Consumer Behavior in Airport Selection

The case of "Ticket-tax" in The Netherlands

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Abstract

In response to the implementation and abolishment of a tax on all O&D airline tickets in The Netherlands, research has been initiated in order to investigate how airport choice by passengers, competition between substitute airports and the decisions made by the supply-side of the market have evolved in the period before, during and after the tax. The focus of this paper is on the effects of bounded rationality (habitual behavior, incomplete information) and the interaction between actors. An application of system dynamics modeling is explored to investigate the process of information acquisition about the alternatives by air travelers and the transfer of this information. The model includes the airports of Eindhoven, Niederrhein and Charleroi and uses a multinomial logit function to determine market shares. Preliminary results show that a structural change has occurred in the level of awareness of Niederrhein airport after the taxation.

Keywords: bounded rationality; decision modeling; airport competition; system dynamics

1 Introduction

On the first of July 2008, a tax on all airline tickets for flights originating from Dutch airports was introduced. With the implementation of the tax, passengers flying from The Netherlands to European destinations were charged an additional €11,25. Passengers for intercontinental flights were charged €45,-. The main purpose of the tax is to (partially) internalize the negative externalities associated with air travel. The decision was also affected by the lack of duty on kerosene and VAT on airline tickets (Ministerie van Financiën, 2007). The projected 350 million euro that the tax should generate per year (SEO, 2007) would be invested in sustainable forms of energy. The lifetime of the tax however has been short. On July the first 2009 the tax was reduced to €0,- and later abolished for all passengers due to the economic recession and a strong lobby by airlines and air travel agencies.

Today, roughly a year after the tax has been reduced, data about the actual effects on the involved airports is being collected. Using these data it is possible to derive how airport choice of passengers, the competition between substitute airports and the decisions made by the supply-side of the market in the period before, during and after the tax has evolved. However, the purpose of this research is to gain a deeper insight in the mechanisms that caused the observed behavior with the final aim to develop effective policies that can be used in order to influence passenger choice . It is of special interest to analyze the effects of bounded rationality (incomplete information and habitual behavior) and actor interaction since these are only sparsely covered in existing literature. The insights that are created can serve well when similar taxation plans or related fiscal policy propositions enter the political arena in The Netherlands or abroad.

The paper comprises of four sections. In Section 2 the choice of methodology is discussed. In Section 3 a model is conceptualized. In Section 4 the preliminary results of the simulations are described. Finally Section 5 concludes this paper and discusses the further limitations and possibilities.

2 Methodology

2.1 Methodological requirements

The amount of complexity that a human being can deal with cognitively is limited. Modeling is used in this research as a tool to reduce the complexity of the real-world environment into a more easily and comprehendable environment in which time can be shifted (forecasting) and experiments can be conducted. The elements that make up the modeled environment have been chosen explicitly by the modeler, and capture what the modeler believes are the most relevant factors contributing to what can be observed in the real-world and that relate to the purpose of the study.

In order to comprehend the complex environment of air travel it is decided to use a modeling method. This method should meet a number of requirements in order to be to contribute to the purpose of this research. First, in order to be able to relate the output of the model to time, a methodology should be selected that allows for time dependency (temporal). Second, because we are interested in the interaction between airlines and consumers and vice versa (feedback), the model should be dynamic. Third, in order to transfer the understanding about systemic influences the model should reveal its inner structure (”white box”). This aspect is also desired when policy measures need to be developed and tested. Fourth, the model should facilitate the specification of soft variables since bounded rationality is assumed to play a role in all decision-making processes and is of specific interest in this research.

Besides the direct requirements that can be derived from the research question there are other constraints that limit the number of applicable methods. Data availability is one of these constraints. The data that is available for this research is limited due to the high costs associated with the collection and due to sensitivity of certain data to competition. The second major constraint is the amount and the level of detail of accessible knowledge of the system. The fewer data and the less knowledge about the system, the more aggregate the resulting model will be.

2.2 Currently applied methods

In research on airport choice and demand, a number of methods are frequently used. Table 1 lists the methods that were encountered most in literature and states the general purpose of each method. In the third column of the table the method is characterized by stating the most important properties.

