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Article

# Tourism development: A capacity dynamic

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**Abstract:** The internationally adopted definition of tourism prompts to develop a systemic dynamic approach of tourism development. The paper proposes to conceptualize tourism development as a system interlinking three agents: transport, domestic tourism activities and the visitor; generating three types of development tourism development dynamics. In a second step, it uses this framework to develop, with a minimalist set of hypotheses, a capacity-based model enabling to consider destination tourism development as a microfounded supply-driven systemic dynamic process. Through the lens of the model, exhaustion or asymmetric distribution of market power may halt destination tourism development. Using the model's framework, the structuring forces of the Tourism Area Life Cycle (TALC) are explained by the dual impact of capacity dynamics: accelerating by increasing arrivals, and at the same time decelerating by declining price elasticities.

**Keywords:** tourism development; systemic dynamic approach; capacity dynamics; microfoundation; TALC

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## 1. Introduction: A systemic dynamic approach of destination tourism development

Visitors, activities, and travel are the three pillars that underpin the definition of tourism adopted internationally in 2010 (United Nations, World Tourism Organization, Organization for Economic Co-operation and Development and Eurostat [1] consider that “Tourism is a social, cultural and economic phenomenon that involves the movement of people). This definition has two consequences or corollaries and allows to conceptualize destination tourism development through a dynamic systemic approach.

### 1.1. Two corollaries of international definition of tourism

The first corollary is related to the notion of tourism development. By installing the visitors at the core of the tourism phenomenon, the international definition of tourism enshrines the time evolution of tourist attendance (The paper uses indifferently tourism flow or tourist flow, arrivals, attendance, or tourist numbers to refer to the number of tourists arriving at a destination) as the primary indicator for measuring the tourism development of a destination. All the other indicators of tourism development (bed nights, receipts, ...) are in fact or can be correlated with tourist numbers. This reading of tourism development through time is rooted in a long-term perspective analysis of the change process of tourism, as comprehensively exposed by Noreen Maree Breakey's thesis [2]. Butler's [3] tourism area life cycle (TALC) remains the most widely used long-term model of tourism development by this field of research. It differs from the structural approach extensively adopted by the economics of tourism, which focuses on identifying the determinants of tourism demand, once

assimilated to the tourism flow, in a perspective where time is not the primary factor. (The structural approach can be found in Lim [4] and Stabler et al. [5] carry out a comprehensive literature review of tourism demand modeling, which distinguishes two fields of modeling. The first focuses on the identification of the factors determining tourism flows, initially based on theoretical models, mainly gravity models inspired by international trade theories, then via empirical approaches presented in Li and al [6], Sinclair and Stabler [7] and Stabler et al. [5]. The second, based on a more grounded theoretical base: Static and temporal microeconomic theory of demand, Almost Ideals Demand System model of Deaton and Muellbauer [8], the characteristics approach of Lancaster [9], the discrete choice models of Anas [10], Morley [11], and Alegre and Pou [12] providing a set of explanatory factors for tourism expenditure. Song et al. [13,14] provide a comprehensive review of the theoretical, empirical and methodological literature on the identification of the determinants of tourism attendance. In the latest Handbook of Tourism Economics, Divisekera [15] presents the most recent theoretical and empirical work resulting from this approach, which also integrates structural changes, seasonality, and exogenous events).

The second consequence of the conceptual definition of tourism is the intrinsic link between tourism and transport; since traveling is a component of the tourism phenomenon. According to the international definition there is no tourism without visitors, but also no tourism without travel and thus without transport. References abound with the interdependence of tourism and transport. Macintosh et al. [16] define tourism (including transport) as a coordinated system. Prideaux [17] and Lumsdon and Page [18] conclude that transport and tourism are structurally linked by an asymmetric relationship: the latter's demand and revenues being set by the former, through the infrastructures and carrier decisions. Leaving aside the search for unidirectional causality, Gay [19] indicates that the links between tourism and transport are "cumulative" and that "we must not fall into the "mediological" trap... that would make tourism and tourists, elements determined by the media: i.e., transport". The concepts of "tourist transport" and "supply chain", Page [20] recognize the intrinsically systemic dimension of the relationship between tourism and transport. For Lohmann and Duval [21], the link between transport and tourism is "symbiotic" and a matter of "co-dependence". Finally, through the concept of connectivity, the World Tourism Organization UNWTO [22] underlines the importance of transport capacity dynamics when referring to the imbalances between transport and tourism suppliers.

The definition itself and its corollaries offer a frame to comprehend tourism development of a destination as a dynamic system.

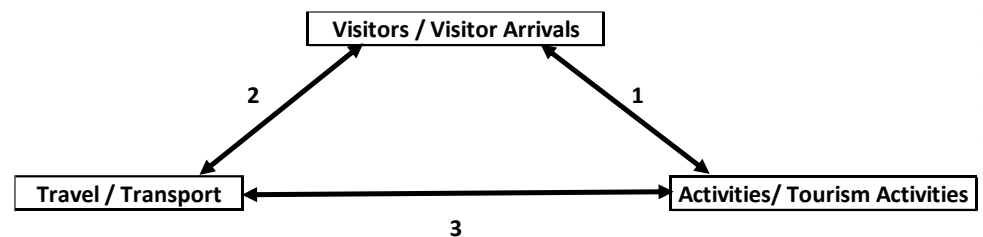
## **1.2. A systemic dynamic approach of destination tourism development**

From the standpoint of a destination, tourism development phenomenon is possible if three components are gathered (the pillars of the international definition of tourism): visitors, tourism activities and transport. These three elements constitute a dynamic system because they are linked and influence each other at one point in time and during the time. Following Durand [23], the systemic approach defines a system as a finite set of elements linked by linear or non-linear interactions, more or less

complex: bidirectional and/or circular, which determine the dynamic evolution of this set described by one or more indicators. The systemic approach considers that the elements of the system are not necessarily aware that they belong to the system, which differentiates it from game theory. As such, the systemic approach facilitates the study of non-cooperative phenomena. The tourism dynamic system can also be read as a dynamic economic system, composed of three elements organized around two poles:

- demand: visitors;
- supply: activities/tourism activities and travel/transport are the supply sides of the system, which produce the goods and services provided to tourists (Activities are not necessarily tourism activities *per se*. They become tourism activities by tourist consumption and World Tourism Organization discriminates “Tourism characteristic products” from “Tourism connected products” for the analysis of economic impact of tourism).

