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Giannoni, Sauveur

University of Corsica

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On the economic rationality of fluctuations in tourism frequentation at nature-based destination

Sauveur Giannoni, UMR CNRS LISA 6240, University of Corsica

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Abstract

The aim of this paper is to answer a simple question: Are fluctuations, and especially temporary decline, in frequentation always harmful for the profit of a tourism destination?

I propose a simple model for a nature-based destination, in which the willingness to pay of a tourist for the destination depends on the stock of natural assets, and I show using simulations that there exists a rational economic incentive to experience a decrease in frequentation for a while in order to let the stock of natural assets regenerates. This is an idea already emphasized by Greiner et al. (2001) and Kort et al. (2002).

I show that anyway the optimal behavior of a profit-maximizing representative tourism firm would generally lead to a monotonic frequentation path. This apparent contradiction is due to the fact that the level of frequentation is not, in the real world, set at its optimal level. Yet it could be good news if at some point, when the stock of natural assets is low, frequentation declines for a while.

1 Introduction

Although it is perceived as a potential levy of development by practitioners and by local and international institutions (Diamond, 1977), tourism is said to suffer of a structural weakness. This weakness is called fluctuations in the level of frequentation over-time inducing fluctuations in tourism receipts, employment, profitability of tourism facilities, etc....¹

The seminal work of Butler (1980) emphasized the famous destination lifecycle. To sum-up every tourism area experiences several phases of tourism development. After a take-off and a phase of rapid growth in frequentation, at some point frequentation reaches a peak and then, because of the combination of different factors, frequentation starts to decline.

This concept has generated a great amount of literature (see for example Oppemann, 1995, Agarwal, 1997, Tooman, 1997).

A major concern of both researchers and tourism practitioners is to find solutions in order to avoid the decline in frequentation and all the associated drawbacks. This is apparently rational since the typical reasoning of a tourism entrepreneur seems to be as follows. For a given level of the price of my product, a fall in frequentation means a fall of my receipts and by the way of my profits. And if it applies to a single entrepreneur of the destination, it should also apply to the destination as a whole.

Formally, a tourism entrepreneur behaves as a rational producer facing the static prototypical problem of profit maximization in a situation of perfect competition.

Furthermore, the law of supply insures that this optimal number of visitors T^* increases if the market price of the product sold by the tourism firm is increasing.

That is to say that the lower is the price that visitors have to pay in order to enjoy the product, the less is the number of tourists that a firm is willing

¹One should distinguish between two kinds of fluctuations. Long-term fluctuations associated with the destination lifecycle and short run fluctuations, the so-called seasonality. In this paper, I do make the distinction since my aim is to discuss the economic rationality of the fluctuation in frequentation whatever its origin.

to host.

But this classical reasoning does not apply exactly this way in tourism. Tourism is a non-standard economic activity because:

1. T is purely exogenous at the destination level, the number of tourists depends on tourists preferences and firms cannot decide if they are going to produce T^* , $T_{LOW} < T^*$ or $T_{HIGH} > T^*$.
2. The price of a journey is not simply set by the market at a given price p . The price of a tourist product depends on its characteristics, it means basically on its quality.

If the quality of the product falls, its price falls and as a result the number of tourists that maximizes the profit of the destination decreases from T^* to T^{**} . The decrease in price creates an incentive for the destination to host less tourists than before.

From that point, the aim of this paper is to answer a simple question: Are fluctuations, and especially temporary decline, in frequentation always harmful for the profit of a tourism destination?

In a first section, I propose a simple model for a nature-based destination, in which the willingness to pay of a tourist for the destination depends on the stock of natural assets, and I show using simulations that there exists a rational economic incentive to experience a decrease in frequentation for a while in order to let the stock of natural assets regenerates. This is an idea already emphasized by Greiner et al. (2001) and Kort et al. (2002).

In a second section, I show that anyway the optimal behavior of a profit-maximizing representative tourism firm would generally lead to a monotonic frequentation path. Finally, I explain that this apparent contradiction is due to the fact that the level of frequentation is not, in the real world, set at its optimal level. Yet it could be good news if at some point, when the stock of natural assets is low, frequentation declines for a while.

2 Tourism profits at nature-based destination

I consider a particular type of tourism destination characterized by the fact that its attractiveness relies on the existence of unique natural capital, i.e. fabulous landscapes, mountains, sea, beaches, etc...