Two streams of models in research on airport choice and demand can be identified. The first and most represented stream is that of determining which of the attributes connected to an airport are most significant or especially influential in the decision process. The data used to estimate the consumer preferences that are used in these models are obtained from revealed or stated preferences acquired by consumer surveys or laboratory experiments.

The second stream of research is concerned with developing demand forecast models. We can distinguish here between short term forecast that are conducted using time series analysis and medium to long term forecasts. The medium and long term forecast models use logit models, and demographic and macro-economic data in order to determine the potential demand. Because the use of a logit model, sufficient data is required to estimate the unknown preference parameters.

To conclude we see that two of the three previously mentioned methods are static models, which means that the output they produce relates to a single point in time. Because the output is directly related to the input, none of the methods can be used to reveal the underlying systemic factors and mechanisms that produce the output. Put in other words, the focus is on output and accuracy of the output. The econometric simulations assume full rationality, e.g. it is assumed that travelers are aware of all airports within their reach and have perfect knowledge about the attributes of these airports. Finally, none of the methods is used to model dynamic interactions between the actors and state variables in the system.

Tab. 1: Common methodologies in airport/transport planning models

Method	Purpose	Characteristics
(Cross- sectional) regression analysis (Hess et al., 2007; Pels et al., 2001)	Find significant airport choice determinants	Static, estimate of consumer preferences at a single point in time.
Time series analysis	Filtering of data, short term demand forecasting	Extrapolation of data, no systemic explanation of unique events
Econometric simulations (Ashley et al., 1995)	Estimate market share of an airport based on current or future utility	Static equilibrium models, full rationality, black box, no dynamics

System dynamics is a modeling methodology that is intended to model complex systems at an aggregate/systems level. The methodology is developed around the philosophy that the behavior of a system over time is driven by the structure of the internal mechanisms (Meadows & Robinson, 1985). These mechanisms comprise of positive (reinforcing) and negative (balancing) feedback loops. The system is specified as a set of (perceived) causal relations reflected in stocks (accumulations), flows, auxiliaries and constants. Together, these components form a system of differential equations that can be solved numerically with the use of computer software. System dynamics is widely used to model complex (social, socio-economic and physical) systems over time(Sterman, 2000).

In Table 2 the requirements imposed by the research issue and purpose are contrasted with the 'summarized' characteristics if the current research methods and with the characteristics of system dynamics. System dynamics is selected as it matches the requirements imposed by the research.

Tab. 2: Comparison current methods with SD

Required	Current methods	SD
System output over time	temporal, cross-sectional	temporal
Understanding of system	'black box'/output oriented	'white box'/system oriented
Dynamic interaction	static (no feedback)	dynamic (feedback)
'soft' factors	numerical accuracy	general tendency

3 Model Description

3.1 Overview of the system

To keep the model from becoming too complex, a set of three airports has been chosen to be assessed. The most important criteria for these airports is that they facilitate services that are (potentially) competitive. An airport that for example only has general aviation is not likely to compete with an airport that is solely designed to facilitate the operation of a large commercial fleet. Less strong, but still relevant is the dedication of an airport to a specific group of users such as business or leisure travelers, and the function of the airport in the network, e.g. regional or hub airport.

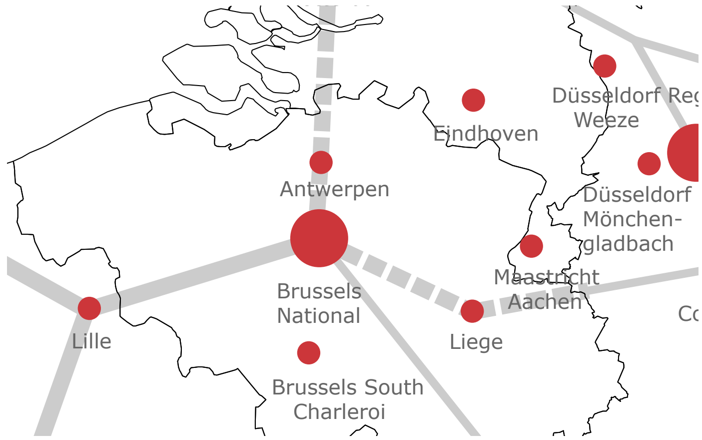


Fig. 1: Map of the modeled airports

In the context of the Dutch ticket tax, three regional airports are specifically interesting namely Eindhoven airport in the south of The Netherlands, Brussels South - Charleroi and Airport Weeze, that is located about 80 kilometers from the city of Dusseldorf (Figure 1). There are four reasons why these airports have been selected. The first is that since they are all regional airports and are located within 2.5 hours (by car) distance from each other, their catchment areas overlap leading to potential competition. The second reason is that all three airports provide a very similar type of services and destinations, which mainly consists of low-cost flights to popular tourist destinations. The more similar these services are, the more perfect the substitutability between the airports.

