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TOURISM TAXATION AND ENVIRONMENTAL QUALITY IN A MODEL WITH VERTICAL DIFFERENTIATION

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The environmental quality of destination has become a tool that hotels have to hold the tourism demand. In this paper we are going to present a model of vertical differentiation in the accommodation industry, where differentiation is associated with quality. Additionally, we assume the existence of a lump sum tax in the accommodation industry. Two are the main results which will be proved in this article; first, if the tourist's willingness to pay for quality increases then both the demand and the price for tourism services increase as a result. However, the increment of the demand for best environmental quality gets higher, and therefore, the environmental quality level of tourism services, that the destination offers, decreases. Second, an increase in the value of the tourism tax leads to an increase in the total environmental quality of the destination.

Keywords: *duopoly, tourism demand, hotel service quality, environment.*

INTRODUCTION

The last years have seen a significant growth in the tourism sector, and in particular in the activities related to the accommodation industry. For instance, the international tourism receipts increased from 207 in 1990 up to 586 billons of Euros in 2006 (data from (UNWT, 2007)). This new scenario has led the importance of the quality of tourism service to a better standard.

Moreover, an important share of the tourism sector is its interdependency with the environmental quality of the destination. On one hand, tourism, as well as all the economics activities, directly affects the environment. The tourism sector and policy makers are interested in

investing on the environmental quality and on a sustainable utilization of the local resources. However, on the other hand, the tourism sector depends on the natural environment; the environmental quality of a tourism destination is therefore an important tool that hotels have to hold the tourism demand. Many articles have studied this aspect: for example (Fick and Ritchie, 1991) shows that the success of a tourism destination depends critically on the quality of the services they guarantee. In this respect, (González and León, 2001), in their study about the adoption of environmental innovations in the hotel industry of Gran Canaria (Spain), found out that hotels have strategic opportunities to improve their net profits through an effective environmental management. These authors show that environmental innovations have a positive impact on tourism demand, and that the public policies can also contribute, through incentives for environmental investments and the diffusion of information on environmental measures. Such a strong interdependency with the environmental quality leads to important consequences. For example (Pintassilgo and Silva, 2007) showed that open market access leads to an overexploitation in respect to economy and environment; as they proved, "Present research shows that tourism can destroy tourism". In fact, these authors recommend limiting the number of firms through many policy instruments such as the use of taxes.

As a result of this interdependency, it can be said that the environmental quality of a tourism region is mainly produced by the accommodation industry. For example, one of the key objectives shared by the biggest hotel chains is the maintenance of bathing water and good beach quality. The animal protection in the nearest of hotels also plays a big rule. Nevertheless, a reduction of environmental impact, through small systematic steps, such as improvements in eco-efficiency can be a huge factor as well. In addition, a good managing of the accommodation industry in respect to the environment `produces' the quality of the tourism destination. In this paper it is taken into account the environmental quality as the quality of the tourism service offered by the accommodation industry.

From a tourist point of view, the importance of the environmental quality is out of the question, since tourists are mainly interested in it. In this respect, (Huybers and Bennet, 2000) analyze the impact of the environment on holiday destination choices of prospective UK tourists. These authors found out that tourists are willing to pay more in order to visit a destination with high environmental quality (see also (Sinclair and Stabler, 1997) and (Clewer, 1992)). From all those studies appears clear that environmental quality is important for tourists and that in a large

number of cases, they are willing to pay for quality. This is another peculiar characteristic of the tourism demand, and one of the components of the model analyzed in this paper.

Many studies in tourism economics focus on the horizontal differentiation of the accommodation industry. In particular, (Calveras, 2003), (Accinelli et al., 2006), (Brida and Pereyra, 2008a) and (Brida and Pereyra, 2008b), studied a model where tourists are characterized by their location. This kind of horizontal differentiation is called Hotelling-type models. In this paper, it is adopted a model of vertical differentiation where all tourists have the same ranking of quality; in fact all tourists agree that high quality is better, but they differ on their willingness to pay for it. However this two models seem to be very different, (Cremer and Thisse, 1991) have proved that the Hottelling model is a special case of a vertical product differentiation model. In this sense, the model that we present in this article, works in a larger range of action than the models above. An interesting model of vertical differentiation in tourism economics is the one presented by (García and Tugores, 2006). In that model, two hotels play a two stage game: at the first, the quality of the services is chosen by hotels, and then they compete in prices. It is shown that hotels choose to offer differentiated services. (Wauthy, 1996), also, gives a complete characterization of quality choices in a duopoly model of vertical product differentiation, in which firms simultaneously choose the quality to offer, and then compete in prices.

