Modeling Sustainability of Mass Tourism in Lisbon

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INTRODUCTION

Tourism is one of the largest industries in the world and with a growth rate of approximately 7% annually (WTO, 2010), it represents very important source of jobs across the globe, especially in the developing countries, and developed countries hit by a recession. Assessing the environmental, economic, social and cultural impacts of tourism development has become one of the major activities within sustainable development communities.

Tourism brings economic benefits by increasing employment, income, revenues for Lisbon. However, it could lead to cultural and environmental degradation if not managed properly. Our research will focus on the impact of mass tourism on culture and cultural identity of the Lisbon region. The System Dynamics methodology is proposed as a very useful tool for policy analysis and to raise awareness about the potential negative impacts of mass tourism. Successful tourism policies can deliver not only economic benefits for Lisbon, as well as country as a whole, but can also facilitate sustainable economic, environmental and cultural development. Within this context, it is important for Lisbon's municipality to incorporate sustainable initiatives on a city level, for example related to tourism development. The question of how policy makers can initiate and develop sustainable policies has been of great importance in many developing tourist destinations, and until now there is no protocol and standard framework for establishing such policies.

In order to enhance decision-making process, System Dynamics modeling can be used as tool to portray the interplay of environmental, social, economic and cultural sectors. By focusing only on cultural identity and its main drivers and trends, we exclude other sectors from the system, as the ones that do not play an important role in cultural identity of Lisbon. The outcome of our research is a generic cultural model constructed from different sectors, such as real estate, generation of tourists and destination attractiveness.

The purpose of the research is to demonstrate the contribution that System Dynamics modeling can make in explaining the possibility of boom and bust in Lisbon's tourism sector, as well as for analyzing policies, which could provide the ground for sustainable tourism. This will add to a wider discussion about the definition of sustainability in tourism and specifically the role of systems thinking (Peeters, 2012; Weaver, 2012)

THEORETICAL BACKGROUND

Definitions of what composes "sustainable" tourism are manifold. We find a gradual progression of the concept. First, sustainable tourism was mainly focused around so called eco-tours and eco-resorts, activities and accommodation that could be branded as friendly for the environment. In a second stage, a wider definition of sustainability was proposed including things like resource recycling, green energy and transportation, organic and material food production (Miller, Merrilees, & Coghlan, 2015). A third phase, not yet crystallized to its full extent, aims to include socio-economic sustainability within the definition. This "triple bottom line" approach has not yet fully taken hold of key industry stakeholders (Timur & Getz, 2009).

The socio-economic sustainable sustainability of urban destinations depends on the fine balance between positive and negative outcomes. Positively, tourism developments leads to physical regeneration of urban areas, and particular of historical centers (Law, 1992). However, the growing volume of visitors might at some point lead to a city reaching its socio-economic carrying capacity (Shoval, 2018). There seems to be positive feedback in the sense that popular destinations become even more popular and attract more visitors than they are able to handle (Popp, 2012). The development of the Airbnb platform has worsened this problem, particularly in residential areas in the urban cores (Gutiérrez, García-Palomares, Romanillos, & Salas-Olmedo, 2017). In Barcelona, this has led to widespread anti-tourism industry protests (Hughes, 2018). More cities are now also implementing or considering to implement policies to reduce tourism visitations, such as tourist levies in Macao (McCartney, 2019).

There is a gap in literature of studies focusing on this socio-economic side of sustainable tourism, and in particular approach that are more holistic and quantitative.

METHODOLOGY

In the tourism sector, a wide variety of actors and audiences interact and make individual decisions following their own vision, which creates individual dynamics that merge in a larger and highly linked system. Namely, interaction and linked consequences of decision-making processes bring complexity to the system. Complexity can induce uncertainty in the systems. The tourism sector is susceptible to economic changes, natural hazards and socio-political changes that disturb the natural or expected behavior in ways that are very difficult to predict and often even more difficult to understand.

Systems thinking aims for an integrated study of human behavior, as well as the natural, economic and social elements involved. As discussed by Farrell & Twining-Ward (2004), the complexity, connectivity and dynamism that characterizes systems, makes it inconsistent to address tourism-related problems with linear approaches. In this context, System Dynamics results to be a good modeling approach to test the tourism system behavior proposed by Complex Adaptive Tourism Systems theory. By building a mathematical model that replicates system's real behavior, SD builds a bridge to take CATS from theory to experimentation as to explore probable futures and improve systems' understanding.

We propose to use System Dynamics Modeling approach among other methodologies available because it is a better fit to develop understanding in the way that systems react to changes (Kelly et al., 2013). Such feature is coherent with tourism systems' cyclical change property explained by CATS. Time delays, nonlinear interactions and feedbacks give rise to cyclical behavior and are extensively explained by SD theory. Taking into account time delays allows for long-term planning. Failing to understand or misperceive delays, leads to focus on the creation of policies that bring mostly short-term benefits. However, these types of policies are often superficial and turn to be prejudicial in the long run.

Given that systems are characterized by connectivity, understanding feedbacks becomes critical to analyze how individual decisions influence and change the system, as well as how other actors and components of the system react to such changes. By understanding the dynamics we aim to unite behavioral science with planning identifying key variables that trigger behavior and could be influenced in a positive way throughout policy design. Implementing a strategy based on the system's behavior increases the success opportunities when implementing policies, as well as the sustainability of the system itself from a long-term perspective.

As explained before, System Dynamics as a modeling tool allows to portray system's functioning as well as stakeholders' decision making processes throughout as series of interconnected equations representing real life delays, feedback and nonlinearities. The Lisbon's tourism model that we developed aims to enhance understanding of the tourism impacts and connections between Real estate sector, Cultural sector and the Tourism development sector taking into account these System Dynamics factors of analysis.

With this in mind, modeling process was designed to involve stakeholders and experts' opinions to tackle uncertainty in parameters and equations used in the model, as well as to validate model structure and system's characterization. Process was developed as follows:

1. Preparatory activities

This first stage included a review on previous mass tourism research (included in the literature review chapter) and most recent reports regarding the tourism industry in Lisbon (Roland Berger, 2014).

After defining a very general scenario of the situation, we decided to use Barcelona case study as a theoretical base to define our dynamic hypothesis because of the similarities between Lisbon and Barcelona as touristic destinations (pointed out by *Plano Estratégico para o Turismo na Região de Lisboa*), and also because of the observed resemblance in community concerns and cultural value changes triggered by mass tourism in Barcelona, which signs are starting to be shown in Lisbon (described in Bye bye Barcelona documentary).

1.1 Review of Tourism Strategic Plan for Lisbon Region *(Plano Estratégico para o Turismo na Região de Lisboa 2015-2019*)

According to the current characteristics of Lisbon as a touristic destination, Amsterdam, Barcelona, Copenhagen, Madrid, Prague and Vienna were identified as direct competitors.

However, it varies from the desired positioning of Lisbon, where desired competitors are Berlin, Istanbul, Paris and Rome.

Barcelona was identified to be the most similar to Lisbon. Both cities were well positioned and highly rated as a city break, food and drinking destinations. Only difference comes to ratings where Barcelona was better rated as a nature destination and Lisbon was better rated as beach destination.

2. Model structure definition

Knowledge and system's understanding gained after this review helped to define and design our Dynamic Hypothesis in the form of a CLD diagram, which was explained in the previous chapter.

The aim of the dynamic hypothesis and CLD diagram is to identify how and what factors of the system's structure give rise to the behavior that explains our main variable, which is total Tourists per year in Lisbon.

Hence, we identified Real Estate and Culture as the main sectors that tourism activity impacts and at the same time, to be the most influencing factors for tourist to come to Lisbon. We define years as our measurement base to analyze changes in such sectors.

3. Data gathering

3.1. Second hand data

Besides the literature review, we needed hard data that would help us to portray the evolution and identify changes in the tourism system.

For this purpose we consulted 3 different sources to get historic statistics about different topics in the tourism sector:

- *Instituto Nacional de Estatística* (Statistics Portugal): public information online
- *Observatório Turismo de Lisbosa* (Statistics Turismo de Lisboa): public information online
- *Trusimo de Lisboa*: direct information from authorities

3.2. Stakeholders participation

Considering that this model represents a large-scale system, geographically a city but with global agents of influence (international tourist), we define that we would need experts in the industry, as well as stakeholders with a high interest and high knowledge in the topic.

From a total of 12 identified and invited stakeholders, we had 9 interviews with representatives of high hierarchy within the next organizations:

- Bloomberg News: insights were used to review the whole model
- Academia NOVA FCT: insights were used to review the whole model
- *Ministro da Economia* (Portugal's Ministry of Economy): insights were used to review the whole model
- *Turismo de Portugal*: insights were used in Tourism Sector
- *Turismo de Lisboa*: insights were used in Tourism Sector
- Jones Lang Lasalle: insights were used in Real Estate Sector
- *Associação de Moradores da Baixa* (Baixa neighbors' Association): insights were used in Real Estate and Cultural Sector
- *União De Associações Do Comércio e Serviços* (Commerce and Services Association): insights were used in Real Estate and Cultural Sector
- *Associaçao de Artesãos da Região de Lisboa* (Lisbon Region's Artisans Association): insights were used in Real Estate and Cultural Sector

Stakeholders and experts were invited to meet with two of our team members. The invitation explained that the purpose of our model was to "improve the understanding of the tourism sector in Lisbon as well as to identify trends and expectations of the industry". Information about the project was too broad to avoid having a biased opinion towards the mass tourism topic.

For the interview, we prepared a list of topics that we consider relevant for stakeholder/expert taking into account the expertise level of the interviewees. We never mention any positive or negative opinion about tourism impacts to the participants. The idea was to develop a free dialogue; in deep conversation allowed identifying their perception as to define whether the formulated theories and visions were realistic or not.

4. SFD construction

At the same time that meetings were scheduled and second hand data was collected, the SFD model was constructed based on the CLD and dynamic hypothesis structure.

5. Defining SFD parameters & equations

Once data was collected, equations were defined in the SFD. Data gathered was also used to fill in parameters and table functions in the model as to have all equations and data needed to run the model.

Statistical data was often used to define parameters or to verify model outputs. Insights from interviews were used to identify causal relations and correlations, to define table functions and to validate model's outputs.