The third reason is that low-cost airlines are in general more ”footloose” than traditional network and full fare carriers (Graham, 2008). There are no concerns regarding the preservation of a network and low-cost airlines are not likely to have substantial sunk costs at specific airports. When a route does not prove to be financially viable, a decision can be made within a relatively short period of time to erase the route from the time tables. These airlines are thus highly capable of quickly adapting to demand. The fourth and final reason is that passengers that are attracted by low-cost airlines are in general relatively price sensitive passengers. Hence, they are more likely to react on an increase in ticket prices as a result of the Dutch imposed ticket tax.

The model is spatially distinct in three geographic regions. The reason for defining these regions is that due to the existence of national and language boundaries, communication between groups of people might be reduced. Consider for example the level of information transfer between two Dutch speaking citizens and between a Dutch and German speaking citizen. Besides the language barrier, the probability to encounter each other is simply smaller. The three regions that are specified comprise a Dutch territory, a German territory and a Belgium territory. It is assumed that travelers originating from the same territory speak the same language.

3.2 The simulation model

The simulation model comprises of three subsystems (Figure 2). Each of the systems is described separately below. Several properties have been assigned to the passengers in the model in order to keep track of the developments. These properties are; last airport used, awareness of the other airports in the model, utility perception of the other airports, travel motive and location of origin. The model does not consider individual passengers, in stead groups are modeled. As a member of a group you share the properties that the other members of the group have. When you change between groups, the airport related properties properties that you have inherited from the first group will be taken to the second group. If the values of these properties differ, the average value of these properties in the new group will change. This construct ensures that knowledge and experience does not disappear suddenly.

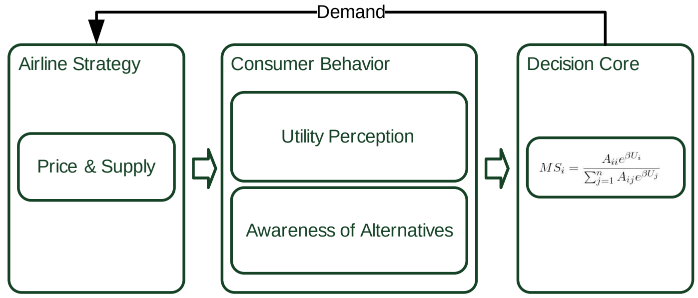


Fig. 2: Model overview

3.2.1 Consumer behavior

A literature study has been conducted to identify what decision-making is about. The decision-making process is described by the cognitive decision sequence (Erasmus et al., 2001), Figure 3. It is generally accepted that every decision process starts with the identification of a problem, for example to book a holiday. When the problem is clear, information is required to ensure the most adequate decision can be made. Three items of information are required to make a decision. The alternatives have to be known (awareness), the properties of the alternatives have to be known (utility) and finally, one must know their own preferences. With awareness, the probability to consider an airport as a suitable alternative is modeled. The utility is defined by the frequency of flights, the access time and the average ticket price at the airport. These three items have been found in various studies to be most significant in airport choice.

The required information can be obtained in three ways. The first is by own experience with the chosen alternative. This information is subject to the least amount of bias. The second and third way of obtaining information is through communication. This communication can either be social or commercial (marketing) (Howard & Sheth, 1969). Social communication, e.g. talking to friends, neighbors and relatives, is called word-of-mouth (Arndt, 1967). Commercial information can contribute to the prestige and branding that is perceived of a product as well as to the knowledge of the product attributes (Ackerberg, 2003). The bias and resistance that is evoked by commercial sources is thought to be higher than with non-commercial information transfer (Tiemeijer et al., 2009). The amount of commercial and non-commercial communication determines the level of social exposure to a given airport. Once the information is (partially) obtained, it is matched with the preferences of the decision-maker in order to produce a ranking.