**Figure 1** figure out the destination tourism development system and is a symbolic representation of the systemic dynamic approach of destination tourism development.



**Figure 1.** Systemic dynamic approach of destination tourism development.

To avoid repetition the paper uses indifferently destination tourism development, destination tourism development system or tourism development system. As mentioned earlier, a synthetic indicator or a holistic view of the state of the system at one point in time is visitor attendance (Attendance is preferred to the overall tourism revenue of the two sectors, since the latter is dependent on the former. It was also preferred to capacity since there is no tourism without tourists, even if capacity exists. Sectoral profits and occupation coefficients are also dependent on attendance). Its time evolution indicates tourism development of the destination. The links between the elements of the tourism development system, the bi-directional arrows, express their bi-causal dynamic influences. These links govern the state and motion of the development tourism system, and therefore its holistic indicator: tourism arrivals. They cause and plot the time evolution of tourist attendance. Each bi-causal link expresses a sub-dynamic enacted by the relations between a pair of components and identifies a type of destination tourism development dynamic. As a synthesis, a systemic dynamic approach conceives destination tourism development as a system composed of the three components of international definition of tourism with links between each pair of the components expressing a specific sub-dynamic enabling through their combination the dynamic of the whole system.

Bi-directional arrow n°1 expresses a “by activities/products” tourism development, where qualitative and quantitative demand-supply dynamics link visitors and the destination itself. On the qualitative side the types of tourists (demographics, tastes, preferences and expectations) influence the different activities

produced by the destinations. Inversely, the features of the destination (physical nature (sea, mountains, towns, sceneries ...), culture, local productions (types of restaurants, accommodations, leisure)) select the type of tourists. From the quantitative perspective, this dynamic reflects the demand-supply process that cause tourism development. On the demand side tourist arrivals is the impetus to create tourism products or for the gradual expansion of the consumption basket of tourists during their stay in the destination. On the supply side the innovation process generates new activities for new types of visitors and therefore tourism arrivals. This tourism development dynamic can be related to the works of Candela et al. [24,25] and Andergassen et al. [26].

Arrow  $n^{\circ}2$  is a “transport based” destination tourism development dynamic which is also a crossed causal demand-supply dynamic. It refers to technological effects on destination tourism development due to the increasing capacity of transport and to reduced travel time. These supply side innovations entail new transport means and expand the markets open to destinations. Conversely, those innovations are responses to the will of new territories to develop tourism, as a consequence of the expansion of tourism demand, due to economic growth. This dynamic can be related to a forementioned literature [Macintosh et al. [16], Prideaux [17], Lumsdon and Page [18], Gay [19], Page [20], Lohmann and Duval [21] and with some empirical studies, where the price of transport is an explanatory factor of tourist demand [5].

Unlike arrows  $n^{\circ}1$  and  $n^{\circ}2$ , arrow  $n^{\circ}3$  is a full “supply side sub-dynamic”, for it does not relate directly the demand and the supply sides of the tourism development system. It reflects the way in which the interrelationship between the services providers (the supply pole of the system) conceptually pivotal to tourism definition, is able to generate tourist attendance and thus tourism development. The rationale behind this dynamic can be summarized or comprehend as follows: an insufficient transport supply hinders the development of the number of tourists. Simultaneously, local limited tourism activities discourage the development of transport. According to our best knowledge destination tourism development through the transport-activity dynamic has not yet been examined.

Similarly, we haven't any knowledge of analyses of destination tourism development i.e., the long-term change process of destination tourism, combining the three systemic sub-dynamics, inspired by the previously exposed systemic dynamic approach of destination tourism development.

The paper proposed a formalized model of the systemic dynamic approach of Destination Tourism Development previously exposed, which allows to combine simultaneously its three sub-dynamics. It explores the mechanics of destination tourism development, through a system of dynamic equations. The model enables to better characterize destination tourism development. As such it can provide tourism planners with tools to manage the systemic interactions between the components during the destination tourism development. It is general enough to provide a microfounded understanding of the TALC.

Three sections organize the paper. The first section presents a formalized systemic dynamic model of destination tourism development and the learnings it brings to characterize destination tourism development. In a second section, the model offers a frame to microfound the TALC. Some concluding remarks ends up the paper.

## **2. A systemic dynamic model of destination tourism development**

This section presents a formalized systemic dynamic model of destination tourism development, combining its three sub-dynamics, inspired by the previous approach. A first sub-section exposed the model mechanics based on a minimalist set of hypotheses. A second sub-section outlines the understanding of destination tourism development the model can provide.

### **2.1. A capacity-based destination tourism development model**

This sub-section presents successively: the hypotheses of the model, the agents involved in the destination tourism development system, their behavior, their inter-links and the effects of these on tourism development.

Assumptions: The formalized version of systemic dynamic destination tourism development approach adopts 4 assumptions that bring it closer to tourism reality:

- 1) Destinations are different and cannot be perfect substitutes inducing that transport (giving access to them) and tourism activities (in the destination) considered as economic sectors can be modeled as price makers maximizing revenue monopolist firms (hereafter transport and tourism activities sectors are referred as sector-firm);
- 2) Sector-firms supply capacity units of transport and reception measurable in numbers of persons, combined as complementary goods bought by optimizing visitors;
- 3) Sector-firm production technology depends uniquely on capital (due to the acknowledged complementary between capacity and the labor factor in transport and tourism activities) and their investment function adopts the internal financial theory [27–29]. This is to be coherent with their maximizing revenue behavior [30] and because a perfect financial market does not necessarily exist at the destination level; especially for small of tourism activities.
- 4) A non-cooperative, incomplete and imperfect information frame for the relations between the two sector-firms.