6. Continuous improving and adapting process

The whole modeling process (from step 2 to 5), involved adjustments and changes from one step to another. Model structure was reviewed after each interview. Sometimes, changes were required after getting new insights from experts.

Any change made in the CLD was also portrayed in the SFD. Equations and parameters in the SFD were strongly related with data gathering process.

Model's structure and behavior were validated from both interviews and statistical data. Qualitative (interviews) or quantitative (statistics) data was coupled and analyzed together to validate theories and better understand system's behavior. Validation of multiple data sources was especially useful when divergent opinions came from the interviews. In case of disagreement among participant's points of view, quantitative data analysis (if available) was used as to define insight's objectivity.

3. DYNAMIC MODEL OF LISBON TOURIST SYSTEM

3.1 PROBLEM STATEMENT

The development of tourism in a sustainable way requires co-management of many subsystems. This paper provides main dynamics about problem of mass tourism and its influence on cultural heritage of Lisbon area.

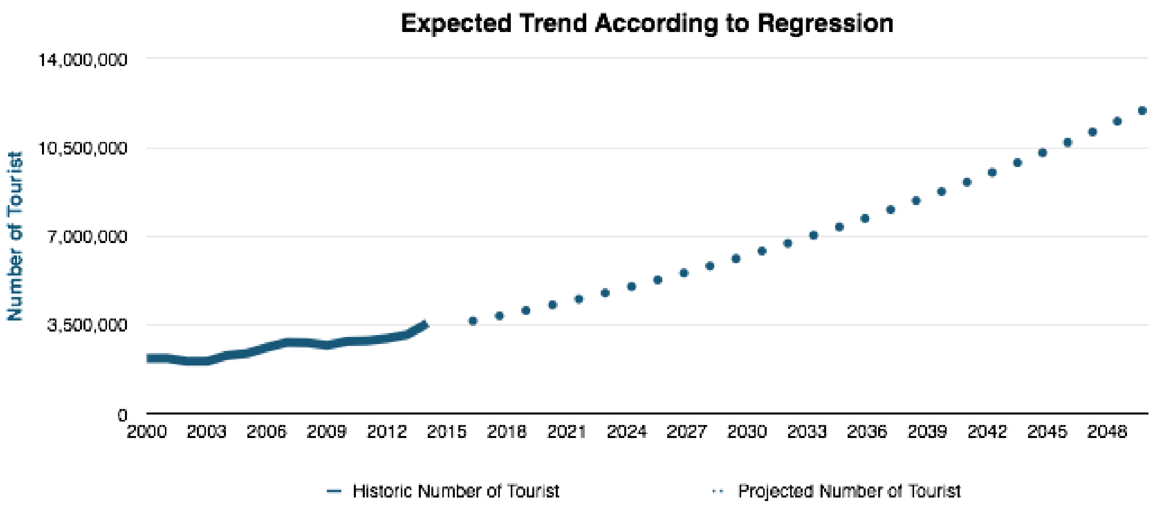

Figure 1: *Historic number of tourist in Lisbon, from Turismo de Lisboa data*

Reference mode is defined as number of tourists per year, with emphasis on seasonality and carrying capacity of researched area. The simple regression from 2015 to 2050 is applied in order to replicate the growing trend in last 15 years. As we observe in the graph, the actual number of tourist drastically increased in the last 10 years, more than 60%. Local municipality is harvesting many benefits from this recent trend in Lisbon, one of the main destination to visit in last years. Among many things, Lisbon area provides unique experience for visitors, offering UNESCO protected heritage sites, historical facilities which symbolize an era of European renaissance, well preserved and maintained throughout the history. Therefore we identified it as a factor, which attracts tourists from around the world, and relevant part of our modeling process. Latest research indicates that capital investments in cultural facilities stand bellow desirable levels, which can lead to long-term problem of losing leverage point for attracting visitors.

Problem statement can be portrayed through previously mentioned life cycle theory. In order to define the problem, more specific approach will be used. Many models are developed to identify main phases of mass tourism. One of the widely used models for this theory is Butler's model (1980) where he describes tourism as a products with certain lifetime containing different phases: exploration, involvement, development, consolidation, stagnation and post-stagnation

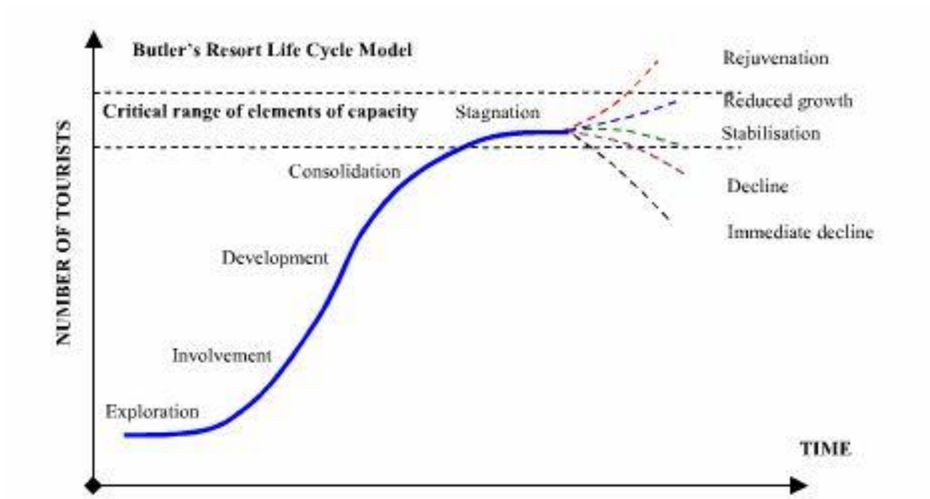

Figure 2: *Butler's Model, Source: Butler* (1980)

At the first stage, visitors are introduced to destination and attracted to its raw and unexplored beauty. Second stage results with increased number of visitors, which creates incentives for local community to get involved in tourism activities. Third phase describes scenario where mass tourism comes to act, and local community cannot control the flow anymore, thus government and policy makers have to plan and standardize facilities. Foreign investments are introduced at this stage as demand for services increases drastically. At the fourth stage, growth rate declines, and destination attracts fewer tourists, although tourist flow is still positive. Marketing and promotion efforts are increased to attract more potential tourists. Fifth stage is characterized by stabilized number of visitors, reached carrying capacity which results in economic, social and environmental problems. Consequently, tourism development negatively affected qualities that attracted people to the destination. At the final stage, range of possibilities is presented, and all of them depend on intervention policies of local and national government.

With regards to the model, we conclude that Lisbon might be in third, development stage, thus there are many reasons to be concerned about future development. The identified problem statement can be valuable for multiple stakeholder groups. Policy makers can benefit from creation of mental models with multiple delays about undesired and mostly hidden consequences of uncontrolled growth of mass tourism in Lisbon area. Local residents can get information about driving forces of identity loss, and their correlations in the complex system. Overall, simulation results can act as warning signal to the industry.

Mass tourism is perceived by many researchers as a potential destruction force for cultural identity, which transforms authentic local communities into tourism adjusted communities. Impact of mass tourism on cultural heritage can lead to problems which will reverse the above mentioned trend of tourist increase, and create vicious circle of identity loss and collapse of tourism. The purpose of the model is to simulate maximum sustainable number of tourists, and develop different scenarios as an answer to the defined problem statement.

3.2 DYNAMIC HYPOTHESIS

The dynamic hypothesis is represented by the system structure that, before analyzing the system, we presume, creates the reference mode behavior. The hypothesis is formulated in terms of a formal model. In System Dynamics, models are dynamic with stocks and flows, they reflect a feedback perspective, and they have closed boundaries. The dynamics hypothesis (causal loop diagram) can be observed in Figure 4. The related stock and flow structured model can be observed in Appendix 1.

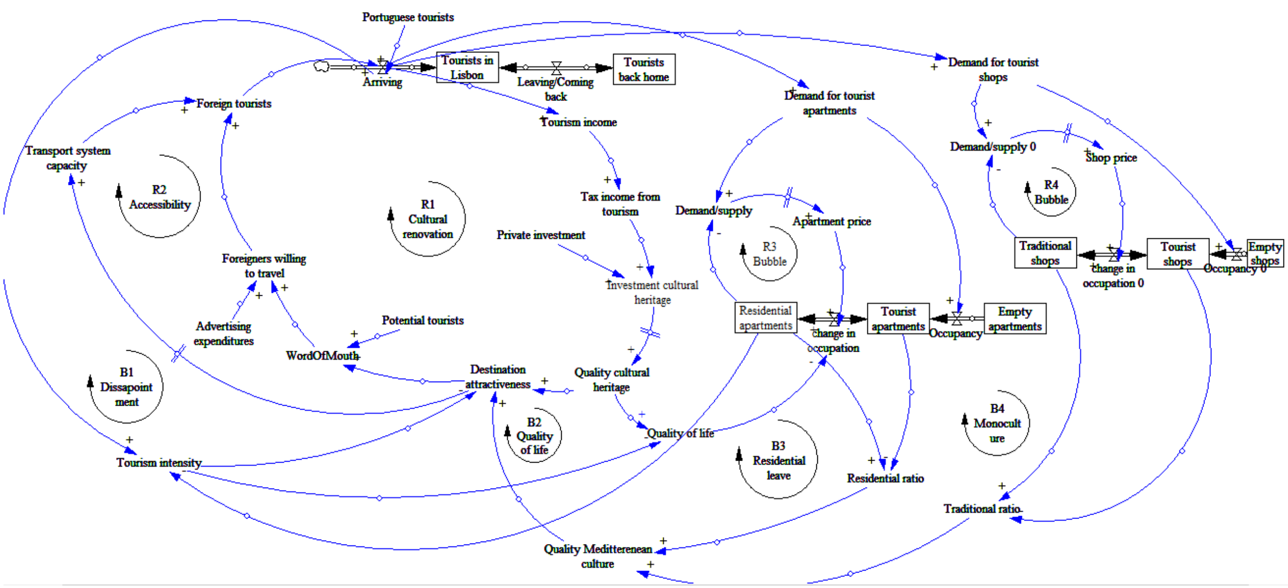

Figure 3: Dynamic Hypothesis of Lisbon Tourism Case in the form of Casual Loop Diagram

The dynamic hypothesis in our research is based on Barcelona's case study about massive tourism. The reason for basing our dynamic hypothesis on the case study of Barcelona is that the tourism development in Barcelona is already in a more mature state, and it could be implied that Lisbon as a tourist destination is currently where Barcelona was around 5-10 years ago. Therefore the Lisbon tourist system might learn from dynamics currently identified in the Barcelona's experience.