In such a destination, the number visitors at any time period t is exogenously given by T_t .

The problem is to know what does the marginal receipt of tourism, the price of the journey\the willingness to pay of a tourist depends on.

Following Cerina (2007), I consider that the willingness to pay of a tourist is given by a hedonic price function (Rosen, 1974).

The willingness to pay of a tourist positively depends on the natural quality of the destination given by the stock Q_t of natural assets.

Furthermore, I assume that the higher is the frequentation the lower is the willingness to pay of a tourist *ceteris paribus* denoting the existence of a crowding effect.

I define the hedonic price function:

$$\begin{aligned} p_t &= p(Q_t, T_t) \\ p_Q &= \frac{\partial p_t}{\partial Q_t} > 0, p_{QQ} = \frac{\partial^2 p_t}{\partial Q_t^2} < 0 \\ p_T &= \frac{\partial p_t}{\partial T_t} < 0, p_{TT} = \frac{\partial^2 p_t}{\partial T_t^2} < 0 \\ p_{QT} &= p_{TQ} = \frac{\partial p_t}{\partial Q_t \partial T_t} \geq 0 \end{aligned}$$

The market structure is such that at time t for a given level of tourist T_t there exists a unique equilibrium price $p(Q_t, T_t)$. To put it differently, for every level of supply T_t , if the price is different of $p(Q_t, T_t)$, the demand is 0 whereas for the same level of supply T_t demand is T_t if the price just equals $p(Q_t, T_t)$.

The stock of natural assets Q_t is affected by two different processes. First, tourism frequentation generates an environmental damage, $\phi(T_t)$, a pollu-

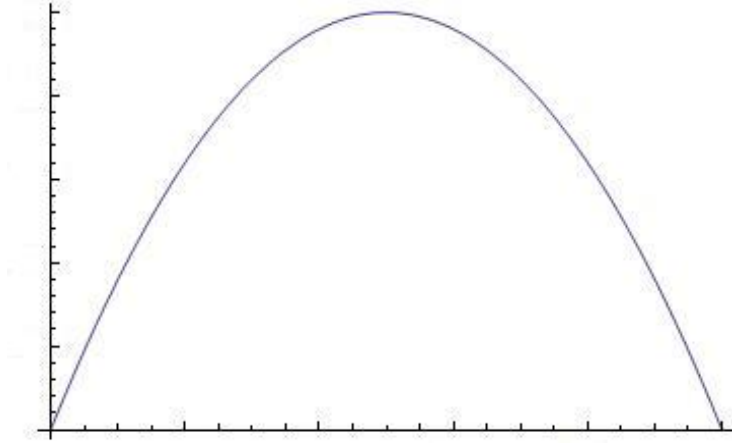


Figure 1: The regeneration capacity of the natural stock of assets as a function of the stock

tion, leading to the decrease of the stock of natural assets ($\phi'(T_t) > 0$, $\phi''(T_t) > 0$).

Second, this stock of asset is governed by a natural growth process taking the form of a logistic function $r(Q_t) > 0$ and there exists an amount of natural assets \bar{Q} such that $r'(Q_t) > 0, \forall Q_t < \bar{Q}$, $r'(Q_t) < 0, \forall Q_t > \bar{Q}$ and $r'' < 0$.

This type of function is of common use in bioeconomics problems (Clark, 1990). It means that the regeneration capacity of the environment depends on the current stock of environmental assets. For a high stock of natural assets, the regeneration capacity is relatively low because the stock of natural assets cannot grow forever. Conversely, for a low stock of natural assets the regeneration capacity is relatively high since the stock of assets is far from its highest reachable value.

Putting all these elements together, I build an economic model describing the evolution over-time of the profit of the destination.

The profits derived from tourism at time t are given by:

$$\pi_t = p(Q_t, T_t) T_t - c(T_t)$$

$c(T_t)$ is the total cost of hosting T_t visitors

The evolution of the stock of natural assets is described by the following differential equation:

$$\dot{Q} = r(Q_t) - \phi(T_t)$$

The key feature of this model is the relation between the number of visitors, the stock of natural assets and the willingness to pay of the visitor for a journey in the destination.

