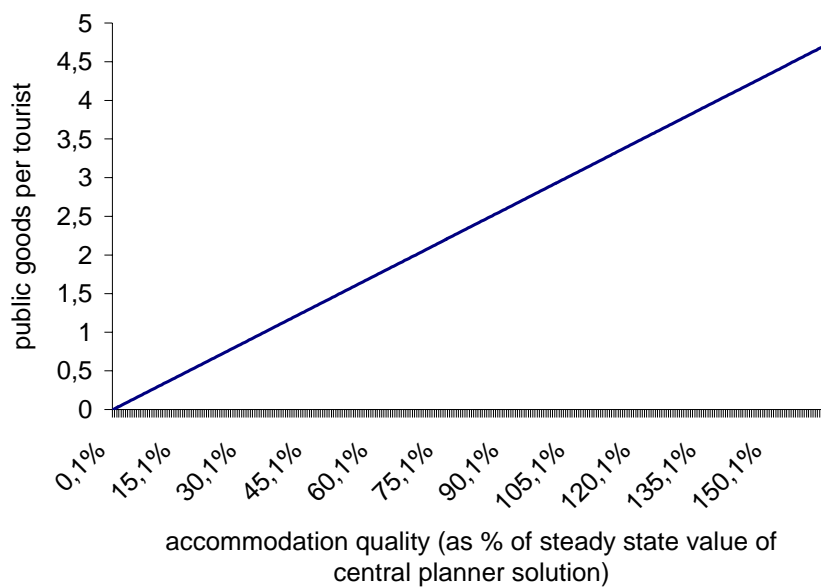


Figure 7. Relationship between environmental quality and accommodation quality in the steady state (constant tax rate)