#### **2.1.1. Agents and behaviors**

The supply pole of the tourism development system consists of two production agents: the economic sectors of transport and tourism activities/products. The transport sector aggregates all the firms that serve the destination. It offers a transport service, i.e., the possibility for a visitor to reach the destination. The sector produces units of transport capacity, and its overall production is equal to the overall transport capacity available for the destination in a given period. It is measured by the maximum number of people that can be transported. The tourism activities sector is the aggregation of all firms that offer complementary and substitutable services to tourist visitors (accommodation, catering, and leisure activities). The various tourism services share a common feature: their limited receiving capacity or the maximum number of people that can be received in a given period. Thus, the tourism activities sector offers a reception capacity in the destination. It produces units of reception capacity linked to a given space-time. Its overall production is a receiving capacity during a given time interval; measured by the maximum numbers of persons (This approach to the tourism sector makes it possible to consider all types of visitors: tourists and excursionists).

Thus, the tourism sector reflects a variety of situations, from hotel establishments to the attractions parks, up to the destination itself in its space dimension: spatial, social and environmental (carrying capacity). The model considers the two sectors as monopolistic, henceforth called the sector-firm in the paper. The monopolistic feature of the two sectors expresses the imperfect nature of the tourism market (close to monopolistic competition), where the various destinations (transport and tourism sectors) are not perfectly substitutable, as Bull [31] suggests. As monopolistic firms, transport and tourism activities are “price-makers”. They set the price of their product: the unit of transport and reception capacity, under the sole constraint of their overall capacity and considering the only demand for their own product; without any consideration of possible interactions. Thus, their behavior indicates a limited awareness of system interactions (incomplete information); expressing a specific knowledge or a set of empirical beliefs about the demand for their own product. Therefore, the model reflects the actual non-coordination situation that generally prevails in tourism activities; on the one hand between the two sector-firms and on the other hand between the multitude of branches that tourism activities aggregate. On the supply side, the tourism development system models a “non-cooperative, incomplete and imperfect information” situation.

Tourist visitors are the consumers of transport and reception capacity units. To be in a touring situation, visitors necessarily buy the two services, hence their complementarity. Therefore, the number of tourism activities-transport bundles/packages equals the number of tourists i.e., the number of visitors transported and received. This equivalence results from the strict correspondence between a bundle of transport-tourism goods and a visitor. Thus, the number of bundles of the two complementary goods is similar to the tourist flow, since their combination corresponds to a transported and a received visitor number. The complementarity of the transport and tourism units ensures a strict equivalence of their respective demand to the tourist flow. As “price takers”, under the constraint of their travel budget (tourism + transport), tourists maximize a utility function, which integrates transport and tourism goods as defined above (capacity of transport and reception unit). Visitor’s optimization behavior determines the number of tourists visiting the destination.

The previous presentation of the different agents allows to formalize their behavior as follows. Index “tr” is for transport and “to” for tourism;  $i$  indicates indifferently the sector-firms:

The behaviors of sector-firms: The decision variable of the two monopolist sector-firms is the price of their product: the unit of reception or transport capacity. They maximize their revenue: the product of price ( $p_i$ ) by their perception or knowledge of the demand for their service  $[Q_i(p_i)$  with  $\frac{\delta Q_i}{\delta p_i} < 0]$ , under the constraint of a fixed overall capacity = sum of the capacity units produced and available in a given period ( $T_i$ ). The sector-firms optimization program is as follows:  $\text{Max} p_i Q_i(p_i)$  under constraint,  $T_i \geq Q_i(p_i)$ . The solution of the program (see Appendix A) gives the price function of the sector-firms:

$$p_i^* = Q_i^{-1}(T_i) \quad (1)$$

where  $Q_i^{-1}$  is the inverse function of  $Q_i$ . Prices are inversely related to capacities;

increase (decrease) in supply entails decrease (increase) in price.  $p_i^*$  are short term prices, with their time motion in the long run set by capacities time motion.

According to the 4th assumption sector-firms' outputs are  $T_i = G_i(K_i)$  with  $K_i$  the sector-firm capital, it comes  $K = G_i^{-1}(T_i)$ , with  $G_i' > 0$  and  $G_i(0) = 0$  and  $\dot{K}_i$  their investment function depends on profit and/or capacity utilization (or occupancy) rates. Defining  $F$  as tourist arrivals and:

- Sector-firm profits as:  $\pi_i = Q_i^{-1}(T_i)F - d_i[G_i^{-1}(T_i)]$ ; with  $d_i[K = G_i^{-1}(T_i)]$ , a cost function describing expenses linked to the use of capital  $K_i$ (maintenance, rents, various costs related to sustainability, Interest rate in case of debt financing);
- Capacity occupancy rates as:  $\psi_i = \frac{F}{T_i}$ .

it comes  $\dot{K}_i = h_i(\pi_i, \psi_i) = h_i(F, T_i)$  (with  $h_i' > 0$  and  $h_i(0) = 0$ , and  $\dot{K}_i$  can be  $< 0$ ) and  $\dot{T}_i = \left(\frac{\delta G_i^{-1}}{\delta T_i}\right)^{-1} h_i(F, T_i)$  as  $\frac{\delta G_i^{-1}}{\delta T_i} \dot{T}_i = \dot{K}_i \cdot h_i$  (with both or one of the arguments:  $\pi$  and/or  $\psi$ ) can be thought as a financing function or alternatively as performance function: a combination of internal performance indicators that triggers investment. Each equation of system Equation (2) below, relates capacity dynamic of each sector-firms to tourism attendance and the level of its own capacity.

$$\dot{T}_i = \left(\frac{\delta G_i^{-1}}{\delta T_i}\right)^{-1} h_i(F, T_i) \quad (2)$$

At this stage, the system  $\dot{T}_i$  is not a reaction functions system because each equation does not integrate the capacities or conjectured actions, of the other sector-firm.