When the number of visitors is high the stock of natural assets tends to decline *ceteris paribus* leading to a decrease in the willingness to pay of each visitor.

It means that a high level of frequentation generates a loss of economic value of the destination since the willingness to pay is decreasing. Then the profit of the tourism sector in the future may potentially decline even if the frequentation is constant or higher than before since the marginal receipt by tourist is lower.

Then it would be economically rational to observe a decrease in frequentation since it enables the regeneration of natural assets and thereby an increase in the willingness to pay and in tourism profits.

To illustrate the dynamic behavior of the model, I am going to implement some simulations.

First, I use the Euler discretization method in order to rewrite the evolution of the stock of natural assets as follows:

$$Q_{t+1} - Q_t = r(Q_t) - \phi(T_t)$$

Then I define an explicit form for each of the functions.

$$p(Q_t, T_t) = P_0 + Q_t^\alpha + T_t^{-\beta}$$

P_0 is a positive parameter accounting for exogenous price determinants, $\alpha > 0$ is the elasticity of the willingness to pay of a tourist with respect

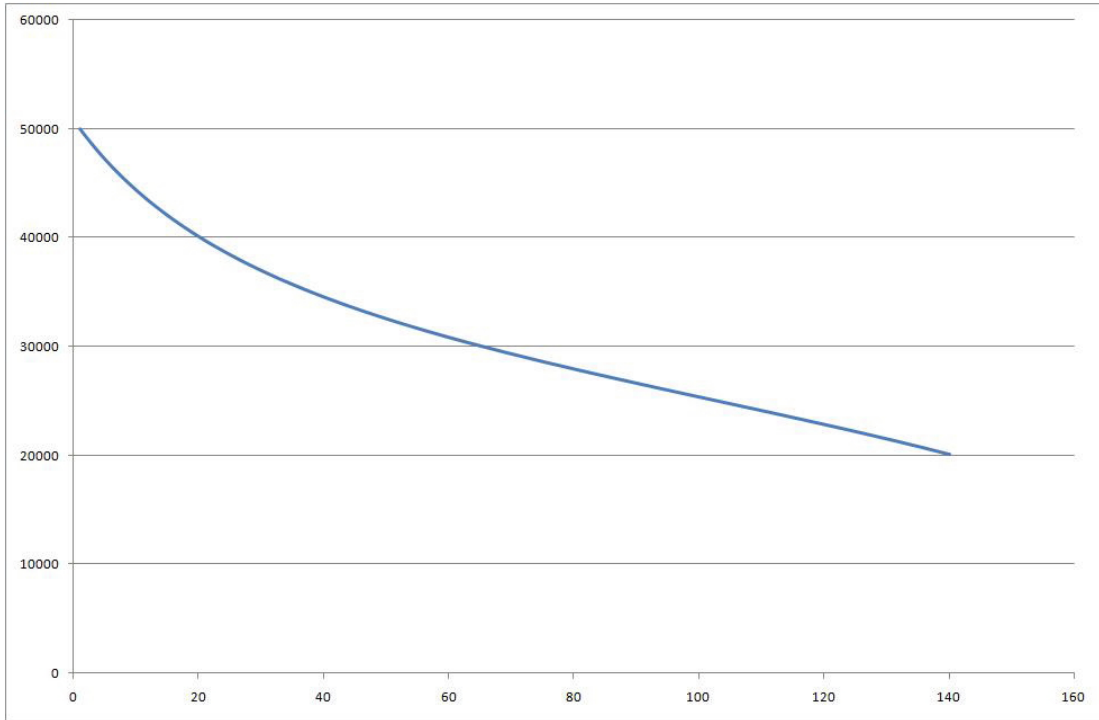


Figure 2: Profit of the tourism sector when the number of visitors is constant over-time

to the stock of natural assets, $\beta > 0$ is the opposite of the elasticity of the willingness to pay of a tourist with respect to the stock of visitors.

$$c(T_t) = \frac{c}{2}T_t^2$$

The total cost of hosting T_t visitors is assumed to be quadratic, with $c > 0$.