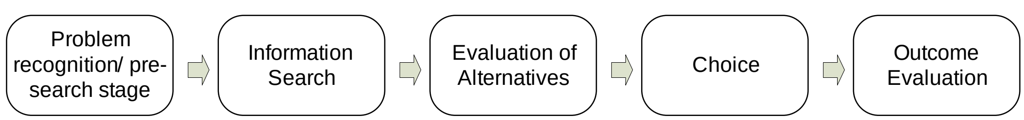


Fig. 3: Cognitive decision sequence, adapted from Erasmus et al. (2001)

In the simulation model both the utility perception, which is the knowledge and valuation of the attributes of an alternative, and awareness of an alternative are considered. Both aspects are considered to be properties of a specific group of people and not of an individual. The values of these properties are updated by the before mentioned concepts of learning (direct experience), marketing and word-of-mouth. In Figure 4 the feedback structure of the awareness updating process by word-of-mouth is shown. A similar structure exists for the updating process of utility but in order to keep this paper concise only the awareness updating process is described..

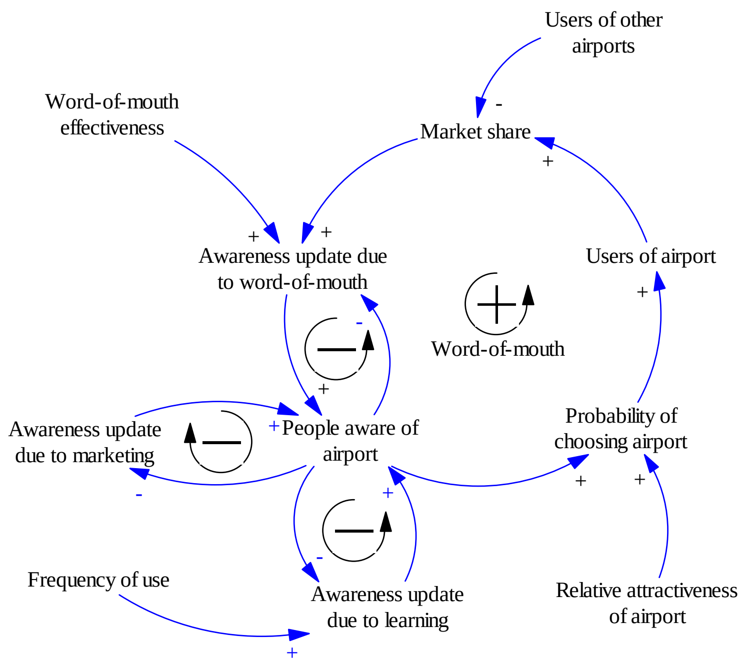


Fig. 4: Awareness updating

The figure should be read as follows; arrows indicated with a + sign indicate that there is a positive relation between the connected factors. For example, the more users of an airport, the higher the market share of the airport if all other things are equal. An arrow that is indicated by a - sign indicates that there is a negative relation between the connected factors. For example, the more users at other airports, the lower the market share of the airport under consideration. The ⟳ symbol indicates a feedback loop. A positive (+) feedback loop is also called reinforcing loop and can cause, under certain circumstances, exponential growth. A negative (-) feedback loop is also called a balancing loop and usually has a dampening function.

What is seen in the figure is that due to the process of word-of-mouth more and more people become aware of the existence of an airport and start considering it as an alternative. Initially, if the market share of an airport is low, the speed at which awareness is updated is low, since the probability to encounter someone that know about the airport is low. When the market share starts to increase, the speed of updating will increase until finally almost everyone is aware of the alternative and the probability that you encounter one that does not know is small and hence the speed of update decreases again. Under ideal circumstances this would lead to the classic S-shape. Awareness is defined as 0 if nobody in the group is aware and 1 if everybody is aware of the alternative and considers it when choosing.