In this article we present a model of vertical differentiation in the accommodation industry, where differentiation will be associated with quality. Additionally, we assume the existence of a lump sum tax in the accommodation sector. Taxing became in fact a very common policy instrument, with the aim of controlling the negative impact of tourism on the environment. There are many economic studies about tourism taxation, as for example (Gooroochurn and Sinclair, 2005), (Aguiló et al., 2005), (Jensen and Wanhill, 2002), (Arbel and Ravid, 1983), (Himiestra and Ismail, 1992), (Bonham and Gangnes, 1996), (Warnken et al., 2004), (Fuji et al., 1985) and (Palmer and Riera, 2003). In this paper such a control operates through a demand reduction. This model looks at the impact of tourism taxation on the environmental quality, and other economic variables. Nevertheless, the value of some parameters, which influence the efficiency of that taxation, has been also taken into account.

The paper is structured as follows. In the next section we will introduce the model, which will be solved in the following chapter. In section 4, the focus is on how environmental quality and tourism taxation interact. Conclusions and further developments are left in the last section.

THE MODEL

The model assumes the existence of two hotels: Hotel 1 and Hotel 2. They offer different tourism services, which are respectively sold at prices p_1 and p_2. Each tourism service is associated with a parameter $v_i > 0$, with $i = 1, 2$, that represents the quality of the service of each hotel. It will be supposed that the quality of the service of hotel 1 is higher than in hotel 2, that is, $v_1 > v_2$. then hotel 1 is associated with the best possible quality. Further in this paper we assume that the environmental quality of the destination equals the sum of the quality of both hotels, i.e. $v = v_1 + v_2$. This assumption is based on the fact that, as we supp.ose, both hotels have the same characteristics, and the main difference between them is how much they invest in the environmental quality of the destination.

On the demand side there is a continuum of tourists distributed uniformly, with unit density, over the interval $\left[\overline{\theta} - 1, \overline{\theta}\right]$ ($\overline{\theta} > 1$). each tourist is defined by a value of the parameter $\theta \in \left[\overline{\theta} - 1, \overline{\theta}\right]$. A higher θ represents a tourist that is willing to pay more for a given quality. All tourists, at a given price, prefer higher quality, but they differ on the willingness to pay for it. Moreover, a higher value of $\overline{\theta}$ implies that all tourists are willing to pay a higher price for quality. As in Tirole (1988) θ can be viewed as the marginal rate of substitution between quality and income, which means that, a low value of θ stands for a high marginal utility of income, and therefore a lower income. Thus, this model is similar to those once, where consumers differ on their incomes such as (Gabszewick and Thisse, 1979) and (Bonano, 1986).

Each tourist goes for one of the following things: buy the tourism service of hotel 1, buy the tourism service of hotel 2, and do not buy at all. Additionally, is supposed the existence of a lump sum tax in the accommodation sector, which is to be intended in the following way: every tourist has to pay a tax when they buy tourism services in both hotels. Such an assumption will be soon developed, since the difference between those costs is one the most relevant points of our analysis. Given the fact that we supp.ose that the cost is higher in hotel 1, we just compute the difference of that cost (that is denoted by t). We assume that the differential tax that tourists have to pay in order to buy services from hotel 1 is not very high, with respect to the top quality and the willingness to pay for it, which produces no demand. In particular (and to simplify the

algebra of the model) we assume that $t < \frac{\overline{\theta} v_1}{12}$. Then a tourist with index $\theta \in \left[\overline{\theta} - 1, \overline{\theta}\right]$ maximizes the following utility function based on (Tirole, 1988):

$$u_\theta = \begin{cases} \theta v_1 - p_1 - t & \text{if the tourist buy from hotel 1} \\ \theta v_2 - p_2 & \text{if the tourist buy from hotel 2} \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Note that, as expected, the utility function is increasing, for any given prices, with quality and willingness to pay for it. Hotels play the following three stage game. First, hotel 1 chooses the quality of the tourism service that will offer (v_1) from the interval $[0, \tilde{v}]$, $\tilde{v} > 0$. Then, hotel 2 observes v_1 and chooses the quality of the service they want to offer v_2 from the interval $[0, v_1]$. In the last stage, both hotels choose the price simultaneously, having observed v_1 and v_2. To solve the model, is used the backward induction, aimed to obtain a sub-game perfect Nash equilibrium.