The growth process of the natural assets takes the logistic form:

$$r(Q) = rQ_t \left(\frac{k - Q_t}{k} \right)$$

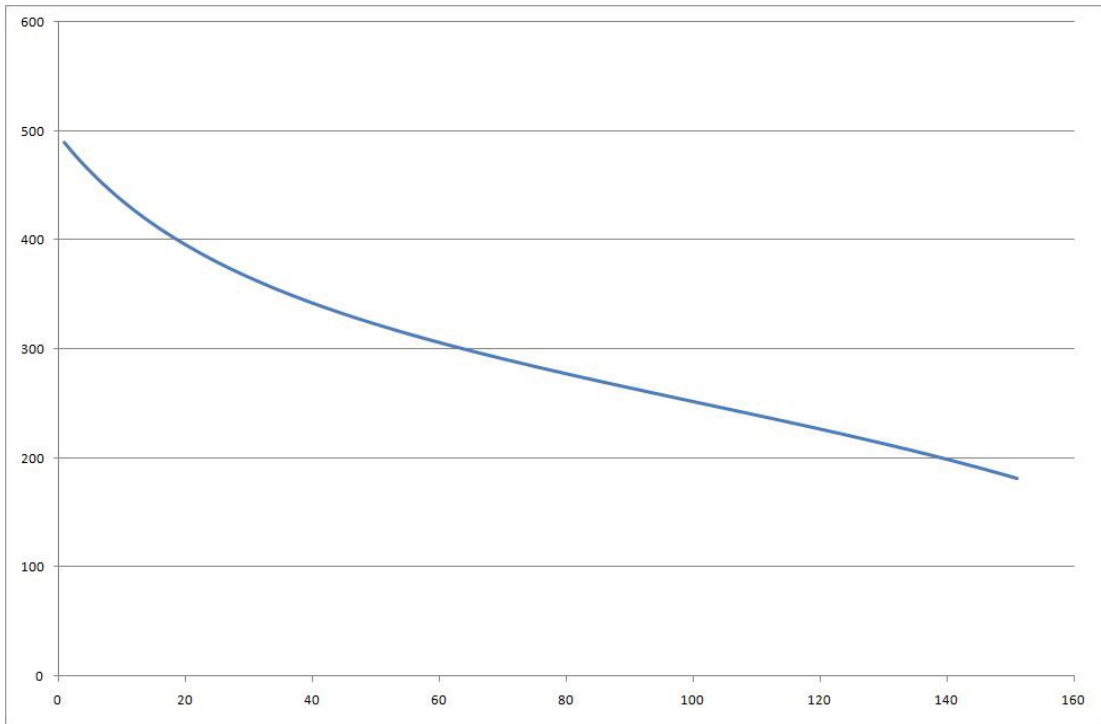


Figure 3: Willingness to pay of a tourist when the number of visitors remains constant over-time

where r is a positive parameter and $k > 0$, is the highest reachable value of Q_t .

And the environmental damage is:

$$\phi(T_t) = \frac{\gamma}{2}T_t^2$$

So that the following model is simulated:

$$\pi_t = \left(P_0 + Q_t^\alpha + T_t^{-\beta} \right) T_t - \frac{c}{2}T_t^2$$

$$Q_{t+1} - Q_t = rQ_t \left(\frac{k - Q_t}{k} \right) - \frac{\gamma}{2}T_t^2$$

Figure 2 above describes the profit at time t of the tourism sector for a given set of parameters² when I assume that the number of visitors at each time is exogenously given and remain constant over-time at $T = 100$.

One can observe that the profit of the tourism sector is monotonously decreasing over-time. As I explained before, this is due to the monotonous decrease in the willingness to pay (figure 3) that is correlated to the decrease of the stock of natural assets over-time. As the subjective value of a journey is decreasing, the profit of the destination is falling over-time even with constant frequentation.

Now let's assume that for the same set of parameters the number of visitors is:

constant $T_t = 100$ for $t \in [0, 50]$

decreasing at the exogenous rate of 5% for $t \in [51, 100]$

increasing at the exogenous rate of 5% for $t \in [101, 150]$

As shown in figure 4, the profit declines as the number of tourists is constant but when the frequentation starts to decline, there is an increase