The behavior of tourist visitors: Under the constraint of their expenditure whose prices come from the behavior of the sector-firms:  $R = p_{tr}^* Q_{tr} + p_{to}^* Q_{to}$ , ( $Q_i$  is the quantity consumed of transport and tourism goods defined as units of transport and reception capacity for a given period), tourist visitors maximize a utility function with strictly complementary goods. The two most used forms of preference are:

- $U = \min(Q_{tr}, Q_{to})$ , for a strict complementarity of the two goods,
- $U = U(Q_{tr}, Q_{to}) - (p_{tr}^* Q_{tr} + p_{to}^* Q_{to})$ , the quasi-linear and quadratic form (Cf. Singh et Vivies [32] and Amir and al. ii [33]), for modular complementarities.  $U(Q_{tr}, Q_{to}) = \theta_{tr} Q_{tr} + \theta_{to} Q_{to} - (\mu_{tr} Q_{tr}^2 + 2\gamma Q_{tr} Q_{to} + \mu_{to} Q_{to}^2)/2$ , with  $\gamma < 0$  measuring the intensity of the goods complementarity.

Formally, the parameters of the utility function are adjusted such that  $Q_{tr} = Q_{to}$  in order to secure the equality of flows transported and received. This adjustment indicates the type of visitors likely to be interested in the destination and the transport to access it, and expresses the destination-transport-visitor strong relation. It confirms the imperfect nature of the tourism market, where every destination is not infinitely substitutable: each one corresponding to a type of customer. Two possible forms of tourist flow ( $F$ ) come out of the a forementioned utility functions and the tourist visitor' optimizing program:

- $F = R/(p_{tr}^* + p_{to}^*)^{-1}$ , with the strict complementary good function:  $\min(Q_{tr}, Q_{to})$ . Then  $R$  is the nominal tourist's budget for the two sector-firms.  $F$  tends to infinity when prices tend towards zero (and inversely);



- $F = \alpha - \beta(p_{tr}^* + p_{to}^*)$  is a linear tourism flow function once the parameters of the quasi linear, quadratic utility function are adjusted such that  $Q_{tr} = Q_{to}$ . Singh and Vives [32] provide the analytical form of the demand functions of each good, from which it is easy to adjust the parameters to secure the equality  $Q_{tr} = Q_{to}$ .  $\alpha$  and  $\beta$  are combinations of the utility function parameters ( $\mu, \theta, \gamma, \gamma$ ).  $\beta$  is necessarily positive [ $\beta > 0$ , because  $p_i^*$  are negatively related to capacities ( $T_i$ )] and  $\alpha$  is the maximum attendance (or potential market expressed in number of visitors) when prices tend towards zero.

Considering the two possible flow functions, attendance is a function of the unit price of the transport-tourism activities bundle:  $P = p_{tr}^* + p_{to}^*$  i.e., the amounts spent by visitors on transportation and tourism; hence  $F = F(p_{tr}^* + p_{to}^*)$ . Combined with Equation (1), the general form of the tourist flow is:

$$F = F[P] = F[Q_{tr}^{-1}(T_{tr}) + Q_{to}^{-1}(T_{to})] \quad (3)$$

The increase in capacity implies an increase in tourist flow (under the constraint  $F \leq \min(T_{tr}, T_{to}) \Rightarrow F \leq \frac{T_{to} + T_{tr} - |T_{to} - T_{tr}|}{2}$ ):  $\frac{\partial F}{\partial T_i} = \frac{\partial F}{\partial P} \frac{\partial Q_i^{-1}}{\partial T_i} > 0$  as  $\frac{\partial F}{\partial P} < 0$  and  $\frac{\partial Q_i^{-1}}{\partial T_i} < 0$ . From Equation (3) the tourist flow dynamic equations is:

$$\frac{dF}{dt} = \dot{F} = \frac{\partial F}{\partial P} \left[ \frac{\partial Q_{tr}^{-1}}{\partial T_{tr}} \dot{T}_{tr} + \frac{\partial Q_{to}^{-1}}{\partial T_{to}} \dot{T}_{to} \right] \quad (4)$$

Equations (3) and (4) express the sub-dynamic 1 and 2 of the systemic dynamic approach of destination tourism development as depicted by **Figure 1**. They provide an equation form for tourism development resulting from “by transport” and “by activities/product” dynamics. Equation (3) is static instantaneous, short term flow of tourists and Equation (4) its law of motion for the long run.

Replacing Equation (3) into the sector-firms profit functions and occupancy rate, gives  $\dot{K}_i = h_i(\pi_i, \psi_i) = h_i(T_{tr}, T_{to})$ , hence the final version of Equation system (2):

$$\dot{T}_i = \left( \frac{\delta G_i^{-1}}{\delta T_i} \right)^{-1} h_i(T_{tr}, T_{to}) \quad (5)$$

This dynamic equation system formalizes sub-dynamic n°3, the supply dynamic of the systemic dynamic approach of tourism development. It links the time evolution one sector-firm’s capacity to the one of the other. Although each equation includes the other sector-firm capacity, the system cannot be considered as a reaction functions system. Firstly, because the equations are not the result of an optimization process, providing best answers according to other agents’ conjectured behavior. Secondly because, from the standpoint of sector-firms, the integration of the other’ capacity is involuntary, induced by the presence of the “involuntary” coordinator visitor. The system does not depict strategic relations of the sector-firms, but systemic relations between the three agents, created by tourism.

### 2.1.2. Interactions

The respective behavior of the three agents leads to interactions in the form of information exchanges, that generate a long-term dynamic. Prices ( $p_i$ ) and capacities ( $T_i$ ) are the basis of interactions. The mechanics of agents’ interactions can be read as follows.