However, the dynamic hypothesis as showed in figure has been updated to further analysis which has been deployed in Lisbon.

As described before, System Dynamics is an approach to identify and understand the relationship between structure and behavior in complex dynamic systems. Within the approach, complex systems are defined as consisting of a combination of accumulation, feedback and nonlinearities (Lane, 2007, p. 17):

> *"System dynamics is based on the idea that although humans may be able to conceptualize complex causal relationships they lack the cognitive capacity to infer their consequences over time. The interaction of state variables and non-linear relationships within loops causes different parts of a model to be important- dominant- at different times. With simulation the surprising, counter-intuitive behavior can be studies in a rigorous yet flexible and compelling way"*

Within the dynamic hypothesis of our research the following dynamic properties can be distinguished:

3.2.1 FEEDBACK LOOPS

> *"The right way to determine the polarity of a loop is to trace the effect of a small change in one of the variables as it propagates around the loop. If the feedback effect reinforces the original change, it is a positive loop (or R); if it opposes the original change, it is a negative loop (or B). You can start with any variable in the loop; the result must be the same"*(Sterman, 2000, p. 144).

R1 "Cultural renovation", in which increasing numbers of tourists in Lisbon increase the income from tourism, which then leads to more investments in cultural heritage, thereby increasing the quality of the cultural heritage. Since the quality of the cultural heritage increases the attractiveness of Lisbon as a tourist destination, Lisbon receives more positive publicity, which will lead to more tourists arriving.

R2 "Accessibility", in which increasing tourist numbers leads to a higher attractiveness, leading to transport companies investing in more capacity to the destination thereby increasing the number of tourists even further.

B1 "Disappointment", in which overcrowding in the downtown area leads directly to a decreased quality of the destination (e.g. experience of tourists), thereby creating negative publicity, leading to decreasing arrivals of tourists.

B2 "Quality of life", in which overcrowding in the downtown area (because the number of tourists is higher than the carrying capacity), leads to a lower quality of life in the city (e.g. because of pollution, traffic and occupation of public space), thereby leading to more local residents leaving the area.

B3 "Residential leave", in which increasing numbers of tourists in Lisbon increases the demand for tourist accommodation, thereby increasing real estate prices. The increased real estate price level leads to local residents leaving Lisbon's downtown area, thus decreasing the quality of the Mediterranean culture (assuming tourists would want to visit areas to see local Portuguese culture and residents). Lower quality of Mediterranean culture will then lead to decreasing numbers of tourists arriving.

B4 "Monoculture", in which the increase in real estate prices and increasing competition from tourist shops and services (e.g. cheap imitations of original handicrafts) leads to traditional shops disappearing from downtown area. Since part of the cultural history of the city disappears, the quality of the Mediterranean decreases, leading to less tourists arriving.

3.2.2 ACCUMULATIONS AND DELAYS

> *"Stocks are accumulations. They characterize the state of the system and generate the information upon which decisions and actions are based. Stocks give systems inertia and provide them with memory. Stocks create delays by accumulating the difference between the inflow to a process and its outflow. By decoupling rates of flow, stocks are the source of disequilibrium dynamics in systems"*(Sterman, 2000, p. 192).

Within our dynamic hypothesis, the main accumulation processes are:

- Tourists in Lisbon and Tourists back home
- Tourist apartments
- Residential apartments
- Tourist shops and services
- Traditional shops and services
- Quality cultural heritage (soft variable)
- Quality of life (soft variable)

3.2.3 NONLINEARITIES

> *"In real systems, there must be shifts in feedback loop dominance, and therefore there must be important nonlinearities in all real systems"*(Sterman, 2000, p. 284).

Nonlinearity is a relationship between two variables, which is disproportional.

Therefore, the main important nonlinearities in the system are:

- **Overcrowding** (defined as the number of tourist/carrying capacity) has no (or minor) effect whenever the number of tourists is lower than the carrying capacity (lower than 1). As the overcrowding becomes higher than 1, there will be a disproportional decrease in the quality of the destination. It can be argued that from a certain number of tourists, the quality of the destination will reach '0', thereby reaching a limit in the system.

Similar nonlinear dynamics can be expected in the causal relationships in which overcrowding effects quality of life, and other relationships within the quality of life, monoculture and housing bubble loop

- **Cultural heritage investments** will be nonlinearly related to quality of cultural heritage, since there will be a limit to how much the quality of the heritage can be increased after a certain amount of money is invested. Thereby the strength and dominance of the reinforcing positive impacts loop is constrained in the long run.
- **Mediterranean culture** level is a result of different identified real estate pressures. Pressures come from number of local residences in downtown area, and number of traditional Portuguese shops. Nonlinearities are recognized in the impact of these pressures on Mediterranean culture, as different shares of apartments and shops will have nonlinear effect on culture. Once the number of apartments owned by local residents drops below 20% of total amount, culture will be endangered severely.
- **Transportation system capacity** will be adjusted with regards to perceived attractiveness. Different levels of attractiveness will have different impacts on adjustments. Low cost carriers will benefit the most from increased attractiveness, and adjust their lines to/from Lisbon according to attractiveness levels. Traditional carriers will however adjust their lines slower and softer, as they are not price competitive. Cruises will adjust their capacities as well, as more attractive the destination is, more demand will increase.
- **Real estate sector** is characterized by many nonlinearities. They are mostly portrayed in relationship between apartment price and distribution of apartments with regards to different purposes. Higher the price, bigger the pressure is to sell/rent apartment in order to benefit from real estate bubble. However there is a limit on how much price can impact the decisions to change apartment's purpose. Same nonlinearities are identified for shops.

3.2.4 TIPPING POINTS

Thresholds occur in ecosystems and in social systems. In social systems they are more often referred to as "tipping point." A tipping point refers to a certain state of the system, after which a small change can lead to strong changes in behavior. In our dynamic hypothesis we assume that there might be important tipping point effects within the tourist system in Lisbon.

It might be that because of the dominance of the housing bubble loop, a large proportion of the local residents will leave the downtown area of Lisbon. Because there is still a portion of local residents left, the city keeps being attractive for tourists (assuming tourists value the presence of local inhabitants while visiting the city).

When the overcrowding loop starts to effect the remaining local residents in leaving the downtown area, there might be a certain tipping point (in the number of local residents remaining), after which tourists will start to perceive the quality of cultural heritage in a negative way. This tipping point effect is described by Chibás (2014) as the city's transforming process into a 'papier-mâché city.'

3.2.4 SYSTEM ARCHETYPE

The identified and hypothesized system structure belongs to a group (or archetype) of problems from previous research such that it can be used to analyze the possible behavior of the system (Braun, 2002). At first, the system has the potential to create exponential behavior, in which our main stock (the number of tourists in Lisbon) grows at an ever increasing rate.

> *"However, no real quantity can grow (or decline) forever; eventually one or more constraints halt the growth. A commonly observed mode of behavior in dynamic systems is S-shaped growth- growth is exponential at first, but then gradually slows until the state of the system reaches an equilibrium level"*(Sterman, 2000, p. 118).

> *"To understand the structure underlying S-shaped growth it is helpful to use the ecological concept of carrying capacity. The carrying capacity of any habitat is the number of organisms of a particular type it can support and is determined by the resources available in the environment and the resource requirements of the population"*(Sterman, 2000, pp. 118–119).

In our tourist system in Lisbon model carrying capacity can be defined as the number of tourists the city of Lisbon can support. In our analysis we well determine the limiting factors within the system, which could, for example, be related to the size of the tourist area and infrastructural capacity.

> *"S-shaped growth requires the negative feedbacks that constrain growth to act swiftly as the carrying capacity is approached. Often, however, there are significant time delays in these negative loops. Time delays in the negative loops lead to the possibility that the state of the system will overshoot and oscillate around the carrying capacity"*(Sterman, 2000, p. 121).

Delays in the balancing feedback loops play an important role in this behavior, and they determine how much the main stock (the number of tourists) will overshoot before it turns back to more desirable behavior. In our case study on the city of Lisbon, we hypothesize that the long delays in the return of local inhabitants and shops after they left the downtown area, could lead to a long period in which the quality of the cultural heritage is low. Thus this could trigger the collapse in the number of tourists visiting Lisbon, also taking into account the fact that negative publicity often has a longer-lasting effect than positive publicity. The collapse of the number of tourists will, over time, lead to decreasing real estate prices, which could extract the local residents back to the downtown part of the city.

4. ANALYSIS

4.1 MODELING PROCESS

4.3 TESTING THE MODEL

One of the key elements in model validation is to test the usefulness of the model for the purpose of the modeling exercise (Forrester, 1961). As yet, there are no cities which have experienced boom and bust behavior pattern, but that outcome is certainly feasible, if the things remain unchanged. This model suggests feasibility - a possible but not assured eventuality. The model testing is an essential step embedded in every system dynamics model construction process. A System Dynamics model addresses a problem and is designed to answer a reasonably well-defined set of questions.

Structure verification test asks whether the model is consistent with knowledge of the real system and relevant to the purpose (Xing & Dangerfield, 2011). This included presentations of Causal Loop diagrams to stakeholders at Turismo de Portugal and experts at NOVA FCT. Other tests conducted for this model include sensitivity analysis. This involved changing assumptions about parameters values and examining the outputs for consequent changes.

To be an effective policy analysis tool, a System Dynamics model should also be able to reproduce relevant aspect of past history (Homer, Keane, Lukiantseva, & Bell, 1999). Our model allows an assessment of the impact off different sectors, namely real estate and tourist dynamics on culture and destination attractiveness. The high increase in tourists from 2010-2014 was explained through introduction off low cost carriers and increased number of cruise ships after the social instability occurred in Northern Africa. These changes are introduced in the model via shocks, as one-time events. Oscillations observed in 2008 and 2009 were due to economic crisis, thus considered irrelevant for our historical behavior. We created simple structural mechanism which supports tourists flow and its consequences on cultural identity.

Validation of complex socio-economic system is an ongoing process, and the model has a potential to grow when more data and facts are established. Presently, however, model helps us to think harder about complexity of tourism industry, and impacts of mass tourism on cultural identity. As such, model could be useful for analysts and policy makers to deal with delays and nonlinearities, which are the inevitable parts of every complex system.