²	α	β	γ	c	r	k	P_0
	1	2	0.15	0.005	0.05	500	10000

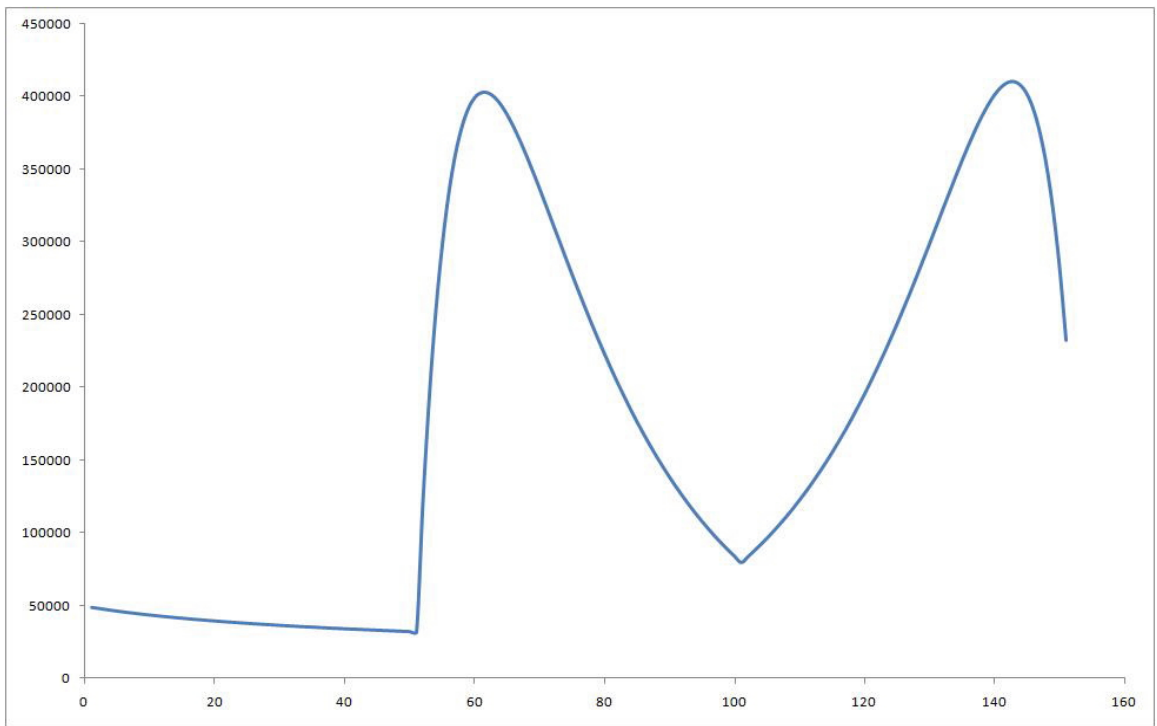


Figure 4: Profit of the tourism sector when frequentation is varying over-time

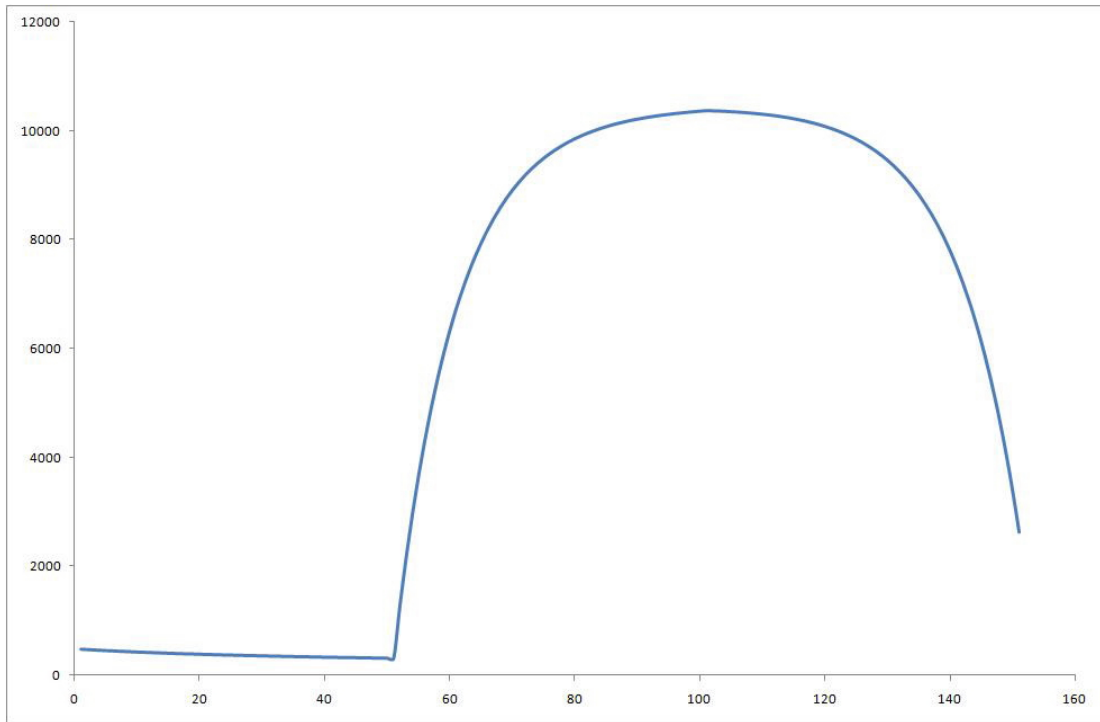


Figure 5: Willingness to pay of the tourist when frequentation is varying over-time

in profit. This is due to the fact that the fall in frequentation leads to an increase in the willingness to pay for a journey since the stock of natural assets regenerates (figure 5).

The simulations of this model illustrate that rational economic entrepreneurs would be willing to experience a decrease in frequentation when the stock of natural assets and, as a consequence, the tourist willingness to pay are low.

This is because constant and/or increasing frequentation harms the economic value of the destination and the only solution to make this value grow again is to decrease the level of frequentation.

I have just shown that it could be economically rational to have fluctuations in frequentation from the firm point of view. In the next section I show,

that anyway this is not economically optimal.

3 On the economic optimality of fluctuating frequentation

In this section, I answer the following question: Is it economically optimal for a destination in a position to set at each time the optimal number of visitors to experience fluctuating frequentation?

I show that if the profit of the destination is described by the model of the previous section, the general answer is no. Economic optimality requires to have a constant frequentation, except in a really special and limit cases.

Consider a representative entrepreneur in tourism of the destination described in the previous section. He knows that the destination has some monopoly power and is in a position to define the number of visitors at each time.

The objective of the entrepreneur is to find at each time the level of frequentation T_t that maximizes the infinite sum of discounted profits over-time for $t \in [0, +\infty]$ subject to the law of motion of the natural stock of assets.