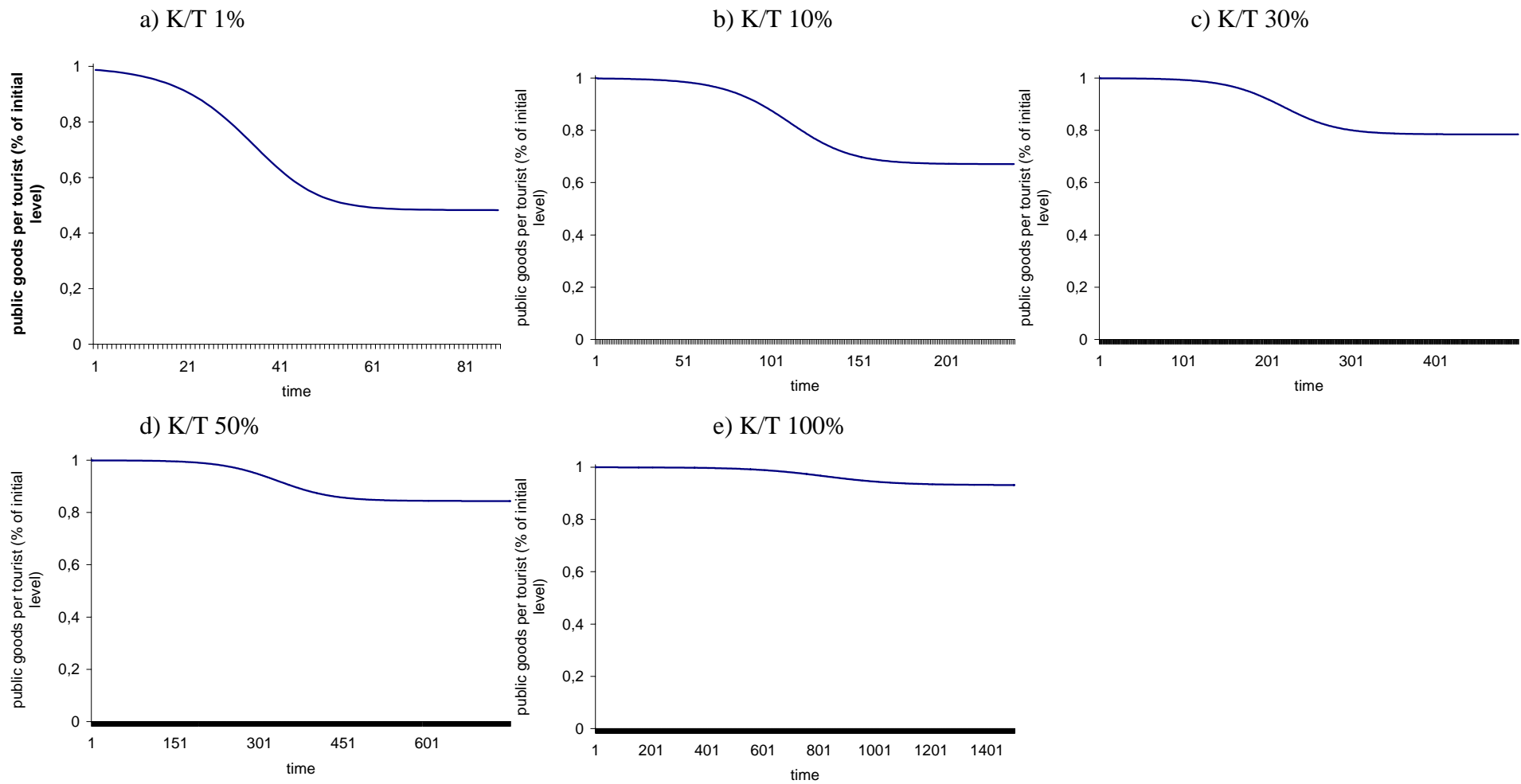


Figure 8. Evolution of public goods congestion for different levels of accommodation quality

3.5. Instantaneous utility

Finally, figure 11 represents the evolution of resident's welfare. The utility function depends on material consumption and environmental quality. Although tourism development implies environmental degradation, the resident's welfare increases through time thanks to the growth in consumption possibilities. As it happens with tourism revenues, long term welfare has a non monotonous relationship with accommodation quality. There is, therefore, an intermediate level of accommodation quality that maximizes steady state welfare⁴.

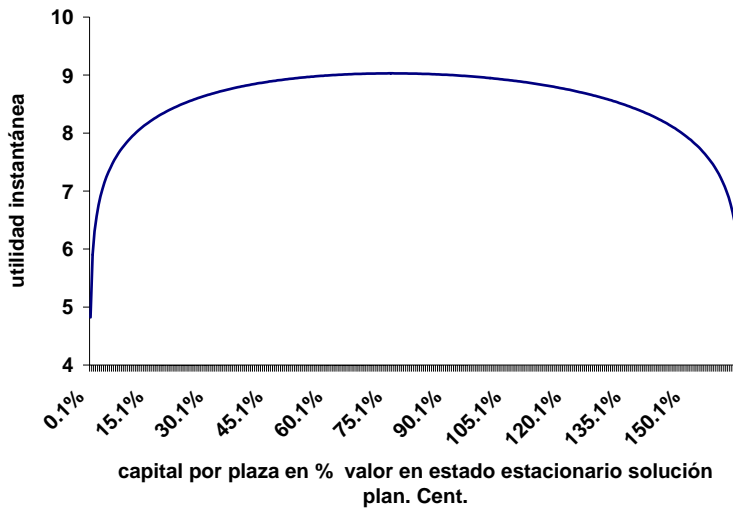


Figura 9. Relationship between accommodation quality and steady state utility.

Finally, figure 10 helps to understand why a “myopic” society with an inadequate perception of the environmental impacts of tourism development may prefer to supply low quality services in the first stages of tourism development. As it is shown, a lower investment effort per accommodation unit allows to reach higher levels of utility in the short run although it implies to reach the stagnation stage quicker and to have a lower long run welfare level.

⁴ It should be stressed that in every case we are dealing with market solutions where there are market failures associated with the environment and the congestion of public goods. Therefore, none of the possible scenarios represented in the figures imply maximum resident's welfare.

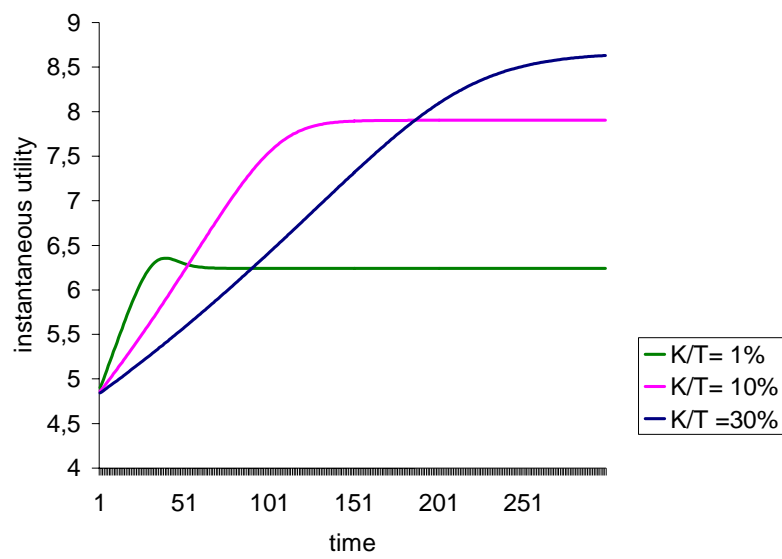


Figura 10. Evolution of resident's welfare for different levels of accommodation quality.