4.4 SIMULATION RESULTS

When running the model from 2015 to 2050 we observe that the current growing trend (historic data from 2000 to 2014) continues to dominate the system until 2035 approximately. Tipping point, according to simulation, is reached around 2038 with a total number of tourists slightly above 5 million people per year. It is followed by decline where total visitors in 2050 are close to current number of visitors (approximately 3.5 million).

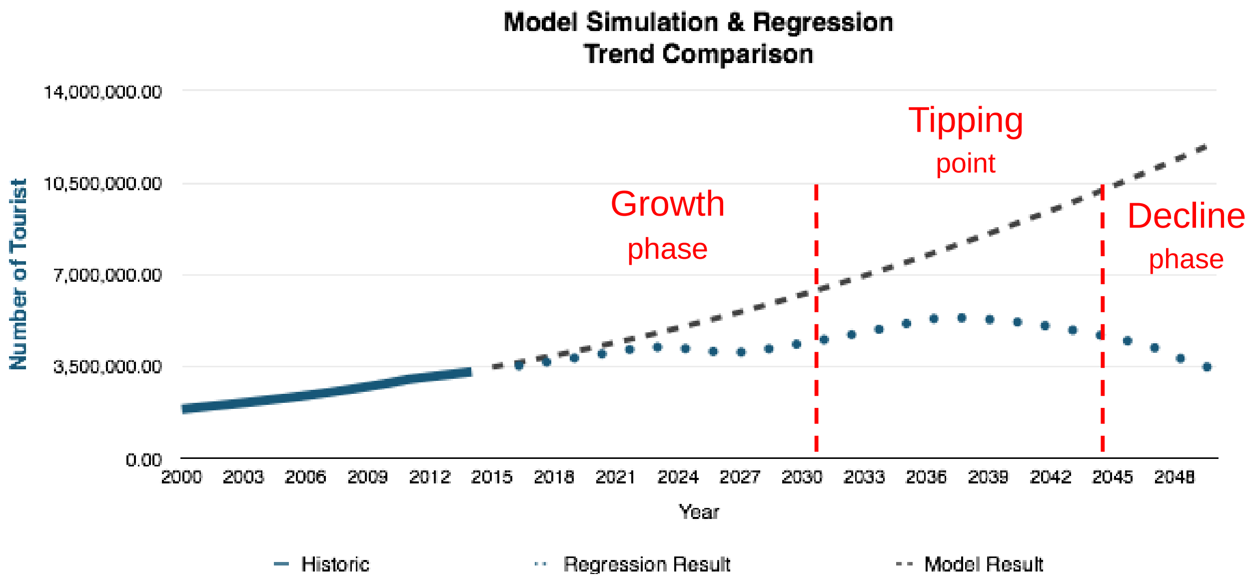

Figure 7: *Expected Tourist per year, SD model results compared to regression exercise, Results from Tourism Sector*

Growth phase - Cultural Renovation R loop dominance

Growth is mainly explained by the continuous investment in historic buildings, museums and touristic spots restoration, as well as in city revitalization and public services maintenance. This increases the Quality of Cultural heritage and Quality of Life downtown respectively (Figure 10). The constant inflow of money coming for tourist expenditures, allows government to keep investing and improving such conditions that lead to increase destination's attractiveness until 2021 (Figure 11).

Tipping point – Disappointment, Quality of life & Monoculture B loops get stronger

Represents the highest level of visitors per year and occurs when the system's reaches its carrying capacity. It is the maximum sustainable yield where tourists still perceive attractiveness high enough to produce a positive Word of Mouth effect that keeps bringing visitors to the city and incentivizes transport industry (airlines and cruises) to increase their supply.

However, when the tipping point is reached, the high number of tourists already had a negative effect in Real estate sector. Traditional shops and apartments inhabited by locals where replaced by tourist shops and apartments for tourist because of demand and price pressure that focus supply on tourist needs instead of local population (Figures 8 & 9). Since perceptions only change with time (information delay), tourists still perceive and positively evaluate Lisbon during this period.

Decline phase – Disappointment, Quality of life & Monoculture B loops dominance

Displacement of locals and traditional shops (occurred in the tipping point) has a lagged effect on attractiveness (Figure 11).

In this stage attractiveness starts to decline and Disappointment loop gets stronger, causing a negative word of mouth effect that would bring less and less tourist to the city despite investments in Cultural Heritage or Quality of Life. It is important to remark that Quality of Life moves in the opposite direction than Tourism Intensity Indicator. This is because the consequences of tourist flows affect local's life style directly by overcrowding, pollution and noise associated with a large number of tourists in town (Figure 10).

Since shops and apartments' market is dominated by long-term investments and price mechanisms, it would take longer for price to drop as to make Real Estate appealing for locals. The system does have a "natural" reorganizing/resilience capacity where the decline in the number of visitors will make the market more attractive for locals than for the weakened touristic demand. However this shift will take more time of what it took to attract touristic services.

At this point Quality of Life for Portuguese people downtown is low. Moreover the dominant number of touristic services, along with the lack of authentic Portuguese experience (traditional shops and Portuguese culture brought by residents) drives Mediterranean culture quality very low, leading to Monoculture loop domination (Figure 8 & 9).

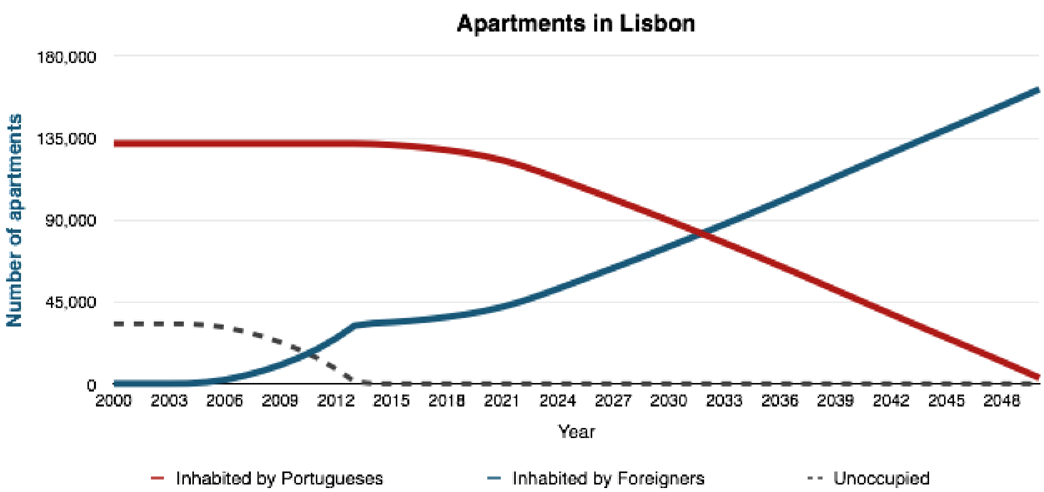

Figure 8*: Apartments in downtown Lisbon by type of inhabitants,*
Results from Real Estate Sector

Figure 9*:Shops in downton Lisbon by owner type,*
Results from Real Estate Sector

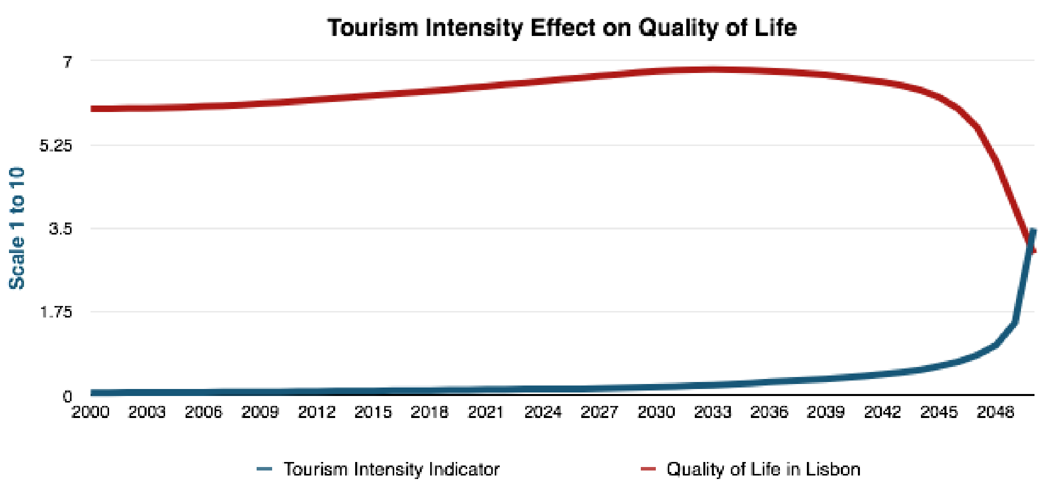

Figure 10: *Comparison between Tourism Intensity Indicator & Quality of Life in Lisbon, Results from Culture and Tourism Sectors*

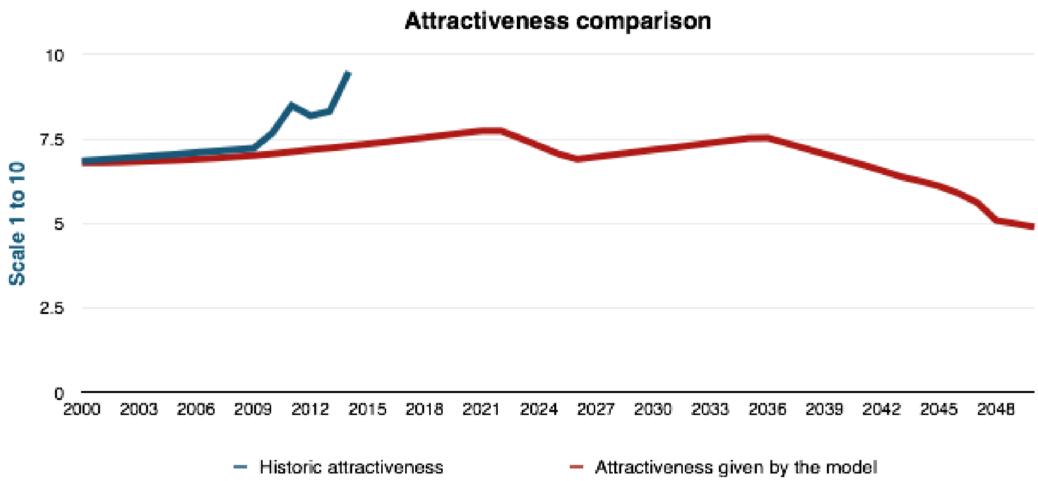

***Figure 11**: Lisbon's perceived attractiveness by tourist, real compared to SD model results Results from Tourism Sector*

5. POLICY SUGGESTIONS

As discussed in the model results, the hypothesized model structure seems to be useful to explain both historical growth trend in tourist numbers as the potential for overshoot and collapse behavior in the future. However, as identified in the chapter about system archetypes, overshoot and oscillation might be observed when tourist collapse leads, over a long time period, to decreasing rental prices and thus a resident population coming back to the downtown area. This behavior is out of the time frame of our model.