In the short run, during the reference period,

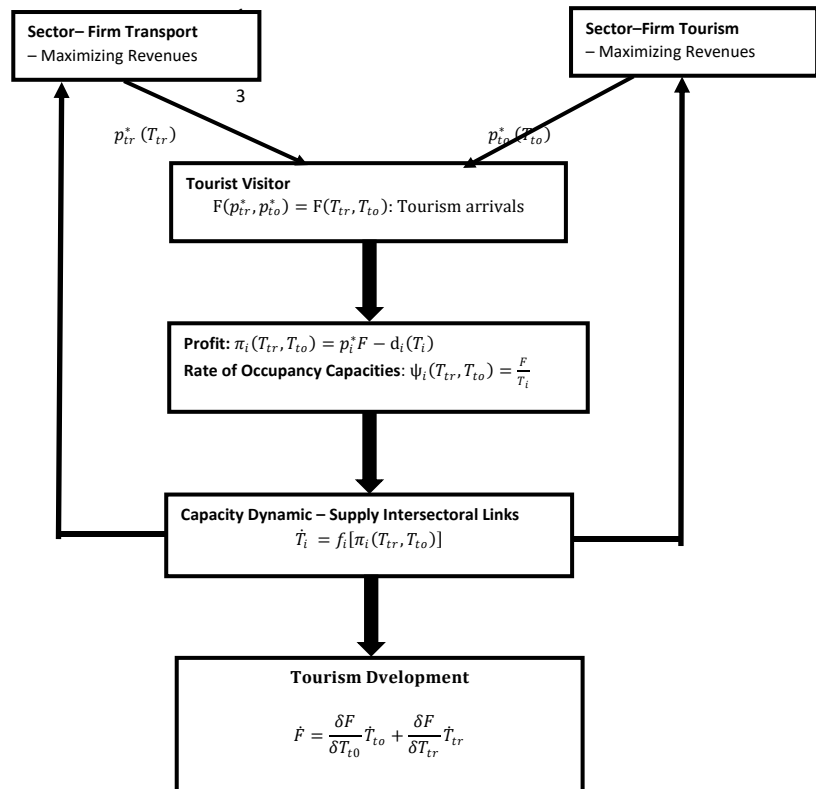
- 1) each sector-firm sets its price ( $p_i^*$ ) to maximize its revenue, inducing prices dependent on sectoral capacities ( $p_i^*(T_i)$ ; Equation (1))
- 2) Producer prices ( $p_i^*$ ) establish the price of the transport-tourism bundle ( $P = p_{tr}^* + p_{to}^*$ ) and consequently tourism flow ( $F$ ), according to Equation (3) [ $F = F(p_i^*) = F[p_i^*(T_i)] = F(T_{tr}, T_{to})$ ]. Sectors' capacities are not necessarily entirely used, and the tourist visitors appear as the period coordinating agent of the two sector-firms [this coordinating role is facilitated by information technology (via platforms or directly with each sector), which allows tourist visitors to bundle themselves the Transport-Tourism products. It reduces the influence of intermediaries (TO, agencies...)].

In the reference period, all the descriptive variables of destination tourism development depend on capacities ( $T_i$ ).

The law of motion of capacities, the capacity dynamic, triggers tourism development:

- 3) According to Equation (4):  $\dot{F} = \frac{\partial F}{\partial P} \left[ \frac{\partial Q_{tr}^{-1}}{\partial T_{tr}} \dot{T}_{tr} + \frac{\partial Q_{to}^{-1}}{\partial T_{to}} \dot{T}_{to} \right]$
- 4) Under the control of the model's inter-sector interactions, according to Equations (7) and (8).

**Figure 2** depicts the interactions of the model.



**Figure 2.** Systemic dynamic capacity-based model of destination tourism development.

Based upon 4 behavioral assumptions of tourism visitors and of supply sector-firms, a systemic dynamic approach of destination tourism development can be

formalized by the following three dynamic equations system:

$$\dot{F} = \frac{\partial F}{\partial P} \left[ \frac{\partial Q_{tr}^{-1}}{\partial T_{tr}} \dot{T}_{tr} + \frac{\partial Q_{to}^{-1}}{\partial T_{to}} \dot{T}_{to} \right] \quad (6)$$

$$\dot{T}_{tr} = \left( \frac{\delta G_{tr}^{-1}}{\delta T_{tr}} \right)^{-1} h_{tr}(T_{tr}, T_{to}) \quad (7)$$

$$\dot{T}_{to} = \left( \frac{\delta G_{to}^{-1}}{\delta T_{to}} \right)^{-1} h_{to}(T_{tr}, T_{to}) \quad (8)$$

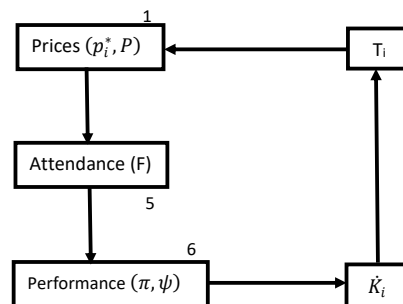
The equations system can also be expressed in a recursive form.

## 2.2. A few learnings from the model

The model provides a general understanding of destination tourism development. It enables to identify structural variables of its mechanic. It also helps to diagnose situations that may halt destination tourism development.

By modelling destination tourism development through a dynamic equations system, the capacity-based model allows to conceptualize destination tourism development as a microfounded supply-driven systemic dynamic process. Microfounded because, destination tourism development is the result of agents' behavior, involved in the process. Visitors are considered rational and optimizing. Similarly, sector firms are regarded as rational and optimizing for setting their prices, and as adopting conventional investment behavior. Destination tourism development is also supply-driven because the main impetus of tourism attendance comes out sector-firms production capacity ( $T_i$ ) and their time law of motions ( $\dot{T}_{tr}, \dot{T}_{to}$ ), as outlined by Equation (4). It is also dynamic for it is formalized as a dynamic equations system, able to generate a wide spectrum of tourism attendance time path. Finally, it is systemic because interlinked capacities, its main driving force, generates consequences (tourism time attendance) that do not necessarily spring up out of perfectly informed or projected agents' decisions. In summary, the short term micro or meso level (transport and tourism activities being considered as sectors) generates a macrodynamic providing the time evolution of the all the variables featuring the tourism system: prices of capacity units [ $p_i^*(T_i)$ ], sectoral capacities ( $T_i$ ), occupation coefficients [ $\psi_i = \frac{F}{T_i}$ ], sectoral profits ( $\pi_i$ ), and global receipts at destination level.