In the model it is also considered that when people are not using an airport, they slowly forget about it and about the attributes that it has. Furthermore, it is assumed that when a habit is formed, other alternatives are (partially) ignored. Habits are formed when the same airport is chosen consecutively. How long it takes before a habit is formed depends on the time it takes to reduce the awareness of other alternatives. In case the frequency of flight is high, and the users are choosing between all alternatives, a habit is unlikely to be formed. The more individuals from the group will consistently choose for one specific airport, the less aware the group becomes of the other alternatives, the stronger the habit is assumed.

If we combine the updating and forgetting we can compose the formal differential equation in which i and j are the indexes of the n airports and range from $\{1, ..., n\}$:

$$\frac{dA_{ij}}{dt} = E_{ij}(A_{jj} - A_{ij}) - F_{ij}A_{ij} \quad (1)$$

In which:

$$E_{ij} = \alpha_j + c_{ij}MS_j \quad (2)$$

Where E_{ij} represents social exposure of users of airport i to airport j. Social exposure is a function of α_j (marketing effectiveness of airport j), the effectiveness of word-of-mouth c_{ij} between users of airport i and the users of airport j and the market share MS_j of airport j. The word-of-mouth effectiveness multiplied by the market share can be interpreted as a measure for the probability that a user of airport i encounters a user of airport j.

The forgetting rate is defined as:

$$F_{ij} = F_0\, f(E_{ij}) + \frac{1}{\tau_I} \quad (3)$$

The equation combines two effects. The first term of the equation represents the forgetting effect as a result of insufficient social exposure. In which F_0 is the maximum forgetting rate and a function of social exposure is included because it is assumed that forgetting takes more time in case the social exposure is high. The second term of the equation represents the part of forgetting that is independent of social exposure and in which τ_I is the standard ignorance time related to the formation of a habit. A large standard ignorance time will result in a very gradual formation of a habit, even if just one airport is consecutively chosen. However, when the standard ignorance time is small, a habit can quickly be formed.

3.2.2 Decision core

The decision core of the model determines what share of the population considered in the model will go to each airport based on the awareness and perceived utility. The actual utility is composed of a deterministic part and a random part (Ben-Akiva & Lerman, 1985). It is assumed that the market shares are distributed according to the relative difference between the utilities of the alternatives and the awareness of each alternative. It is also assumed that the random parts of the utility for each alternative are equal and thus can be left out of the equation.

The deterministic part of utility is defined as:

$$V_i^a = \beta_P P_i + \beta_T T_i. + \beta_F ln\,(F_i) \quad (4)$$

Where V_i^a is the deterministic actual utility of airport i, P_i is the average ticket price at airport i in euro, T_i is the access time in minutes and F_i is the number of flights per week. The beta (β) values in this equation are measures for the relative importance passengers give to the different attributes (preferences), that are considered stable over time. Because the beta values are multiplied with the attribute values, the absolute difference between the utilities increases or decreases. The logit function then makes sure that the larger the absolute difference in utilities, the larger the difference in market shares. A very high beta value will thus yields a market share of near to 100% for the alternative with a slightly higher unweighted utility.

The fraction of users of airport i choosing for airport j can now be calculated by using the multinomial logit equation:

$$MS_{i\to j} = \frac{A_{ij}e^{V_{ij}^p}}{\sum_{k=1}^{n} A_{ik}e^{V_{ik}^p}} \quad (5)$$

In which A_{ij} represents the awareness of travelers that previously used airport i with airport j, V_{ij}^p is the perceived utility that users of airport i hold of airport j. The perceived utility is only equal to the actual utility in case there is perfect information. Finally, V_{ik}^p is the perceived utility that users of airport i hold of airport k, in which $k \epsilon n$. It can be concluded that airports of which a user is not aware of are not considered in the decision process, e.g. $A_{ij} = 0$ yields $MS_{i \to j} = 0$. With the market shares we can than calculate the inflow of passengers to each airport.

Finally the number of passengers choosing for airport i equals:

$$PAX_{\to i} = \sum_i \sum_j MS_{j \to i} PAX_{j \to} \tag{6}$$

Where $PAX_{\to i}$ is the number of passengers changing to airport i and $PAX_{j \to}$is the number of passengers that have used airport j and are about to make a new traveling decision.