Since the dynamic model seems useful for the reference mode, the next step could be to formulate hypotheses about policies that could alleviate the problem. For this part of the modeling process, the iterative process used to build system understanding has been repeated. In the policy model, the goal is not to replicate the reference behavior, but indeed to find policies which will lead to more desirable system behavior.

5.1 LEVERAGE POINTS

Within the system dynamics methodology, potential for policy intervention starts with an analysis of the 'high' leverage points in the system, which are parts of the system in which changes made are likely to have a big impact on the behavior of the whole system.

In the tourist system of Lisbon, one such leverage point can be identified, namely the 'residential ratio'. Referring back to the dynamic hypothesis CLD in figure 4, it can be seen that this variable plays an important role in three out of the four balancing loops. The strength of this leverage point is related to the 'tipping point' analogy described earlier.

As the number of residents living downtown declines further than a certain threshold (assumed around 20%), the system will face a high impact in the sense that the attractiveness of Lisbon will be strongly affected. Thus designing a policy to keep the residents ratio within safe distance from the tipping point could be a good starting point in the quest for more desirable system behavior.

5.2 TOURIST TAX

After having identified the main leverage point in the system, policies could be designed to change system behavior. In this scoping model, a simple tax policy has been designed which will tax tourists who are renting a tourist apartment in the downtown area of Lisbon because of their negative impact on the quality of the Mediterranean culture.

This policy is a logical next step, since in 2014, there has been implemented a legislation which requires that all tourist apartments must be officially registered at the municipality. From the system dynamic model, it can be identified that, because of price elasticity of tourists, a tourist tax on the renting of tourist apartments could offset the increasing trend in demand for tourist apartments. As this trend is tempered, there will be less pressure on real estate prices, thus leading to fewer residents leaving the area.

POLICY SIMULATIONS

In the System Dynamic model, a management interface has been designed for testing different policy strategies and scenarios. It is possible to test system behavior when switching policy start date and by increasing the tax cost. Figure 12 and 13 show the dynamic results of running the business as usual scenarios versus two scenarios in which the tourist tax is activated with different monetary values.

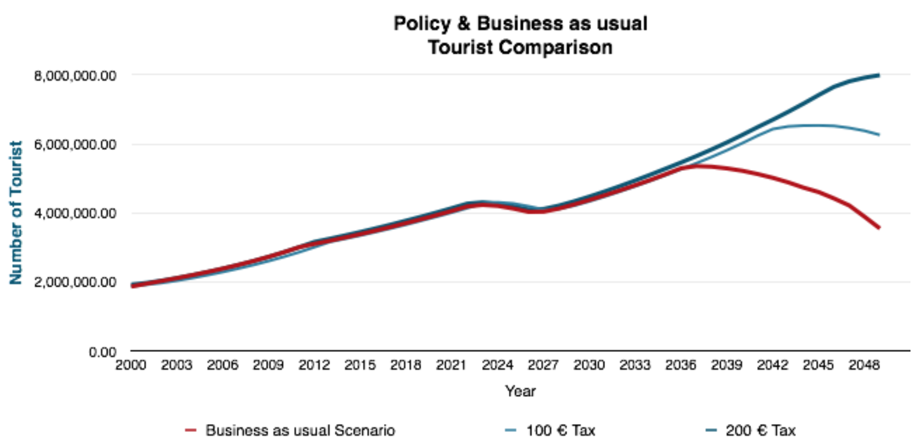

***Figure 12**: Policy versus business as usual comparison (number of tourists)*

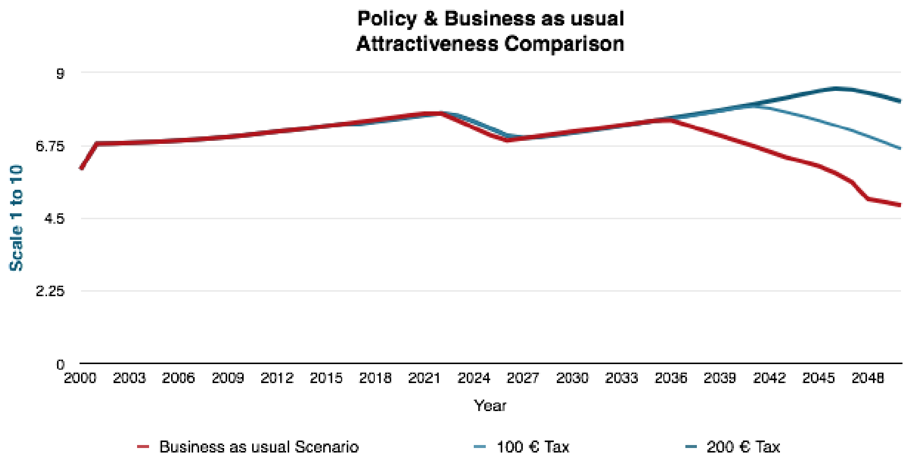

Figure 13*: Policy versus business as usual comparison (destination attractiveness)*

A first hypothesis about the simulated results can be that 'managing' the leverage point has led to the system being able to support a higher number of tourists arriving. However, since more tourists must eventually lead again to more pressure on the system, it is expected that eventually the number of tourists must level off again in the future.

6. CONCLUSION

Recent trends and developments within the tourism sector have led to a need for 'revision' of the sustainable tourism concept. Opposed to the limited concept of energy efficiency and other green measures within the tourism industry, sustainable tourism seems to include also important aspects related to the cultural heritage within destinations. Especially within cities, tourism has become more and more integrated with the daily life of citizens, leading to impacts on local residents and infrastructure.

A dynamic approach has been proposed to deal with impacts and changes over time in the relationship between tourists and culture in cities. In this research, a System Dynamics methodology has been applied to gain an understanding of the driving forces behind increasing tourist numbers in Lisbon (reference behavior).

Additionally, the Dynamic Hypothesis has been used to create awareness of what might happen within the tourism system in Lisbon when developments are not managed properly. This Dynamic Hypothesis (in the form of a stock and flow and related CLD model) explains how increasing tourist numbers lead, over time, to the activation of balancing mechanisms, which will eventually lead to a stagnation, and possible collapse, of the number of tourist arriving. The hypothesis is based on an understanding of the role of delays, feedback and tipping points within the tourism system.

An important leverage point has been identified within the system structure, which is related to the ratio of residents in downtown Lisbon compared to the number of tourists. From structural analysis, it can be concluded that the value of Lisbon for tourist is based on both a relatively permanent (beaches, weather, castles, museums) value and a more volatile cultural (local people, gastronomy, traditional shops) value. The cultural value is more volatile in the sense that increasing tourist numbers could lead to a slow or sudden decline in real Portuguese culture.

Since this value is, through feedback, related to the attractiveness for tourists, lowering cultural value could lead to negative Word of Mouth effect and a related decrease in tourist numbers. While investors could more easily switch to other cities (which then seem more attractive), the city will be left with an infrastructure which is designed for large tourist numbers. Thus the city has lost its cultural and infrastructural diversity.

A policy to manage this leverage point has been designed and tested on more desirable system behavior. From the policy, it could be concluded that, even when more desirable behavior was simulated, more growth will eventually lead again to balancing mechanisms getting activated. Thus, within a limited environment (physical boundaries of the city), growth cannot continue forever.

Currently, these dynamic properties are witnessed on a bigger level within the city of Barcelona, which has been used as a comparison case study within our research. Since Lisbon could profit from its relatively early understanding of system behavior, leading to an increased awareness, our conclusion is that more effort should be aimed at exploring alternative ways in dealing with tourism within the city.

7.2 LIMITATIONS

Some of the main limitations of the research and proposed model are related to time and resource constraints. Because of limited time, assumptions in the formal model had to be made which could not be based on the available data. Additionally, since the model has a strong focus on qualitative relationships (such as cultural), it difficult and arbitrary to translate these relationships into quantitative equations.

A second group of limitations is related to the modeling methodology, namely System Dynamics. Within this methodology, the main stocks are often considering homogenously and modeled in an aggregated way. These limitations had led to the problem of spatial and seasonal distribution of the tourists in Lisbon, which are important features related to cultural pressure.

Thirdly, the model is mainly focused on explaining cultural carrying capacity. However, it can be assumed that there are other important carrying capacities within the city which could have interplay with the cultural one. Such carrying capacities (for example gastronomical or environmental) have not been considered within this research.

7.3 FURTHER RESEARCH

Further research on this topic should firstly be aimed in elaborating the models structure. Therefore, more stakeholders should be consulted, surveys could be used and additional statistical data could be useful.

One proposal for further research would be to disaggregate the tourists arriving into different categories, dependent on their behavior in the system; for instance, mass tourists versus cultural explorers. This disaggregation could then be further combined with destination management strategies, in which the city can be designed to focus more on facilitating groups of tourists, which have a more broader and desired impact on the city and its surroundings.

After elaborating the model, it could also be useful to apply and calibrate it to different cities within Portugal or Europe, such as Porto, which is currently facing a comparative surge in tourist numbers as Lisbon a few years ago.

Acknowledgements

We would like to thank Dr. P. Antunes, Dr. R. Santos and Dr. N. Videira for their supervision and support during the project. And special thanks goes out to Sergio Guerreiro, Director of the strategic control department of Turismo de Portugal, for enabling decision-making support during the progress of the project.

Please consider this paper as an integral, though not exclusive part of the research. The paper should be considered complementary to the System Dynamics model that has been developed in iThink software, and which reveals a more elaborate and detailed picture of the system, including story-telling modes and a flight management simulator.