Through the prism of the model, destination tourism development can be structurally conceptualized as a system relating 4 variables or indicators: price, capacities, tourism attendance, and performance, as depicted by **Figure 3**:



**Figure 3.** Tourism dynamic system variables.

Visitors' sensibility to price and sector-firms' pricing behavior to capacity changes  $[\frac{\partial Q_i^{-1}}{\partial T_i}, \frac{\partial F}{\partial P}]$ , as well as capacity production technologies  $[\frac{\delta G_i^{-1}}{\delta T_i}]$  are structuring parameters of destination tourism development. Together with the performance functional forms, they decide the speed, modulate or shape destination tourism development trajectory; as they are multiplicative factors of the equations system. In a technological stable situation, the model identifies pricing reaction to capacity changes, by sector-firms, as the primary tools for monitoring destination tourism development.

The model offers a large spectrum of possible destination tourism development paths: linear, non-linear, logistic, stable or not, converging or chaotic, according to the structuring parameters and functional forms of performance. Thus, it could be used for simulation, forecasts, and to understand agents' behavior through estimating structuring parameters. The capacity-based model allows to identify two situations that can stop destination tourism development:

- When changes in the optimal prices of sector-firms offset each other: each change in optimal price of a sector-firm is the exact opposite of the change of the optimal price of the other  $\frac{dp_{tr}^*}{dp_{to}^*} = -1$  [From the bundle transport-tourism activities price,  $P = p_{tr}^*(T_{tr}) + p_{to}^*(T_{to})$ , it comes  $\dot{P} = \frac{dp_{tr}^*}{dT_{tr}} \dot{T}_{tr} + \frac{dp_{to}^*}{dT_{to}} \dot{T}_{to}$ , with:  $\dot{P} = 0 \Rightarrow \frac{dp_{tr}^*}{dp_{to}^*} = -\frac{dT_{tr}/dt \dot{T}_{to}}{dT_{to}/dt \dot{T}_{tr}} \Leftrightarrow \frac{dp_{tr}^*}{dp_{to}^*} = -1 \Leftrightarrow p_{tr}^* = p_{to}^*$ . A constant P means a constant F, and  $\dot{F} = 0$  and  $\frac{\partial F}{\partial P}[0] = 0$ , according to Equation (4)]. Dynamic stability aside, a constant bundle transport-tourism activities' price describes an asymmetric situation where one sector exhaust all the destination market power of the destination by increasing its price leaving the other sector to decrease its to maintain the tourist attendance. This situation also means an opposite time variation of capacities: one sector-firm reduces its capacity while the other increases its  $[\frac{dp_{tr}^*}{dT_{tr}} = -\frac{dp_{to}^*}{dT_{to}} \frac{dT_{to}}{dT_{tr}} \Rightarrow \frac{dT_{to}}{dT_{tr}} < 0]$ ;
- Destination tourism development also turn off, when sector-firms' capacities dynamic simultaneously ceases (Equations 6 and 7,  $\dot{T}_{tr} = \dot{T}_{to} = 0$ ) which imply constant capacities ( $T_i$ ) and consequently constant attendance and prices ( $F$ ,  $p_{to}^*$ ,  $p_{tr}^*$  and  $P$ ). It implies a specific relation (or a given capacities ratio) between sector-firms capacities (from  $(\frac{\delta G_{tr}^{-1}}{\delta T_{tr}})^{-1} h_{tr}(T_{tr}, T_{to}) = 0$ , and  $(\frac{\delta G_{to}^{-1}}{\delta T_{to}})^{-1} h_{to}(T_{tr}, T_{to}) = 0$ . The simultaneous nullity of capacity dynamics ( $T_i = 0$ ) implies the nullity of the performance function  $[h_i(\pi_i, \psi_i) = 0$  with  $h_i(0) = 0]$ . This can be the result of 0 profit in each sector-firm: a situation revealing the exhaustion of profit, that disappears with the continuous increase in capacity ( $T_i$ ), as signaled by monopolistic competition theory.

The common feature of those situations of tourism non-development is linked to the market power created by imperfection competition on the tourism market: its exhaustion or its asymmetric distribution may end destination tourism development.

The following section expose the ability of the capacity-based model to generate

a TALC-compliant logistics destination tourism development path and helps to better understand it from a microfoundation perspective.

### 3. The talc as a capacity-based model of destination tourism development

There are some rationales to model the TALC with the capacity-based dynamic systemic model previously presented. Firstly, modeling the TALC through a unique logistic differential equation makes it a black box type macro model. The capacity-based model allows TALC to be viewed as a supply-side process, rather than a macro-demand process as is thought by tourism planners and some academic work. Moreover, it proposes a supply side microfounded understanding. Secondly, the deceleration and acceleration forces listed by Butler [34] have rarely been modeled. Very few attempts to model the determinants of the TALC, using dynamic systems had been tried [35–40]. Thirdly, despite the results of Kato [41] (Which point out the importance of technical progress in the transport sector for logistical TALC profile of tourist flows in the case of Hawaii) and to our best knowledge, no paper has specifically modeled the influence of transport in the TALC framework.

The logistic path is a possible trajectory of the capacity-based tourism development model. By specifying tourists and sector-firms' behaviors, and technology, the model allows replication of TALC's logistical trajectory for tourist attendance. As such, the model enables to microfound the TALC: it provides a theoretical framework for understanding the TALC from microeconomic behaviors.

According to the capacity-based model, tourism attendance follows a logistic curve, if Equation (4)  $\dot{F}$  is:

- A degree 2 quadratic function with two variables (polynomial equation of degree 2, which generic writing is:  $AT_{to}^2 + BT_{tr}^2 + CT_{to} + DT_{tr} + ET_{to}T_{tr} + C$ ;
- Conform to an elliptical parabola (inverted U-shaped with a single inflection point) ideally with an initial point equal to the nullity (at time  $t_0$ ,  $T_{tr}=T_{to}=0$  since without capacity there can be no tourist flow), requiring:
  - $4AB - E^2 > 0$ , with  $A$  and  $B < 0$  (or in the case where  $4AB = E^2$ , if  $DE - 2CB = 2AD - CE = 0$ ).