The outflow of passengers from the stock of airport users is a function of the frequency of flight and the total number of users of that specific airport. Strictly speaking this means that passengers will remain at the last airport they have chosen until they will have their next flight. The simple equation used to control this is:

$$PAX_{i \to} = PAX_i f \tag{7}$$

Where f represents the number of flights per time unit in the model and PAX_i is the number of people that last used airport i.

3.2.3 Supply side

After demand is generated based on the total population and the shares of passengers choosing for each airport the airlines have to ensure that there is sufficient capacity to actually facilitate the demand. The model uses a simplistic setup that uses the forecasted demand to determine the gap between the desired number of seats and the available number of seats. This gap is then closed by adding flights. The model considers just one single airline that operates on all airports. The strategy of the airline on each airport is thus identical. Transfer of flights from one airport to the other only takes place if demand at one airport decreases and increases at the other. The price of a ticket reacts on demand. When flights are above (below) the normal average load factor (which is assumed to be 0.8 for low cost carriers (Kangis & O'Reilly, 2003)) the price will increase (decrease) according to a predefined non-linear function. In Figure 5 the feedback structure of this sub-model is captured.

The first step of the subsystem is to determine the future demand based on the current trend by:

$$PAX_i^F = (1 + r_i)^{\tau_p} PAX_i \tag{8}$$

In which PAX_i^F is the forecasted number of passengers at airport i, r_i is the growth rate of airport i and τ_p is the time horizon for the forecast. The forecasted number of passengers is obtained through the use of an expectation formulation structure originally developed by Sterman (2000, pp. 631-642). The desired number of flights can then simply be calculated by:

$$F_i^d = \frac{PAX_i^F}{S \cdot lf_N} \tag{9}$$

Where F_i^d is the desired number of flights per time unit at airport i, S is the average number of seats per aircraft and lf_N is the normal average load factor. The change of flights per time unit at airport i then becomes:

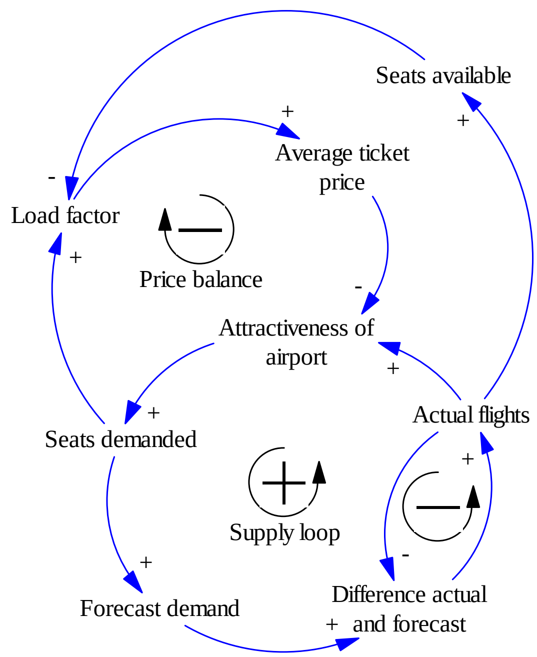


Fig. 5: Airline behavior

$$\frac{dF_i^a}{dt} = \begin{cases} \frac{(F_i^d - F_i^a)}{\tau_s} & F_i^d \geq F_i^a \\ 0 & F_i^d < F_i^a \end{cases} \tag{10}$$

Here the distinction between capacity deficit and surplus is made since an airline can choose not to reduce flights in times of reduced demand in order to keep the attractiveness high. In this equation F_i^a represents the actual number of flights per time unit offered at airport i and τ_s is the average scheduling delay between realizing demand and actually operating an additional flight.

The load factor is calculated by:

$$lf = \frac{PAX_i}{F_i^a S} \tag{11}$$

The price is a function of the average ticket fare ($\bar{P}_i$), the load factor and the normal average load factor:

$$P_i = \bar{P}_i f(\frac{lf}{lf_N}) \tag{12}$$

The function is defined graphically and results in 1 if the current load factor is equal to the normal average load factor and runs asymptotically to 1.3 at load factors larger than the average. The load factor runs asymptotically to 0.7 for load factors smaller than the average.