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Appendix 1 Stock and Flow model

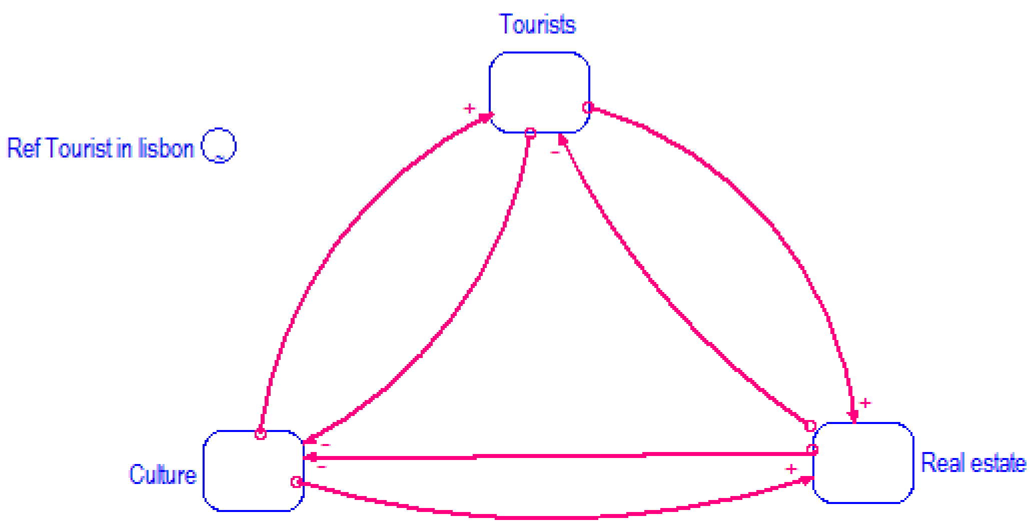

Figure 14*: Dynamic Hypothesis Sector model*

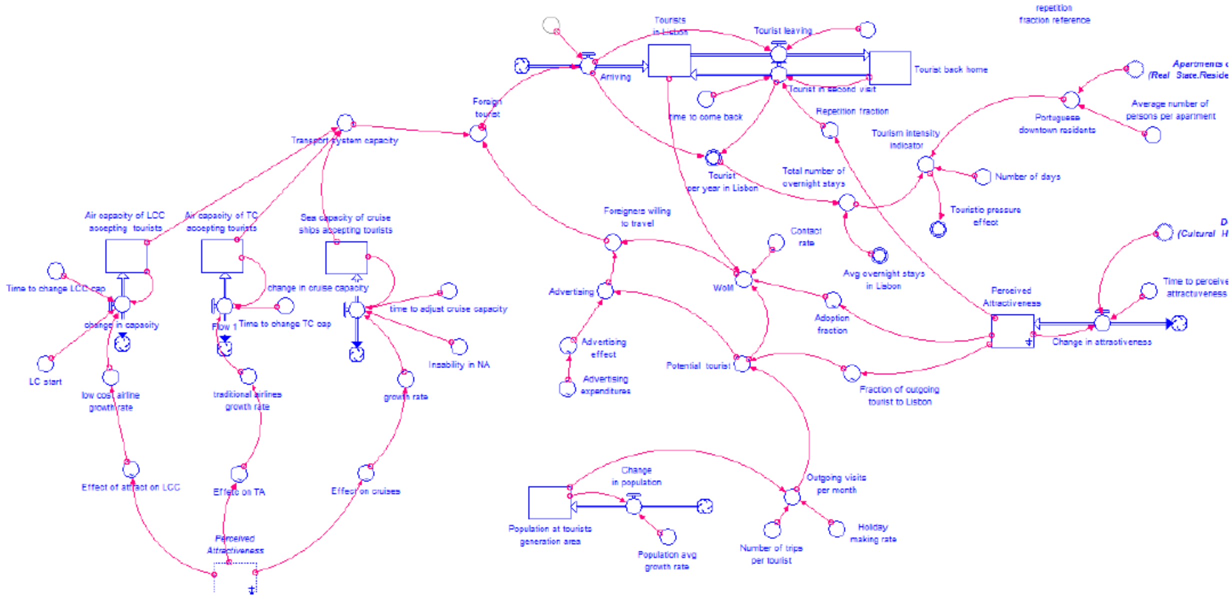

Figure 15*: Dynamic Hypothesis Tourist sector*

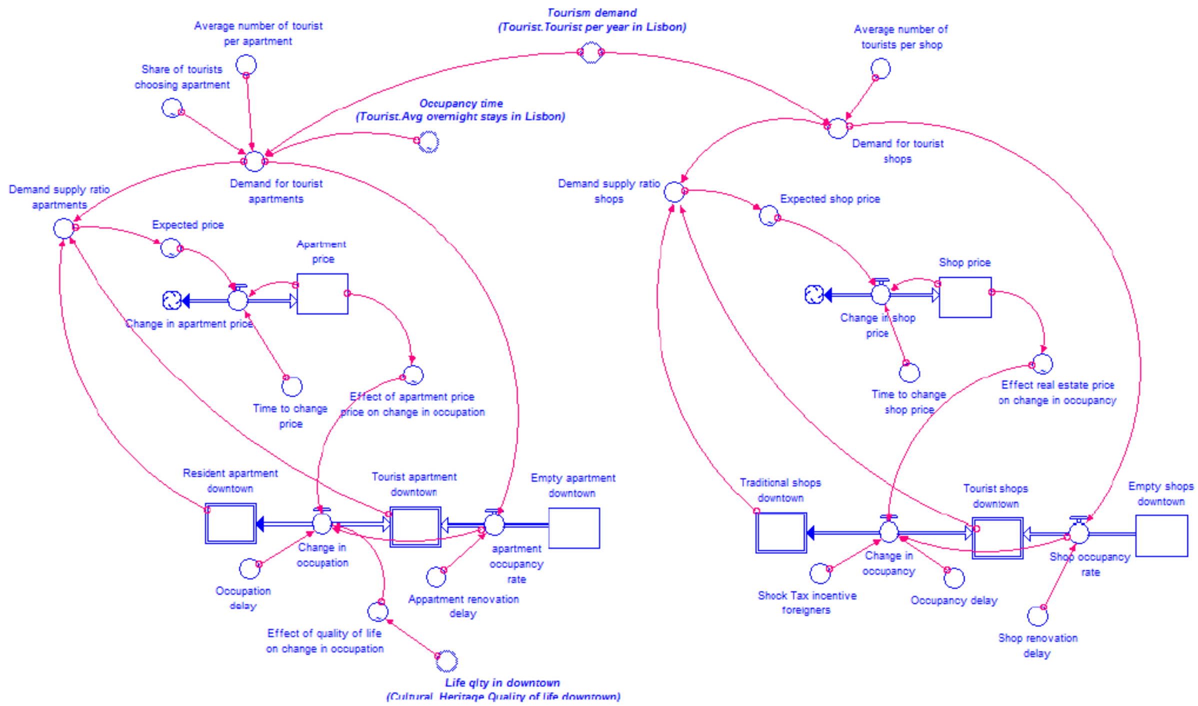

***Figure 16**: Dynamic Hypothesis real estate sector*

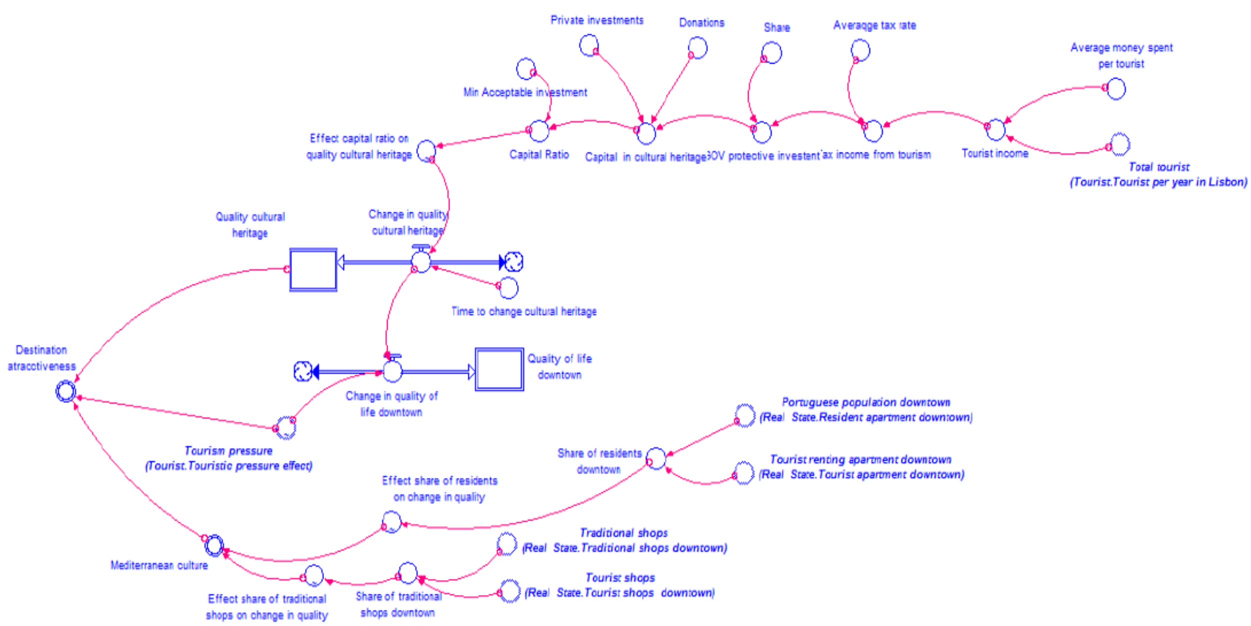

***Figure 17**: Dynamic Hypothesis Cultural sector*

APPENDIX 2 MODEL EQUATIONS

Ref_Tourist_in_lisbon = GRAPH(TIME)

(2000, 2.2e+006), (2004, 2.3e+006), (2008, 2.8e+006), (2013, 3e+006), (2017, 3.6e+006), (2021, 4.2e+006), (2025, 5e+006), (2029, 5.8e+006), (2033, 6.7e+006), (2038, 7.7e+006), (2042, 8.8e+006), (2046, 1e+007), (2050, 1.1e+007)

Quality_Cultural_Heritage(t) = Quality_Cultural_Heritage(t - dt) + (Change_in_quality_cultural_heritage) * dt