These conditions are met when technology and agents' behaviors are linear. The combination of:

- 1) A constant return to scale linear production technology, under assumption 3, implying  $K_i = v_i T_i$  with a constant  $\left(\frac{\delta G_{tr}^{-1}}{\delta T_{tr}}\right)^{-1}$  inducing a linear total cost function (for example, an AK-type technology [Romer (1987), Rebelo (1991)] gives  $T_i = A_i K_i$  and induces  $\left(\frac{\delta G_{tr}^{-1}}{\delta T_{tr}}\right)^{-1} = A$ , with a Total Cost Function:  $CT = d_i K_i = d_i \frac{T_i}{A_i}$ ;
- 2) With a linear sector-firms' pricing behavior:  $Q_i^{-1}(T_i) = p_i^* = a_i - b_i T_i$ , generating a constant  $\frac{\partial p_i^*}{\partial T_i}$ ;
- 3) With tourist linear demands functions entailing a linear tourist flow function:  $F =$

$\alpha - \beta(p_{tr}^* + p_{to}^*)$  producing a stable  $\frac{\partial F}{\partial T_i} = \beta$ ;

4) With a linear investment behavior linearly relating  $\dot{K}$  with performance indicators ( $\pi$  and/or  $\psi$ ) and more generally with sector-firms revenues:

Necessarily formalize  $\dot{F}$  as quadratic function. Conditions 1, 2 and 3 produce quadratic revenue and profit functions for the sector-firms, as exposed below, with  $F = \beta(b_{to}T_{to} + b_{tr}T_{tr})$ , the meaning and consequences of which is explained in Appendix B:

$$\begin{aligned} \pi_{to} &= \frac{(a_{to} - b_{to}T_{to})[\beta(b_{to}T_{to} + b_{tr}T_{tr})]}{\text{Revenue}} - \frac{T_{to}/v_{to}}{\text{Cost}} \\ &= \frac{a_{to}\beta b_{to}T_{to} + a_{to}\beta b_{tr}T_{tr} - \beta b_{to}^2 T_{to}^2 - \beta b_{to}b_{tr}T_{to}T_{tr}}{\text{Revenue}} - \frac{T_{to}/v_{to}}{\text{Cost}} \\ \pi_{tr} &= \frac{(a_{tr} - b_{tr}T_{tr})[\beta(b_{to}T_{to} + b_{tr}T_{tr})]}{\text{Revenue}} - \frac{T_{tr}/v_{tr}}{\text{Cost}} \\ &= \frac{a_{tr}\beta b_{to}T_{to} + a_{tr}\beta b_{tr}T_{tr} - \beta b_{tr}^2 T_{tr}^2 - \beta b_{to}b_{tr}T_{to}T_{tr}}{\text{Revenue}} - \frac{T_{tr}/v_{tr}}{\text{Cost}} \end{aligned}$$

Condition 4 expresses the linear link between investment and profit or revenue:  $\dot{K}_i = h_i(\pi_i, \psi_i) = m_i \times \pi_i$  or  $m_i \times \text{Revenue}_i$  [Revenue= Potential Revenue  $p_i^*(T_i) \times T_i \times \psi$  ( $= \frac{F}{T_i}$ )], with  $m$  measuring the sensibility of investment to profit (or revenue) or the percentage of profit (or revenue) dedicated to fund investment.

Considering the linearity conditions, attendance time motion becomes a quadratic function like the one below (with revenue only for simplicity):

$$\dot{F} = \beta[a_{to}(v_{to})^{-1}m_{to}(a_{to}\beta b_{to}T_{to} + a_{to}\beta b_{tr}T_{tr} - \beta b_{to}^2 T_{to}^2 - \beta b_{to}b_{tr}T_{to}T_{tr}) + a_{tr}(v_{tr})^{-1}m_{tr}(a_{tr}\beta b_{to}T_{to} + a_{tr}\beta b_{tr}T_{tr} - \beta b_{tr}^2 T_{tr}^2 - \beta b_{to}b_{tr}T_{to}T_{tr})].$$

$\dot{F}$  is quadratic because  $[a_{tr}(v_{to})^{-1}m_{tr}a_{tr}(v_{tr})^{-1}m_{tr}]^2[4\beta^2 b_{tr}^2 b_{to}^2 - \beta^2 b_{tr}^2 b_{to}^2] > 0$ .

The capacity dynamic model of TALC implies a continuous increase in aggregate capacity of transport and tourism activities and induces a steady decline in their individual prices; and consequently, in the bundle price. This regular decline in price, driven by the increase in capacity, is the impetus for the growth in tourist numbers, until the stagnation period, with the equilibrium prices and capacities. All things being equal, the model allows to identify linear behaviors of sector-firms and tourist necessary to generate a TALC tourism development process. Linear behaviors entail changing elasticities over time. Thus, attendance is more elastic to bundle price early in the development process (before half the potential market). Similarly, sector-firms prices are inelastic to new capacities ( $|ep_{i,T_i}| < 1$ ) and capacity-elasticity of price decreases over the course of tourism development, making “rejuvenation” a possible issue for competition regulation. In summary, the model highlights evolution of capacities as the accelerating force in TALC (increasing arrivals), itself generating its own decelerating force: a decreasing price elasticities (a declining flow due a lesser of impact of capacities on prices).