THE OPTIMAL ELECTION OF QUALITY AND PRICE

To compute the demand that each hotel faces, first we must find the indifferences points. Then, we denote as θ_1 the tourist indifferent between going to hotel 1 or 2. Using (1) it can be found that:

$$\theta_1 = \frac{(p_1 - p_2) + t}{v_1 - v_2} \quad (2)$$

Similarly, θ_2 represents the tourist's indifference between going to hotel 2 or staying at home:

$$\theta_2 = \frac{p_2}{v_2} \quad (3)$$

We compute now the demands for both regions. Tourists with $\theta \ / \ \overline{\theta} - 1 \le \theta \le \theta_2$ do not buy tourism services in the hotels; if it happ.ens $\theta \ / \ \theta_2 \le \theta \le \theta_1$ then the tourist will prefer to buy at hotel 2 rather than not to buy. Finally tourists with $\theta \ / \ \theta_1 \le \theta \le \overline{\theta}$ will buy tourism services

at hotel 1. Then using (2) and (3), the demand functions of both hotels will be:

$$D_1 = \overline{\theta} - \frac{(p_1 - p_2) + t}{v_1 - v_2} \tag{4}$$

$$D_2 = \frac{(p_1 - p_2) + t}{v_1 - v_2} - \frac{p_2}{v_2} \tag{5}$$

where D_i is the demand faced by hotel $i = 1, 2$. Observe that, as asserted in (González and León, 2001), both demand depends positively on the quality of the tourist's services.

To solve the game, we first have to consider the choice of prices of both hotels. Then we will study the choice of quality of hotel 2, based on the choice of hotel 1. Therefore, the process has to be divided in two stages, which we are going to analyze.

Stage 1: As it is usual in industrial economic models, we assume that costs of production are zero. Then the problem faced by hotel 1 is to select the best price for the tourism service that maximizes its profits π_1 :

$$\max \pi_1 = \max\ p_1 D_1 = \max\ p_1 \left(\overline{\theta} - \frac{(p_1 - p_2) + t}{v_1 - v_2} \right) \tag{6}$$

From the first order conditions it can be found:

$$p_1 = \frac{p_2 + \overline{\theta}(v_1 - v_2) - t}{2} \tag{7}$$

The correspond problem faced by hotel 2 is:

$$\max \pi_2 = \max\ p_2 D_2 = \max\ p_2 \left(\frac{(p_1 - p_2) + t}{v_1 - v_2} - \frac{p_2}{v_2} \right) \tag{8}$$

Then, solving (8) we have:

$$p_2 = \frac{v_2 (p_1 + t)}{2 v_1} \tag{9}$$

If we combine (7) and (9) to find the prices corresponding to the Nash equilibrium, we obtain:

$$p_1 = \frac{2\overline{\theta}v_1(v_1 - v_2) - t(2v_1 - v_2)}{4v_1 - v_2}$$
$$p_2 = \frac{\overline{\theta}v_2(v_1 - v_2) + tv_2}{4v_1 - v_2} \quad (10)$$

Observe that p_1 is decreasing on t. The reason is that if the tax increases (that is, if it is more expensive to buy from hotel 1 or cheaper from hotel 2), then by (4), the demand for tourist's service of hotel 1 falls, causing a decrease in price. A quite similar consideration can be done by looking at p_2, however, in this case, the function is increasing on the value of the tax. Another interesting point is given by the effects of changes in $\overline{\theta}$. Given that in (10) both prices are increasing on $\overline{\theta}$, an increase in this parameter will produce an improvement of the prices. That is because all tourists are willing to pay more for quality. In this respect, if tourists believe that environmental quality is more important, then prices will become higher as a consequence. This last result is in line with the conclusions of (Keane, 1997), where is explained how prices are a sign of the quality of a tourism destination.