$$\begin{aligned} & \text{Max}_T \int_0^{+\infty} e^{-\rho t} [R(T_t, Q_t) - c(T_t)] dt \\ \text{s.t. } & \dot{Q} = r(Q_t) - \phi(T_t) \end{aligned}$$

$R(T, Q) = P(Q_t, T_t) T_t$ are the tourism receipts of the destination. $\rho > 0$ is the rate of discount of the entrepreneur, the higher is ρ the more the entrepreneur favors present profits compared to future ones. The initial situation of the destination is given by $Q(0) = Q_0 > 0$.

To find the optimal path of frequentation, I use the Maximum Principle.

The current-value Hamiltonian of this program is:

$$H(Q_t, T_t, \lambda_t) = R(T_t, Q_t) - c(T_t) + \lambda_t [R(T_t, Q_t) - c(T_t)]$$

λ_t is the co-state variable associated to the stock of natural assets Q_t and reflects the value in terms of profit of the preservation of one more unit of natural assets. To state it differently, if at time t Q_t increases of one unit the profit of the destination increases of λ_t units.

The Maximum Principle yields:

$$\frac{\partial H}{\partial T_t} = 0 \Leftrightarrow R_T - c' = \lambda \phi'$$

This equation states that along an optimal frequentation path, the profit associated with a marginal increase in frequentation must equal the loss in terms of profit of the environmental degradation.

$$\frac{\partial H}{\partial Q_t} = \rho \lambda_t - \dot{\lambda} \Leftrightarrow \dot{\lambda} = \lambda_t (\rho - r') - R_Q$$

Using $\frac{\partial H}{\partial T_t} = 0$, I express the optimal frequentation as an implicit function of Q_t and λ_t and I obtain:

$$\frac{dT_t}{dQ_t} = -\frac{R_{TQ}}{R_{TT} - c'' - \lambda \phi''} > 0$$

$$\frac{dT_t}{d\lambda_t} = \frac{\phi'}{R_{TT} - c'' - \lambda \phi''} < 0$$

The previous relations state that along an optimal path, the frequentation is increasing with the stock of natural assets and decreasing with the value in terms of profit of an additional unit of natural assets.