INIT Quality_Cultural_Heritage = 5

INFLOWS:

Change_in_quality_cultural_heritage = Effect_capital_ratio_on_quality_cultural_heritage/Time_to_change__Cultural_Heritage

Quality_of_life_downtown(t) = Quality_of_life_downtown(t - dt) + (Change_in_quality_of_life_downtown) * dt

INIT Quality_of_life_downtown = 6

INFLOWS:

Change_in_quality_of_life_downtown = (0.2*Change_in_quality_cultural_heritage)+touristic_pressure_effect

Average_money_spent_per_tourist = 100

Averaqge_tax_rate = 0.2

Capital_Ratio = Capital__in_cultural_heritage/Minimun_acceptable_investment

Capital__in_cultural_heritage = GOV_protective_investment+Private_investments+Donations

Destination__attractiveness = (0.6*quality_mediterranean_culture)+(0.4*Quality_cultural_Heritage)+touristic_pressure_effect

Donations = 100000

Effect_capital_ratio_on_quality_cultural_heritage = GRAPH(Capital_Ratio)

(0.00, -2.00), (0.5, -1.00), (1.00, 0.00), (1.50, 0.4), (2.00, 0.5), (2.50, 0.6), (3.00, 0.7), (3.50, 0.85), (4.00, 0.9), (4.50, 1.00), (5.00, 1.00)

Effect_of_quality_of_life_on_change_in_occupation = GRAPH(Quality_of_life_downtown)

(0.00, 2000), (1.00, 1500), (2.00, 1200), (3.00, 500), (4.00, 250), (5.00, 0.00), (6.00, -300), (7.00, -500), (8.00, -800), (9.00, -900), (10.0, -10000)

Effect_share_of_residents_on_change_in_quality = GRAPH(Share_of_residents_downtown)

(0.00, -5.00), (0.2, -3.00), (0.4, 0.00), (0.6, 0.00), (0.8, 0.00), (1.00, 0.00), (1.20, 0.00), (1.40, 0.00), (1.60, 0.00), (1.80, 0.00), (2.00, 0.00)

Effect_share_of_traditional_shops_on_change_in_quality = GRAPH(Share_of_traditional_shops_downtown)

(0.00, -2.00), (0.1, -1.00), (0.2, 0.00), (0.3, 0.00), (0.4, 0.00), (0.5, 0.00), (0.6, 0.00), (0.7, 0.00), (0.8, 0.00), (0.9, 0.00), (1.00, 0.00)

GOV_protective_investment = Tax_income_from_tourism*share

Minimun_acceptable_investment = 2000000

Private_investments = 100000

Quality_Mediterranean_Culture =
8+Effect_share_of_residents_on_change_in_quality+Effect_share_of_traditional_shops_on_change_in_quality

Share = 0.05

Share_of_residents_downtown = (Resident_apartment_downtown)/(Resident_apartment_downtown+Tourist_apartment_downtown)

Share_of_traditional_shops_downtown = Traditional_shops_downtown/(Traditional_shops_downtown+Tourist_shops_downtown)

Tax_income_from_tourism = Tourist_income*Averaqge_tax_rate

Time_to_change__Cultural_Heritage = 3

Tourist_income = tourist_per_year*Average_money_spent_per_tourist

Real_estate.Resident_apartment_downtown =

Real_estate.Tourist_apartment_downtown =

Real_estate.Tourist_shops__downtown =

Real_estate.Traditional_shops_downtown =

Real_estate.Resident_apartment_downtown =

Tourists.Touristic_pressure_effect =

Tourists.Touristic_pressure_effect =

Tourists.Tourist_per_year_in_Lisbon =

Real_estate.Tourist_apartment_downtown =

Tourists.Tourist_per_year_in_Lisbon =

Real_estate.Tourist_shops__downtown =

Real_estate.Traditional_shops_downtown =

Apartment__price(t) = Apartment__price(t - dt) + (Change_in_apartment_price) * dt

INIT Apartment__price = 400

INFLOWS:

Change_in_apartment_price = (Expected__apartment_price-Apartment__price)/Time_to_change__apartment_price

Empty_apartments_downtown(t) = Empty_apartments_downtown(t - dt) + (-Apartment__occupancy_rate) * dt

INIT Empty_apartments_downtown = 33000

OUTFLOWS:

Apartment__occupancy_rate = Demand_for_tourist_apartments/renovation_delay

Empty_shops_downtown(t) = Empty_shops_downtown(t - dt) + (-Shop__occupancy_rate) * dt

INIT Empty_shops_downtown = 500

OUTFLOWS:

Shop__occupancy_rate = Demand_for_tourist_shops/shop_renovation_delay

Resident_apartment_downtown(t) = Resident_apartment_downtown(t - dt) + (-Change_in_apartment_occupancy) * dt

INIT Resident_apartment_downtown = 132000

OUTFLOWS:

Change_in_apartment_occupancy =
IF((Effect_of_apartment_price__on_occupancy_change+Effect_of_quality_of_life_on_change_in_occupation)<apartment__occupancy_rate)
THEN(0)
ELSE(((Effect_of_apartment_price__on_occupancy_change+Effect_of_quality_of_life_on_change_in_occupation)/Occupation_delay))-
Apartment__occupancy_rate

Shop_price(t) = Shop_price(t - dt) + (Change_in_shop_price) * dt

INIT Shop_price = 300

INFLOWS:

Change_in_shop_price = (Expected__shop_price-Shop_price)/Time_to_change__shop_price

Tourist_apartment_downtown(t) = Tourist_apartment_downtown(t - dt) + (Change_in_apartment_occupancy + Apartment__occupancy_rate) * dt

INIT Tourist_apartment_downtown = 0

INFLOWS:

Change_in_apartment_occupancy =
IF((Effect_of_apartment_price__on_occupancy_change+Effect_of_quality_of_life_on_change_in_occupation)<apartment__occupancy_rate)
THEN(0)
ELSE(((Effect_of_apartment_price__on_occupancy_change+Effect_of_quality_of_life_on_change_in_occupation)/Occupation_delay))-
Apartment__occupancy_rate

Apartment__occupancy_rate = Demand_for_tourist_apartments/renovation_delay

Tourist_shops__downtown(t) = Tourist_shops__downtown(t - dt) + (Change_in_shop_occupancy + Shop__occupancy_rate) * dt

INIT Tourist_shops__downtown = 50

INFLOWS:

Change_in_shop_occupancy = IF((Effect_real_estate_price__on_occupancy_change)<Shop__occupancy_rate) THEN(0)

ELSE((Effect_real_estate_price__on_occupancy_change/Occupancy__delay)-Shop__occupancy_rate)

Shop__occupancy_rate = Demand_for_tourist_shops/shop_renovation_delay

Traditional_shops_downtown(t) = Traditional_shops_downtown(t - dt) + (-Change_in_shop_occupancy) * dt

INIT Traditional_shops_downtown = 3000

OUTFLOWS:

Change_in_shop_occupancy = IF((Effect_real_estate_price__on_occupancy_change)<Shop__occupancy_rate) THEN(0)

ELSE((Effect_real_estate_price__on_occupancy_change/Occupancy__delay)-Shop__occupancy_rate)

Average_number_of_tourist_per_apartment = 4

Average_number_of__tourists_per_shop = 3000

Demand_for_tourist_apartments =
if(policy_status=0)then(tourist_per_year*Share_of_tourists_choosing_apartment/Average_number_of_tourist_per_apartment/avg_overnight_stays_in_Lisbon)

else(tourist_per_year*Share_of_tourists_choosing_apartment/Average_number_of_tourist_per_apartment/avg_overnight_stays_in_Lisbon)*Effect_of_tax

Demand_for_tourist_shops = tourist_per_year/Average_number_of__tourists_per_shop

Demand_supply__apartment_ratio = Demand_for_tourist_apartments/(Resident_apartment_downtown+Tourist_apartment_downtown)

Demand_supply__shop_ratio = Demand_for_tourist_shops/(Traditional_shops_downtown+Tourist_shops__downtown)

Effect_of_apartment_price__on_occupancy_change = GRAPH(Apartment__price)

(200, -1000), (400, 0.00), (600, 4000), (800, 5000), (1000, 6000), (1200, 7000), (1400, 8000), (1600, 9000), (1800, 10000), (2000, 11000)

Effect_of_tax = GRAPH(Tourist_apartment_tax)

(0.00, 1.00), (41.7, 0.98), (83.3, 0.8), (125, 0.77), (167, 0.7), (208, 0.65), (250, 0.6), (292, 0.4), (333, 0.38), (375, 0.34), (417, 0.3), (458, 0.25), (500, 0.2)

Effect_real_estate_price__on_occupancy_change = GRAPH(Shop_price)

(200, -386), (330, 0.00), (460, 50.0), (590, 100), (720, 150), (850, 200), (980, 250), (1110, 300), (1240, 350), (1370, 400), (1500, 500)

Expected__apartment_price = GRAPH(Demand_supply__apartment_ratio)

(0.00, 300), (0.1, 400), (0.2, 500), (0.3, 700), (0.4, 800), (0.5, 1000), (0.6, 1200), (0.7, 1500), (0.8, 1700), (0.9, 1900), (1.00, 2000)

Expected__shop_price = GRAPH(Demand_supply__shop_ratio)

(0.00, 250), (0.1, 350), (0.2, 500), (0.3, 700), (0.4, 800), (0.5, 900), (0.6, 1000), (0.7, 1100), (0.8, 1200), (0.9, 1300), (1.00, 1500)

Occupancy__delay = 1

Occupation_delay = 1

policy_start_time = 2017

policy_status = if(policy_switch=1)and(time>policy_start_time)then(1)else(0)

policy_switch = 0

renovation_delay = 3

Share_of_tourists_choosing_apartment = GRAPH(TIME)

(2000, 0.00), (2003, 0.00), (2007, 0.025), (2010, 0.04), (2013, 0.07), (2017, 0.08), (2020, 0.09), (2023, 0.1), (2027, 0.11), (2030, 0.11), (2033, 0.11), (2037, 0.11), (2040, 0.11), (2043, 0.11), (2047, 0.11), (2050, 0.11)

shop_renovation_delay = 4

Time_to_change__apartment_price = 1

Time_to_change__shop_price = 1

Tourist_apartment_tax = 100

Tourists.Avg_overnight_stays_in_Lisbon =

Culture.Effect_of_quality_of_life_on_change_in_occupation =

Culture.Effect_of_quality_of_life_on_change_in_occupation =

Tourists.Avg_overnight_stays_in_Lisbon =

Tourists.Tourist_per_year_in_Lisbon =

Tourists.Tourist_per_year_in_Lisbon =

Perceived_Attractiveness(t) = Perceived_Attractiveness(t - dt) + (Change_in_Attractiveness) * dt