Now substitute (10) on (6) and (8) to obtain the profits function of both hotels:

$$\pi_1 = \frac{\left(tv_2 - 2tv_1 + 2\overline{\theta}v_1^2 - 2\overline{\theta}v_1v_2\right)^2}{\left(v_2 - 4v_1\right)^2\left(v_1 - v_2\right)}$$
$$\pi_2 = \frac{v_1v_2\left(t + \overline{\theta}v_1 - \overline{\theta}v_2\right)^2}{\left(4v_1 - v_2\right)^2\left(v_1 - v_2\right)} \quad (11)$$

Stage 2: On the first stage of the game, hotel 1 chooses the quality of its services in the interval $[0, \tilde{v}]$. Then hotel 2, observed the value of v_1, chooses v_2 to maximize π_2. As it is asserted by (Wauthy, 1996), $v_2 = v_1$ cannot be the best reply of hotel 2, because this choice yields Bertrand competition and zero out the profits in the price game. Then v_2 must be strictly less than v_1. The first order conditions for the profits maximization of hotel 2 is:

$$\frac{\partial \pi_2}{\partial v_2} = 0 \Leftrightarrow \left(4tv_1^2 - 2tv_2^2 + 4\overline{\theta}v_1^3 + 7\overline{\theta}v_1v_2^2 - 11\overline{\theta}v_1^2v_2 + tv_1v_2\right)\left(t + \overline{\theta}v_1 - \overline{\theta}v_2\right) = 0 \quad (12)$$

Then to maximize its profits, hotel 2 must choose a quality v_2 that verify:

$$\left(t+\overline{\theta}v_1-\overline{\theta}v_2\right)=0 \qquad (13)$$

or

$$\left(4tv_1^2-2tv_2^2+4\overline{\theta}v_1^3+7\overline{\theta}v_1v_2^2-11\overline{\theta}v_1^2v_2+tv_1v_2\right)=0 \qquad (14)$$

The equation defined by (13) leads to the following solution:

$$v_2=\frac{1}{\overline{\theta}}\left(t+\overline{\theta}v_1\right)=\frac{t}{\overline{\theta}}+v_1 \qquad (15)$$

However, since by hypothesis $v_1 > v_2$, this solution must be discarded. Then the solution is defined by (14), so that the optimal election of quality is[2]:

$$v_2=\frac{v_1\left((t-11\overline{\theta}v_1)+\sqrt{3\left(t-3\overline{\theta}v_1\right)\left(11t-\overline{\theta}v_1\right)}\right)}{2(2t-7\overline{\theta}v_1)} \qquad (16)$$

Finally we brought the following values to the equilibrium. They stand for the quality of the tourist sector in each hotel:

$$v_1=\hat{v}$$
$$v_2^*=\frac{\hat{v}\left((t-11\overline{\theta}\hat{v})+\sqrt{3\left(t-3\overline{\theta}\hat{v}\right)\left(11t-\overline{\theta}\hat{v}\right)}\right)}{2(2t-7\overline{\theta}\hat{v})} \qquad (17)$$

Now by substituting (17) with (10), we will find the exact equilibrium prices.

ENVIRONMENTAL QUALITY AND TOURISM TAXATION

The model we have solved in the last section will be used now to study the effects of changes of some variables in the equilibrium values. In this respect, the first important result is the following:

Proposition 1: If the tourist's willingness to pay for quality increases,

[2]See appendix I for the details.

then:

1) *The demand for tourism services faced by hotel 1 (the best quality hotel) increases by more than the demand of hotel 2.*
2) *The price for tourism services of hotel 1 increases by more than the price of hotel 2.*
3) *The quality level of tourism services offered by hotel 2 decreases.*

Proof:

1) When equation (10), is substituted by (4) and (5), we find that:

$$D_1 = \frac{2\overline{\theta}v_1(v_1 - v_2) - t(2v_1 - v_2)}{(v_1 - v_2)(4v_1 - v_2)} \tag{18}$$

$$D_2 = \frac{\overline{\theta}v_1(v_1 - v_2) + v_1 t}{(v_1 - v_2)(4v_1 - v_2)} \tag{19}$$

Now can be computed the derivative of both demands respect $\overline{\theta}$:

$$\frac{\partial D_1}{\partial \overline{\theta}} = \frac{2v_1}{4v_1 - v_2} \tag{20}$$

$$\frac{\partial D_2}{\partial \overline{\theta}} = \frac{v_1}{4v_1 - v_2} \tag{21}$$

Then, since $\frac{\partial D_1}{\partial \overline{\theta}} > 0$ and $\frac{\partial D_2}{\partial \overline{\theta}} > 0$, an increase in the tourist's willingness to pay for environmental quality, produces an increment of the demand faced by both hotels. However, since $\frac{\partial D_1}{\partial \overline{\theta}} > \frac{\partial D_2}{\partial \overline{\theta}}$,the increase of demand for hotel 1 is higher than the change of the demand for hotel 2; this is a logical assertion, since the tourist's services given by hotel 1 is the best possible quality.