Then it is possible to express the so-called modified-Hamiltonian-system that only depends on Q_t and λ_t .

$$\dot{Q} = r(Q_t) - \phi[T_t(Q_t, \lambda_t)]$$

$$\dot{\lambda} = \lambda_t (\rho - r') - R_Q [T(Q_t, \lambda_t), Q_t]$$

In this paper, my aim is not to study the long-term values of the variables but to assess the "form" of the optimal frequentation path. Since the modified-Hamiltonian system is a system of two non-linear differential equations, I assume that there exists a pair (Q^*, λ^*) that is a particular solution, a steady-state solution, of this system.

Now form the Jacobian matrix of this system and let's evaluate it at the steady-state, one finds:

$$J^*(Q^*, \lambda^*) = \begin{bmatrix} r' + \frac{\phi' R_{TQ}}{R_{TT} - c'' - \lambda \phi''} & -\frac{\phi'^2}{R_{TT} - c'' - \lambda \phi''} \\ -\lambda_t r'' + \frac{(R_{TQ})^2}{R_{TT} - c'' - \lambda \phi''} - R_{QQ} T & \rho - \left(r' + \frac{R_{TQ} \phi'}{R_{TT} - c'' - \lambda \phi''} \right) \end{bmatrix}$$

The eigenvalues of J^* are:

$$\mu_1 = \frac{\rho + [\rho^2 - 4Det(J^*)]^{\frac{1}{2}}}{2}$$

$$\mu_2 = \frac{\rho - [\rho^2 - 4Det(J^*)]^{\frac{1}{2}}}{2}$$

$$\text{Where } Det(J^*) = \rho \left(r' + \frac{\phi' R_{TQ}}{R_{TT} - c'' - \lambda \phi''} \right) - \left\{ (r')^2 + 2 \frac{r' \phi' R_{TQ}}{R_{TT} - c'' - \lambda \phi''} + \frac{\phi'^2}{R_{TT} - c'' - \lambda \phi''} [\lambda_t r'' + R_{QQ}] \right\}$$

It is known (Léonard and Van Long, 1992) (and can be verified by the inspection of μ_1 and μ_2) that provided $Det(J^*) < 0$, the system is saddle-point stable with real eigenvalues.

Economically, it means that the representative entrepreneur would choose a path of frequentation that is monotonically converging toward a steady-state in which the number of visitors remains constant.

Furthermore, if $0 < Det(J^*) < \rho^2$, eigenvalues of J^* are complex with a positive real part. It means that the frequentation would take the form of explosive fluctuations.

The analyze of the determinant enables three propositions:

Proposition 1 *Provided both the initial stock and steady-state stock of natural assets are high enough, $Q^* > \bar{Q}$, the optimal frequentation path is monotonically increasing until reaching the constant frequentation level T^* .*

Proof. Given in the appendix A. ■

Proposition 2 *The optimal path of frequentation would consist of explosive fluctuations provided the steady-state stock of natural assets is low-enough, $Q^* < \bar{Q}$, and in the meantime the marginal willingness to pay for natural assets is high enough. Furthermore, explosive fluctuations path are unlikely to happen.*

Proof. Given in the appendix B. ■

Proposition 3 *Fluctuating optimal path, it means limit-cycles, do not exist in this model.*

Proof. Given in the appendix C. ■

4 Discussion of the results

The aim of this paper was to answer a simple question. Are fluctuations, and especially temporary decline, in frequentation always harmful for the profit of a tourism destination?

Defining a dynamic economic model of a nature-based destination and using simulations, I have shown that a temporary decrease in frequentation could be associated with an increase in profits whereas constant or increasing frequentation would lower profits.

This is due to the fact that frequentation has a negative impact on the economic value, the tourist willingness to pay, of the destination.

It is possible to understand that a decrease in frequentation at some point enables the stock of natural assets to regenerate and by the way the willingness to pay is growing again and so is the profit.

Then, I studied the optimal frequentation path that a profit-maximizing entrepreneur subject to environmental constraint would choose and I have shown that except in extreme cases the optimal path is increasing over-time until reaching a constant frequentation in the long-run.