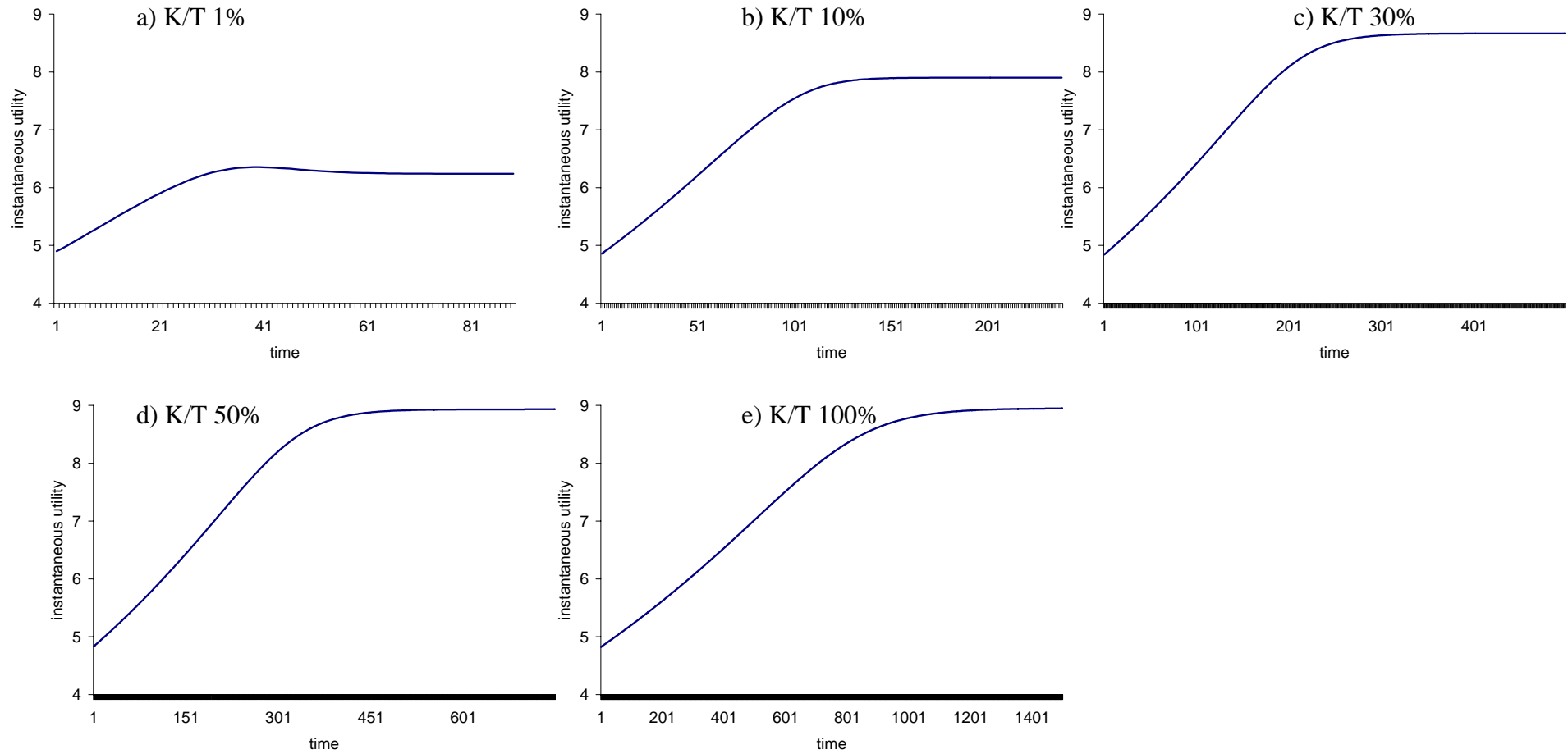


Figura 11. Evolution of instantaneous utility for different levels of accommodation quality

4. Conclusions

In this paper an analysis of the evolution of tourism destinations is made from the point of view of the economic growth theory. Specifically, we build an environmental growth model to give some insights about the dynamics of the number of tourists, tourism revenues, environmental quality, congestion of public goods and welfare. We also show how the pattern of evolution depends on the average quality of private tourism services supplied in the tourism destination.