2) The increase of the demand proved in the last point produces an increase in prices and, as predictable, the price for tourism service of hotel 1 increases by more than the price of hotel 2. In fact, by computing $\frac{\partial p_i}{\partial \overline{\theta}}$ will be found that:

$$\frac{\partial p_1}{\partial \overline{\theta}} = \frac{2v_1(v_1 - v_2)}{4v_1 - v_2} \tag{22}$$

$$\frac{\partial p_2}{\partial \overline{\theta}} = \frac{v_2(v_1 - v_2)}{4v_1 - v_2} \tag{23}$$

Moreover $\frac{\partial p_1}{\partial \overline{\theta}} > \frac{\partial p_2}{\partial \overline{\theta}}$, means that the change in the price of hotel 1 is bigger than the change in the case of hotel 2.

3) In appendix II we will prove that $\frac{\partial v_2^*}{\partial \overline{\theta}} < 0$. An increase in the tourist's willingness to pay for quality, produces a decrement in the quality of tourism services given by hotel 2. Since a high $\overline{\theta}$ produces a higher demand that tourism destination faces, leading to a development in such areas, as many authors observed, (see for example (Pintassilgo and Silva, 2007)), this has a negative effect on the environmental quality of the tourism destination. Therefore, in order to minimize this effect, a taxation policy can be successfully introduced. It is then important to study the effect of the possible variation of this tax, in respect to the quality of the tourism service offered. Look carefully at the following statements:

Proposition 2: An increase of the value of the tourism tax leads to a higher quality of the tourism services of hotel 2, and to an increase of the total environmental quality of the tourism destination. Additionally, a low value of the tourist's willingness to pay for quality, leads to a higher effect of the tourism tax.

Proof: in Appendix II we present the proof of $\frac{\partial v_2^*}{\partial t} > 0$. The economic reason for it is that, an increment of the tourism taxation decreases the demand faced by hotel 1 (see equation (4)), forcing this hotel to increase its quality in order to hold its demand. Nevertheless, the quality of hotel 2 increases as well, to maximize its benefits. In fact, it can be easily explained that $\frac{\partial v_2^*}{\partial v_1} > 0$ by using the algebra; therefore, the total environmental quality of the tourism destination increases, and additionally, we will give proof that:

$$\frac{\partial v_2^*}{\partial \overline{\theta}} = -\frac{t}{\overline{\theta}} \frac{\partial v_2^*}{\partial t} \tag{24}$$

Thus, if the willingness to pay for quality has a low value, then, to compensate a decrease in the environmental quality, generated by an

increase of $\overline{\theta}$, the tourism tax must increase less than if the willingness to pay for quality has a high value. If the parameter $\overline{\theta}$ is viewed as the tourist's income level, then a high value of $\overline{\theta}$ implies that the tax that each tourist pays has to increase more than if the level income were lower; this to recover the loose of environmental quality, caused by an increase in the demand. Many authors have studied the effects of tourism taxation, and in particular (Palmer and Riera, 2003) analyzed the effects of the application of an environmental tax in the Balearic Islands. Also for this case, (Aguiló et al., 2005) observed and estimated the demand decrease as a consequence of the 'Balearic Ecotax'. Thus, taxation is a policy instrument to maintain the environmental quality of a tourism destination high, but its efficiency depends, according to this model, on the value of the tourist's willingness to pay for environmental quality, or similar, on the tourist's income level.

CONCLUSIONS AND FURTHER RESEARCH

The accommodation industry impacts, and is affected, by the natural environment. On one hand, tourism as all economics activities directly affects the environment through the movement of people and vehicles, and the abuse of natural resources and infrastructures. On the other hand, the tourism sector depends of the natural environment: in fact, the environmental quality of a tourism destination is an important tool that hotels have to hold the demand. A very important consequence of such interdependency is that open market access may lead to an overexploitation in an economic and environmental context, and could therefore destroy the region as a tourism destination. For this reason, many authors recommend the utilization of policy instruments to control the negative impact of tourism on the environment. A very common instrument is the accommodation taxes, already used, in fact, by many countries and regions.