#### 4. Concluding remarks

The international definition of tourism prompts to develop a dynamic systemic approach of tourism development underpinned by three dynamic: a transport-demand

dynamic, a product/activities-demand process and a supply side transport-activities dynamic. Inspired by the dynamic systemic approach and with a minimalist set of hypotheses, it is possible to derive a capacity-based model enabling to consider destination tourism development as a microfounded supply sided systemic dynamic process. Destination tourism development can be structurally conceptualized as a system relating four variables: price, attendance, performance, all dependent on the fourth: sector-firms capacity of transport and tourism activities. The dynamic of the system, and consequently of destination attendance in time, is monitored by parameters expressing visitors' sensibility to bundle-price, sector-firms pricing behavior to capacity changes and production technology of capacities. The model offers a large spectrum of possible destination tourism development paths. A such, it can be used for simulation, forecasts, understanding agents' behavior and to provide tools for tourism planners. Also, it highlights exhaustion or asymmetric distribution of market power as two situations able to halt destination tourism development. The capacity-based model of destination tourism development identifies the double impact of capacity dynamic on TALC forces: accelerating by increasing arrivals, and at the same decelerating by declining price elasticities.

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## Appendix A

Sector-firms' pricing behavior:

From the sector-firms optimization program  $\text{Max}_{p_i} Q_i(p_i)$  Under constraint,  $T_i \geq Q_i(p_i)$  follows the optimality conditions:

- $Q_i(p_i) - p_i \left| \frac{\delta Q_i}{\delta p_i} \right| + \lambda \left| \frac{\delta Q_i}{\delta p_i} \right| = 0,$
- $T_i \geq Q_i(p_i),$
- $\lambda \geq 0, \lambda [T_i - Q_i(p_i)] = 0.$

This leads to retaining the constraint saturation  $[T_i = Q_i(p_i)]$ , since a Lagrangian equal to nullity imposes a relative inelasticity of demand that undermines the generality of the model.  $\lambda = 0$  satisfies the second condition and  $\Rightarrow Q_i(p_i) = p_i \left| \frac{\delta Q_i}{\delta p_i} \right| = 0$ , hence  $T_i \geq p_i \left| \frac{\delta Q_i}{\delta p_i} \right| \Rightarrow \frac{T_i}{Q_i(p_i)} \geq \frac{p_i}{Q_i(p_i)} \left| \frac{\delta Q_i}{\delta p_i} \right| = e_i \Leftrightarrow e_i \leq 1$ . Therefore  $\lambda \geq 0$ , the optimizing behavior of producers sets out pricing as follows:

$$p_i^* = Q_i^{-1}(T_i) \tag{1}$$

where  $Q_i^{-1}$  is the inverse function of  $Q_i$ , with  $\frac{\delta Q_i^{-1}}{\delta T_i} < 0$ ; derivatives of inverse functions having the same slope as their initial functions.

## Appendix B

Attendance function without intercept and elasticities:

For  $F$  be written without intercept and starts from 0, it is necessary that:  $\alpha - \beta(a_{to} - b_{to}T_{to} + a_{tr} - b_{tr}T_{tr}) = \beta(b_{to}T_{to} + b_{tr}T_{tr})$  and thus that  $\alpha = \beta(a_{to} + a_{tr})$ . This condition implicitly expresses that the potential market of the tourist destination ( $\alpha$ ) is not only dependent on demand characteristics but also on maximum capacities. Indeed, as  $p_i > 0$ , the maximum capacity is reached when  $p_i = 0$ , i.e.,  $T_i \text{ Maximum} = a_i/b_i \Leftrightarrow a_i = b_i \times \max T_i$ , hence  $\alpha = \beta(b_{to}\max T_{to} + b_{tr}\max T_{tr})$ . Thus, the potential market of the destination ( $\alpha$ ) depends partly on the characteristics of the demand ( $\beta$ ) and the maximum capacities ( $\max T_{to}$ ;  $\max T_{tr}$ ).

$F = \beta(b_{to}T_{to} + b_{tr}T_{tr})$  says that tourist flow is 0 when simultaneously there are no transport and tourism capacities; the occurrence of a single capacity,  $T_{tr} \neq 0$  or  $T_{to} \neq 0$ , makes it possible to initiate the capacity dynamics.

Considering the flow function  $[\beta(b_{to}T_{to} + b_{tr}T_{tr})]$  the inferiority constraint of attendance relative to the capacities ( $\psi_i < 1$ ) is satisfied if  $\beta b_{to} \leq 1$  and  $\beta b_{tr} \leq 1$ , as exposed below:

$$F \leq \min(T_{tr}, T_{to}) \Rightarrow \beta(b_{to}T_{to} + b_{tr}T_{tr}) \leq T_{tr} \text{ or } \beta(b_{to}T_{to} + b_{tr}T_{tr}) \leq T_{to} \Rightarrow (\beta b_{to} - 1)T_{to} \leq -\beta b_{tr}T_{tr} \text{ or } (\beta b_{tr} - 1)T_{tr} \leq -\beta b_{to}T_{to}.$$

Hence, whenever  $T_{to} \leq T_{tr}$ , the inferiority constraint of attendance condition is satisfied if  $\beta b_{to} \leq 1$  and  $\beta b_{tr} \leq 1$ . These are necessary and sufficient conditions if the initial zero capacities ( $T_{tr} = T_{to} = 0$ ) converge to positive maximum equilibrium capacities ( $T_{tr}^*$ ;  $T_{to}^*$ ).

Then, if the constraint  $F < \min(T_{tr}, T_{to})$  holds at each instant of time, it comes  $\dot{F} \leq \dot{T}_i$  and consequently elasticity-capacity of prices and flows are necessarily lower than unity since:

- $ep_{iT_i} = \frac{\delta p_i T_i}{\delta T_i p_i} = -b_i \frac{T_i}{p_i} = \frac{-b_i T_i}{a_i - b_i T_i} \Leftrightarrow |ep_{iT_i}| < 1$ ;
- $eF_P = \frac{\delta F}{\delta P} \frac{P}{F} = \beta \frac{a_{to} + a_{tr} - (b_{to}T_{to} - b_{tr}T_{tr})}{\beta(b_{to}T_{to} + b_{tr}T_{tr})} \Rightarrow eF_P > 1 \Rightarrow \frac{\alpha}{2} > F$ , as  $F$  is supposed to start from 0. This means that the capacity elasticity of attendance is greater than unity up to half the potential market.