What does these two results together mean?

As I said in the introduction, a common idea among tourism practitioners is that a fall in frequentation is harmful for the profit.

In my view, the previous results show that they are partly right and partly wrong.

They are partly right because if the number of visitors at each time was optimally chosen at the destination level, it means in the presence of monopoly power, a decline in frequentation, fluctuations, would be suboptimal. This is what the results of section 3 mean.

But they are partly wrong because as the simulations of section 2 tend to show when the level of frequentation is not optimally chosen, a decrease in frequentation at some point preserve the willingness to pay of the tourists for the future and then insures stable or increasing profits.

In fact, the main conclusion of this paper can be stated as follows. Since, in the real world, frequentation is not set at its optimal level, it could be good news if at some point frequentation declines for a while.

Anyway, the results presented in this paper are not generally admissible and should be confirmed by more applied and theoretical works.

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A Proof of proposition 1

The determinant of the Jacobian of the modified-Hamiltonian system evaluated on steady-state is given by:

$$DetJ^* = \rho \left(r' + \frac{\phi' R_{TQ}}{R_{TT} - c'' - \lambda \phi''} \right) - \left\{ (r')^2 + 2 \frac{r' \phi' R_{TQ}}{R_{TT} - c'' - \lambda \phi''} + \frac{\phi'^2}{R_{TT} - c'' - \lambda \phi''} [\lambda_t r'' + R_{QQ}] \right\}$$

If the steady-state stock of natural assets is such that $Q^* > \bar{Q}$, $r'(Q^*) < 0$ by definition of $r(Q_t)$. Since, we know that:

$$R_{TT} - c'' - \lambda\phi'' < 0$$

$$\phi'R_{TQ} > 0$$

$$\begin{aligned} \rho \left(r' + \frac{\phi'R_{TQ}}{R_{TT} - c'' - \lambda\phi''} \right) &< 0 \text{ and} \\ \left\{ (r')^2 + 2 \frac{r'\phi'R_{TQ}}{R_{TT} - c'' - \lambda\phi''} + \frac{\phi'^2}{R_{TT} - c'' - \lambda\phi''} [\lambda_t r'' + R_{QQ}] \right\} &> 0 \\ \text{so that } DetJ^* &< 0 \end{aligned}$$

As the determinant of J^* is negative, the eigenvalues of J^* are opposite real and opposite in sign so that the optimal frequentation path monotonously converges towards the steady-state.

Furthermore as long as $Q(0)$ is high, it means that $\lambda(0)$ is low and the number of tourists is increasing towards its steady-state value.

B Proof of proposition 2

The determinant of the Jacobian of the modified-Hamiltonian system evaluated on steady-state is given by:

$$DetJ^* = \rho \left(r' + \frac{\phi'R_{TQ}}{R_{TT} - c'' - \lambda\phi''} \right) - \left\{ (r')^2 + 2 \frac{r'\phi'R_{TQ}}{R_{TT} - c'' - \lambda\phi''} + \frac{\phi'^2}{R_{TT} - c'' - \lambda\phi''} [\lambda_t r'' + R_{QQ}] \right\}$$

If the steady-state stock of natural assets is such that $Q^* < \bar{Q}$, $r'(Q^*) > 0$ by definition of $r(Q_t)$.

The sign of $DetJ^*$ is unknown since it depends on the value of $\phi'R_{TQ} > 0$.

There exists a value \bar{R}_{TQ} that is high such that $DetJ^* > 0$. If the determinant is positive the eigenvalues will be complex (provided ρ is low enough)

with positive real-parts (ρ), so that the optimal trajectory would be explosive fluctuations.

Such a situation is unlikely to happen since it requires a high steady-state level of R_{TQ} and a low steady-state level of Q_t . This is possible but if R_{TQ} is high on steady-state, a rational entrepreneur will have an incitation to preserve a quiet high level of Q_t so that when R_{TQ} is high on steady-state, we will have, in general $Q^* > \bar{Q}$ and in such a case proposition 1 holds.

C Proof of proposition 3

Limit-cycles, it means optimal self-sustained fluctuations, occur only if $DetJ^* > 0$ and $\rho = 0$. Since this is impossible by assumption limit-cycles cannot occur in this model.