In this paper we present a model of vertical differentiation in the accommodation industry, where differentiation is associated with quality. Additionally, we suppose the existence of a lump sum tax in such sector. Two main results have been proved in this paper. First, if the tourist's willingness to pay for quality increases then: both the demand and the price for tourism services increase, however, the increment of the demand for best quality gets higher, and the environmental quality level of tourism destination decreases. Second, an increase in the value of the

tourism tax leads to a better quality of the tourism services of the top quality hotel, causing an increase of the total environmental quality of the tourism destination as well. Thus, taxation is a policy instrument which maintains the environmental quality of a tourism destination, but its efficiency depends on the value of the tourist's willingness to pay for quality, or similar, on the tourist's level of income. In this respect, if the willingness to pay for quality has a low value, and then, to compensate a decrease of the environmental quality produced by an increase of $\overline{\theta}$, the tourism tax must increase less than if the willingness to pay for quality has a high value. All this results are in line with many empirical studies that have been conducted in the last years; it reaffirms the important idea of the necessity of public policies aimed to protect the natural environment, through the regulation of the accommodation industry, always based on the principles of efficiency, efficacy and equity.

This study can be extended by modifying the tax type, or by including more hotels and changing the game that hotels play. The horizontal dimension can be also included to compare the results obtained in this article, and to analyze the interaction between horizontal and vertical differentiation. As suggested by the discussants of our paper in the "First Conference of The International Association for Tourism Economics", one way to improve and/or achieve new results, is to use a different definition for the quality of the region. For instance, we can use a weighted meaning for the quality of the two hotels. All these points can be material of future research.

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APPENDIX I

The profit function of hotel 2 is:

$$\pi_2 = \frac{v_1 v_2 \left(t + \overline{\theta} v_1 - \overline{\theta} v_2\right)^2}{\left(4v_1 - v_2\right)^2 \left(v_1 - v_2\right)} \tag{25}$$

In order to maximize this function, hotel 2 must choose a quality level of its services that verifies the following equation (26):

$$\frac{\partial \pi_2}{\partial v_2} = 0 \Leftrightarrow 4tv_1^2 \; 2 \; 3 \; 2 \; 2 \; 1 \; 2 \; 1 \; 2 \; 1 \; 2 = 0$$

As from the text, the second factor of the equation must be discarded since, in that case:

$$v_2 = \frac{1}{\overline{\theta}}\left(t + \overline{\theta} v_1\right) = \frac{t}{\overline{\theta}} + v_1 > v_1 \tag{27}$$

Also by hypothesis we have that $v_1 > v_2$. Then the optimal choice of v_2 must verify:

$$\left(4tv_1^2 - 2tv_2^2 + 4\overline{\theta} v_1^3 + 7\overline{\theta} v_1 v_2^2 - 11\overline{\theta} v_1^2 v_2 + tv_1 v_2\right) = 0 \tag{28}$$

The positive root of this equation is:

$$v_2^* = \frac{v_1\left((t - 11\overline{\theta} v_1) + \sqrt{3\left(t - 3\overline{\theta} v_1\right)\left(11t - \overline{\theta} v_1\right)}\right)}{2(2t - 7\overline{\theta} v_1)} \tag{29}$$

The following two facts have to be verified: $0 < v_2^* < v_1$ and that (25) have a maximum on (29).
To prove the first point, it is important to write (29) as:

$$v_2^* = \left[\frac{\left((t - 11\overline{\theta} v_1) + \sqrt{3\left(t - 3\overline{\theta} v_1\right)\left(11t - \overline{\theta} v_1\right)}\right)}{2(2t - 7\overline{\theta} v_1)}\right] v_1 < v_1 \Leftrightarrow \tag{30}$$

$$\left[\frac{\left((t-11\bar{\theta}v_1)+\sqrt{3\left(t-3\bar{\theta}v_1\right)\left(11t-\bar{\theta}v_1\right)}\right)}{2(2t-7\bar{\theta}v_1)}\right]<1\Leftrightarrow \tag{31}$$

$$\left((t-11\bar{\theta}v_1)+\sqrt{3\left(t-3\bar{\theta}v_1\right)\left(11t-\bar{\theta}v_1\right)}\right)>2(2t-7\bar{\theta}v_1)\Leftrightarrow \tag{32}$$

$$\sqrt{3\left(t-3\bar{\theta}v_1\right)\left(11t-\bar{\theta}v_1\right)}>3(t-\theta v_1) \tag{33}$$