Our simulations show that the tourism destination eventually reaches a stagnation stage. However, the length of the growth period very much depends on the quality of private tourism services. Specifically, higher accommodation quality implies a longer time to reach the stagnation, lower tourists' inflows, higher environmental quality and lower public goods congestion. In terms of long term tourism revenues and residents' welfare, an intermediate level of accommodation quality is the best option.

Numerical calculations are based on hypothetical data since we just want to highlight general dynamic patterns, not precise quantitative results. Nevertheless, beyond the specific results, the paper is an illustration of how economic growth models may help to understand the dynamic behavior of economies based on the tourism industry. A methodology based on the building of dynamic general equilibrium models and their calibration to real data would yield results to compare with actual patterns of evolution of specific tourism destinations. This methodology has successfully employed in other fields of research as business cycles or international macroeconomics and we think it would help to understand the determinants of the evolution of tourism destinations.

Appendixes

Appendix A. Stability of the steady state

In this appendix we discuss the steady state stability conditions.

Combining (2''), (4), (7) (10) and (12) we arrive at:

$$\begin{aligned}\dot{C} &= \frac{C}{\theta} \left\{ (1 - \tau_{TR}) (\kappa^{\alpha+\beta-1} \tau_{TR}^\beta N^\mu)^{1-\beta} - \delta - \rho + \nu(1-\theta) \left(\zeta \frac{\bar{N} - N}{N} - \frac{z}{\kappa} \frac{K}{N} \right) \right\} \\ \dot{K} &= \left\{ (1 - \tau_{TR}) (\kappa^{\alpha+\beta-1} \tau_{TR}^\beta N^\mu)^{1-\beta} - \delta \right\} K - C \\ \dot{N} &= \zeta (\bar{N} - N) - \frac{z}{\kappa} K\end{aligned}$$

Linearization around the steady state results in a system whose Jacobian is:

$$B = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix}$$

$$b_{11} = 0$$

$$b_{12} = -\frac{zv(1-\theta)C^*}{\theta\kappa N^*}$$

$$b_{13} = \frac{1}{\theta} \left[\frac{\mu(\delta + \rho)}{1-\beta} - v(1-\theta)\zeta \right] \frac{C^*}{N^*}$$

$$b_{21} = -1$$

$$b_{22} = \rho$$

$$b_{23} = \frac{\mu(\delta + \rho)K^*}{(1-\beta)N^*}$$

$$b_{31} = 0$$

$$b_{32} = -\frac{z}{\kappa}$$

$$b_{33} = -\zeta$$

The determinant of B is:

$$|B| = \frac{\rho\zeta(\delta + \rho)\mu(\bar{N} - N^*)}{(1-\beta)\theta N^*} > 0$$

The determinant is positive and therefore there are two possibilities: three positive eigenvalues or one positive and two negative. The characteristic equation is:

$$\lambda^3 - \{\rho - \zeta\}\lambda^2 + \left\{ \frac{\mu\zeta(\delta + \rho)(\bar{N} - N^*)}{(1-\beta)N^*} - \zeta\rho \right\} \lambda - |B| = 0$$

This equation cannot be solved analytically. However if we set $\theta=1$ the characteristic equation is:

$$(\lambda - \rho) \left[\lambda^2 + \zeta\lambda + \frac{(\delta + \rho)\mu\zeta(\bar{N} - N^*)}{(1-\beta)N^*} \right] = 0$$

and the eigenvalues are:

$$\lambda_1 = \rho$$

$$\lambda_2, \lambda_3 = \frac{-\zeta \pm \sqrt{\zeta^2 - 4 \frac{\mu\zeta(\delta + \rho)(\bar{N} - N^*)}{(1 - \beta)N^*}}}{2}$$

The first eigenvalue is positive. The other two are negative because:

$$\zeta^2 - 4 \frac{\mu\zeta(\delta + \rho)(\bar{N} - N^*)}{(1 - \beta)N^*} < \zeta^2$$

Therefore, provided that the roots are real, the steady state is a saddle-path. Different values for the intertemporal elasticity of substitution mean horizontal shifts of the characteristic equation.

Therefore, this result would hold for a large range of values for θ .