INIT Perceived_Attractiveness = 6

INFLOWS:

Change_in_Attractiveness = (Destination_attractiveness-Perceived_Attractiveness)/Time_to_perceive__Attractiveness

Air_capacity_LCC_accepting__tourists(t) = Air_capacity_LCC_accepting__tourists(t - dt) + (Change_in_LLC_capacity) * dt

INIT Air_capacity_LCC_accepting__tourists = 0

INFLOWS:

Change_in_LLC_capacity =
(Air_capacity_LCC_accepting__tourists*low_cost_airline__growth_rate)/Time_to_adjust__LCC_capacity+LC_start

Air_capacity_TC_accepting_tourists(t) = Air_capacity_TC_accepting_tourists(t - dt) + (Change_in_TC_capacity) * dt

INIT Air_capacity_TC_accepting_tourists = 1000000

INFLOWS:

Change_in_TC_capacity = (Air_capacity_TC_accepting_tourists*traditional_airlines__growth_rate)/Time_to_adjust__TC_capacity

Population_at_tourists_generation_area(t) = Population_at_tourists_generation_area(t - dt) + (Change__in_population) * dt

INIT Population_at_tourists_generation_area = 284511000

INFLOWS:

Change__in_population = Population_at_tourists_generation_area*Population_avg__growth_rate

Sea_capacity_cruise_ships_accepting_tourists(t) = Sea_capacity_cruise_ships_accepting_tourists(t - dt) + (Change_in_CS_capacity) * dt

INIT Sea_capacity_cruise_ships_accepting_tourists = 20000

INFLOWS:

Change_in_CS_capacity =
(Sea_capacity_cruise_ships_accepting_tourists*Cruise_ships_growth_rate)/Time_to_adjust__CS_capacity+Insability_in__North_Africa

Tourists_in_Lisbon(t) = Tourists_in_Lisbon(t - dt) + (Tourist_in_first_visit + Tourist_in_second_visit - Tourist_leaving) * dt

INIT Tourists_in_Lisbon = (1-equilibrium_switch)*initial_disequilibrium_stock_value

+equilibrium_switch*initial_equilibrium_stock_value

INFLOWS:

Tourist_in_first_visit = local_tourist+foreign__tourist

Tourist_in_second_visit = (Tourist_back_home*Repetition__fraction)/time_to__come_back

OUTFLOWS:

Tourist_leaving = Tourist_in_first_visit/time_to_leave

Tourist_back_home(t) = Tourist_back_home(t - dt) + (Tourist_leaving - Tourist_in_second_visit - Tourist_not_coming_back) * dt

INIT Tourist_back_home = 3000000

INFLOWS:

Tourist_leaving = Tourist_in_first_visit/time_to_leave

OUTFLOWS:

Tourist_in_second_visit = (Tourist_back_home*Repetition__fraction)/time_to__come_back

Tourist_not_coming_back = (Tourist_back_home*not_coming_back_fraction)/time_to_decide

Adoption__fraction = GRAPH(Perceived_Attractiveness)

(3.00, 0.0385), (3.50, 0.044), (4.00, 0.0516), (4.50, 0.0681), (5.00, 0.0769), (5.50, 0.0956), (6.00, 0.112), (6.50, 0.136), (7.00, 0.158), (7.50, 0.178), (8.00, 0.196), (8.50, 0.208), (9.00, 0.215), (9.50, 0.225), (10.0, 0.23)

Advertising = Effect_of_Expenditures_on_Advertising*Potential__tourist

Advertising__expenditures = 0

Average_number_of_persons_per_apartment = 2

Avg_overnight_stays_in_Lisbon = GRAPH(TIME)

(2000, 2.20), (2001, 2.21), (2002, 2.21), (2003, 2.21), (2004, 2.18), (2005, 2.16), (2006, 2.21), (2007, 2.18), (2008, 2.15), (2009, 2.14), (2010, 2.17), (2011, 2.24), (2012, 2.30), (2013, 2.34), (2014, 2.37)

Contact__rate = 5

Cruise_ships_growth_rate = Effect_of_Attractiveness__on_CS

Effect_of_Attractiveness__on_CS = GRAPH(Perceived_Attractiveness)

(0.00, -0.5), (1.00, -0.5), (2.00, -0.4), (3.00, -0.2), (4.00, -0.2), (5.00, -0.1), (6.00, 0.05), (7.00, 0.07), (8.00, 0.1), (9.00, 0.15), (10.0, 0.2)

Effect_of_Attractiveness__on_LCC = GRAPH(Perceived_Attractiveness)

(0.00, -0.5), (1.00, -0.5), (2.00, -0.4), (3.00, -0.2), (4.00, -0.2), (5.00, -0.1), (6.00, 0.05), (7.00, 0.07), (8.00, 0.1), (9.00, 0.15), (10.0, 0.2)

Effect_of_Expenditures_on_Advertising = GRAPH(advertising__expenditures)

(0.00, 0.00), (1.11, 0.000828), (2.22, 0.0018), (3.33, 0.0049), (4.44, 0.00574), (5.56, 0.0063), (6.67, 0.0063), (7.78, 0.0063), (8.89, 0.0063), (10.0, 0.0063)

Effetc_of_Attractiveness_on_TA = GRAPH(Perceived_Attractiveness)

(0.00, -0.5), (1.00, -0.45), (2.00, -0.4), (3.00, -0.3), (4.00, -0.2), (5.00, -0.1), (6.00, 0.05), (7.00, 0.07), (8.00, 0.1), (9.00, 0.11), (10.0, 0.12)

equilibrium_switch = 0

Foreigners_willing__to_travel = WOM+advertising

Foreign__tourist = IF(equilibrium_switch=0)

THEN(MIN(Transport_system__capacity,Foreigners_willing__to_travel))

ELSE(0)

Fraction_of_outgoing_tourist_to_Lisbon = GRAPH(Perceived_Attractiveness)

(0.00, 0.0586), (1.00, 0.0623), (2.00, 0.0989), (3.00, 0.125), (4.00, 0.136), (5.00, 0.158), (6.00, 0.183), (7.00, 0.227), (8.00, 0.264), (9.00, 0.289), (10.0, 0.289)

Holiday__making_rate = 0.3

initial_disequilibrium_stock_value = 2168183

initial_equilibrium_stock_value = 0

Insability_in__North_Africa = STEP(30000,2013)

LC_start = STEP(50000,2013)

Local_tourist = 840000

Low_cost_airline__growth_rate = Effect_of_Attractiveness__on_LCC

Not_coming_back_fraction = 0.82

No_of_days = 365

Number_of_local_residents_living_downtown = Resident_apartment_downtown*Average_number_of_persons_per_apartment

Number_of_trips__per_tourist = 3

Outgoing_visits__per_year = Population_at_tourists_generation_area*Number_of_trips__per_tourist*Holiday__making_rate

Population_avg__growth_rate = 0.1

population_living_in__touristc_area = GRAPH(TIME)

(2000, 37103), (2001, 37103), (2003, 36565), (2004, 36027), (2005, 35488), (2006, 34950), (2008, 34412), (2009, 33874), (2010, 33336), (2011, 32797), (2013, 32259), (2014, 31721)

Potential__tourist = Outgoing_visits__per_year*Fraction_of_outgoing_tourist_to_Lisbon

Reference_Tourist__in_Lisbon = GRAPH(TIME)

(2000, 2.2e+006), (2001, 2.2e+006), (2002, 2e+006), (2003, 2e+006), (2004, 2.3e+006), (2005, 2.4e+006), (2006, 2.6e+006), (2007, 2.8e+006), (2008, 2.8e+006), (2009, 2.7e+006), (2010, 2.8e+006), (2011, 2.9e+006), (2012, 3e+006), (2013, 3.1e+006), (2014, 3.6e+006)

Repetition__fraction = GRAPH(Perceived_Attractiveness)

(3.00, 0.15), (3.50, 0.156), (4.00, 0.163), (4.50, 0.167), (5.00, 0.171), (5.50, 0.177), (6.00, 0.182), (6.50, 0.187), (7.00, 0.19), (7.50, 0.193), (8.00, 0.196), (8.50, 0.198), (9.00, 0.201), (9.50, 0.201), (10.0, 0.2)

Time_to_adjust__CS_capacity = 1

Time_to_adjust__LCC_capacity = 1

Time_to_adjust__TC_capacity = 1

Time_to_decide = 1

Time_to_leave = 1

Time_to_perceive__Attractiveness = 1

Time_to__come_back = 10

Total_number_of__overnight_stays = Tourist_per_year_in_Lisbon*avg_overnight_stays_in_Lisbon

Tourism_intensity__indicator = (total_number_of__overnight_stays/No_of_days)/Number_of_local_residents_living_downtown

Touristic_pressure_effect = GRAPH(Tourism_intensity__indicator)

(0.00, 0.00), (0.0714, 0.00), (0.143, 0.00), (0.214, -0.05), (0.286, -0.07), (0.357, -0.09), (0.429, -0.1), (0.5, -0.15), (0.571, -0.2), (0.643, -0.3), (0.714, -0.4), (0.786, -0.5), (0.857, -0.6), (0.929, -0.8), (1.00, -1.00)

Tourist_per_year_in_Lisbon = Tourist_in_first_visit+Tourist_in_second_visit

Traditional_airlines__growth_rate = Effetc_of_Attractiveness_on_TA

Transport_system__capacity = Air_capacity_LCC_accepting__tourists+Sea_capacity_cruise_ships_accepting_tourists+Air_capacity_TC_accepting_tourists

WoM = ((contact__rate*Adoption__fraction*Potential__tourist*(Tourists_in_Lisbon/(Potential__tourist+Tourists_in_Lisbon))))

Culture.Destination__attractiveness =

Culture.Destination__attractiveness =

Real_estate.Resident_apartment_downtown =

Real_estate.Resident_apartment_downtown =