The last inequality is true, since by the hypothesis of the model, $t-\theta v_1<0.$

Similarly can be also proved that $v_2^*>0.$

Now to prove that on (29) π_2 presents a maximum, must be computed the second derivative of (25), and evaluated on (29). So:

$$\frac{\partial^2\pi_2}{\partial(v_2)^2}=-\frac{1}{2}v_1\left(\frac{t-3\bar{\theta}v_1}{2t-7\bar{\theta}v_1}\right)\left((4t+\bar{\theta}v_1)\sqrt{3\left(-11t+\bar{\theta}v_1\right)\left(-t+3\bar{\theta}v_1\right)}-3\theta v_1\left(11t-\bar{\theta}v_1\right)\right) \tag{34}$$

Since $\frac{t_1-3\bar{\theta}v_1}{2t_1-7\bar{\theta}v_1}>0$, (25) have a maximum on (29) if:

$$(4t+\bar{\theta}v_1)\sqrt{3\left(-11t+\bar{\theta}v_1\right)\left(-t+3\bar{\theta}v_1\right)}-3\bar{\theta}v_1\left(11t-\bar{\theta}v_1\right)>0 \tag{35}$$

But this is correct since $\left(11t-\theta v_1\right)<0.$

APPENDIX II

Proof of Proposition 1 c):
Since the optimal choice for the quality level of tourism services that hotel 2 offers is:

$$v_2^* = \frac{v_1\left((t-11\bar{\theta}v_1)+\sqrt{3\left(t-3\bar{\theta}v_1\right)\left(11t-\bar{\theta}v_1\right)}\right)}{2(2t-7\bar{\theta}v_1)} \tag{36}$$

the derivate in respect to $\bar{\theta}$ can be computed as follows

$$\frac{\partial v_2^*}{\partial \bar{\theta}} = -\frac{tv_1^2\left(15\sqrt{\left(11t-\bar{\theta}v_1\right)\left(t-3\bar{\theta}v_1\right)}+113\sqrt{3}\bar{\theta}v_1-43\sqrt{3}t\right)}{2\left(2t-7\bar{\theta}v_1\right)^2\sqrt{\left(t-3\bar{\theta}v_1\right)\left(11t-\bar{\theta}v_1\right)}} \tag{37}$$

Then, in order to prove that $\frac{\partial v_2^*}{\partial \bar{\theta}} < 0$ just observe that:

$$113\sqrt{3}\bar{\theta}v_1 - 43\sqrt{3}t > 0 \Leftrightarrow \sqrt{3}(113\bar{\theta}v_1 - 43t) > 0 \Leftrightarrow t < \frac{113\bar{\theta}v_1}{43} \tag{38}$$

But the last inequality is true since, by hypothesis $t < \frac{\bar{\theta}v_1}{12}$.

Proof of Proposition 2): We must prove that $\frac{\partial v_2^*}{\partial t} > 0$. And again after computing the derivate of the optimal choice of the quality level of tourism services that hotel 2 offers in respect to we obtain that:

$$\frac{\partial v_2^*}{\partial t} = \frac{\bar{\theta}v_1^2\left(15\sqrt{\left(11t-\bar{\theta}v_1\right)\left(t-3\bar{\theta}v_1\right)}-43\sqrt{3}t+113\sqrt{3}\bar{\theta}v_1\right)}{2\left(2t-7\bar{\theta}v_1\right)^2\sqrt{\left(t-3\bar{\theta}v_1\right)\left(11t-\bar{\theta}v_1\right)}} \tag{39}$$

Given the last prove, is appears now clear that $\frac{\partial v_2^*}{\partial t} > 0$. Also note that if (39) is compared with (37) it is easy to verify that:

$$\frac{\partial v_2^*}{\partial \bar{\theta}} = -\frac{t}{\bar{\theta}}\frac{\partial v_2^*}{\partial t} \tag{40}$$

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