Appendix B. The model in discrete time

The equations of the model in discrete time are the following:

Tourism revenues:

$$TR_t = \kappa_t^{\alpha+\beta-1} K_t^{1-\beta} G_t^\beta N_t^\mu \quad (\text{B.1})$$

Firms' behaviour:

$$T_t = \frac{K_t}{\kappa_t} \quad (\text{B.2})$$

$$(1 - \tau_{IT_t}) \frac{TR_t}{K_t} = (r_t + \delta) \quad (\text{B.3})$$

$$\Pi_t = TR_t - \tau_{TR_t} TR_t - (r_t + \delta) K_t \quad (\text{B.4})$$

Resident:

$$\omega_0 = \sum_{t=0}^{\infty} b^t \frac{(C_t N_t^v)^{1-\theta}}{1-\theta}, \quad b = 1/(1 + \rho) \quad (\text{B.5})$$

$$K_{t+1} = (1 + r_t) K_t + \Pi_t - C_t \quad (\text{B.6})$$

Public sector:

$$\tau_{TR_t} TR_t = G_t \quad (\text{B.7})$$

Environment:

$$N_{t+1} = N_t + \zeta(\bar{N} - N_t) - zT_t \quad (\text{B.8})$$

Residents maximize the following lagrangian:

$$\ell = \sum_{t=0}^{\infty} b^t \frac{(C_t N_t^v)^{1-\theta}}{1-\theta} + \sum_{t=0}^{\infty} b^t \lambda_t [(1+r_t)K_t + \Pi_t - C_t - K_{t+1}]$$

where choice variables are C_t y K_t , $t \in [0, \infty)$ and the remaining variables are given for the resident. Euler equation is:

$$C_{t+1} = C_t \left[b(1+r_{t+1}) \left(\frac{N_{t+1}}{N_t} \right)^{v(1-\theta)} \right]^{\frac{1}{\theta}} \quad (\text{B.9})$$

Combining (B.9) with (B.1) and (B.3) we obtain:

$$C_{t+1} = C_t \left[b \left(1 + (1 - \tau_{TRt}) (\kappa_t^{\alpha+\beta-1} s_t^\beta N_{t+1}^\mu)^{\frac{1}{1-\beta}} - \delta \right) \left(\frac{N_{t+1}}{N_t} \right)^{v(1-\theta)} \right]^{\frac{1}{\theta}} \quad (\text{B.10})$$

Combining (B.6) with (B.1), (B.3), (B.4) and (B.7) we get:

$$K_{t+1} = \left[1 + (1 - \tau_{TRt}) (\kappa_t^{\alpha+\beta-1} \tau_{TRt}^\beta N_t^\mu)^{\frac{1}{1-\beta}} - \delta \right] K_t - C_t \quad (\text{B.11})$$

From (B.2) and (B.8) results:

$$N_{t+1} = N_t + \zeta(\bar{N} - N_t) - \frac{z}{\kappa} K_t \quad (\text{B.12})$$

(B.10)-(B.12) is the system of difference equations that determines the dynamic behaviour of the economy.

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KTHC	67.2005	<i>Sandra WALLMAN</i> (lxxiv): <u>Network Capital and Social Trust: Pre-Conditions for 'Good' Diversity?</u>
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CCMP	97.2005	<i>Francesco BOSELLO, Roberto ROSON and Richard S.J. TOL (lxxvii): <u>Economy-Wide Estimates of the Implications of Climate Change: Human Health</u></i>
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- (lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003
- (lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL), Venice, August 28-29, 2003
- (lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003
- (lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003
- (lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003
- (lxx) This paper was presented at the 9th Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004
- (lxxi) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by Fondazione Eni Enrico Mattei and Consip and sponsored by the EU, Rome, September 23-25, 2004
- (lxxii) This paper was presented at the 10th Coalition Theory Network Workshop held in Paris, France on 28-29 January 2005 and organised by EUREQua.
- (lxxiii) This paper was presented at the 2nd Workshop on "Inclusive Wealth and Accounting Prices" held in Trieste, Italy on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics
- (lxxiv) This paper was presented at the ENGIME Workshop on “Trust and social capital in multicultural cities” Athens, January 19-20, 2004
- (lxxv) This paper was presented at the ENGIME Workshop on “Diversity as a source of growth” Rome November 18-19, 2004
- (lxxvi) This paper was presented at the 3rd Workshop on Spatial-Dynamic Models of Economics and Ecosystems held in Trieste on 11-13 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics
- (lxxvii) This paper was presented at the Workshop on Infectious Diseases: Ecological and Economic Approaches held in Trieste on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics.
- (lxxviii) This paper was presented at the Second International Conference on "Tourism and Sustainable Economic Development - Macro and Micro Economic Issues" jointly organised by CRENoS (Università di Cagliari and Sassari, Italy) and Fondazione Eni Enrico Mattei, Italy, and supported by the World Bank, Chia, Italy, 16-17 September 2005.

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