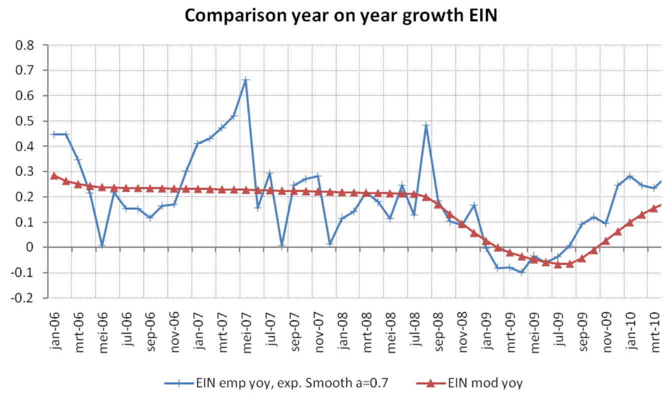


Fig. 6: Comparison with empirical data Eindhoven

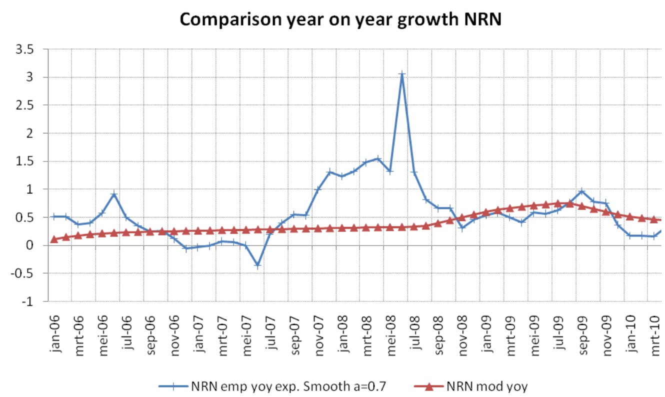


Fig. 7: Comparison with empirical data Niederrhein

4 Preliminary Results

4.1 Comparison with empirical data

The model has been calibrated numerically to be able to reproduce the observed behavior. Figures 6, 7 and 8 show the results of this calibration. The year-on-year growth rate has been calculated based on the modeled passenger numbers and on the empirical data. A slight shift in timing has occurred at Eindhoven that is not explained yet. The large peak at Niederrhein in the period before the tax was implemented was the result of a supply-side decision to double the amount of flights (OAG). At Charleroi nothing seems to happen initially, but a slight growth (empirically) can be observed later. The model was not able to reproduce this behavior.

4.2 The ticket tax mechanisms

The modeled results show that the airport of Charleroi only a slight increase of passengers can be observed as a result of the the Dutch taxation. This can be explained by the large access time from the Netherlands. Niederrhein is a more effective competitor for Eindhoven. It is assumed that the initial awareness in The Netherlands of Niederrhein was rather low at the start of the simulation. Due to the processes of social exposure and learning, awareness started to increase in the period before the taxation and reached an equilibrium value (maximum awareness was not reached due to habit formation). The implementation of the tax was accompanied by a publicity boost that caused

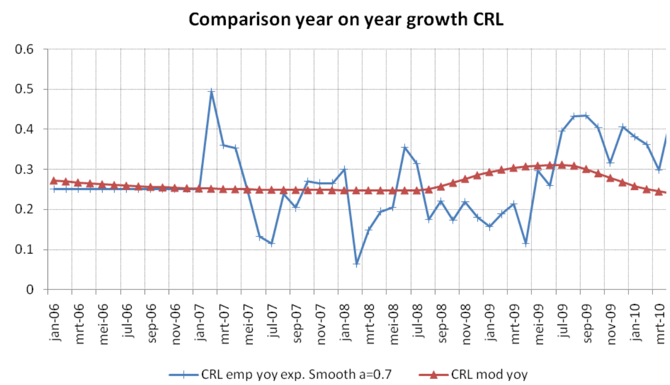


Fig. 8: Comparison with empirical data Charleroi

a temporary increased awareness of Niederrhein. This increased awareness resulted in more people choosing for Niederrhein. The airlines reacted on this by allocating additional flights on the airport. (Figure 9).

After the taxation has been abolished, the airport has become more attractive to travelers as a result of the additional flights (increased utility) and thus has obtained a higher market share in The Netherlands. Because the word-of-mouth effect increases with increasing market share, the social exposure has increased, resulting in a higher awareness equilibrium.

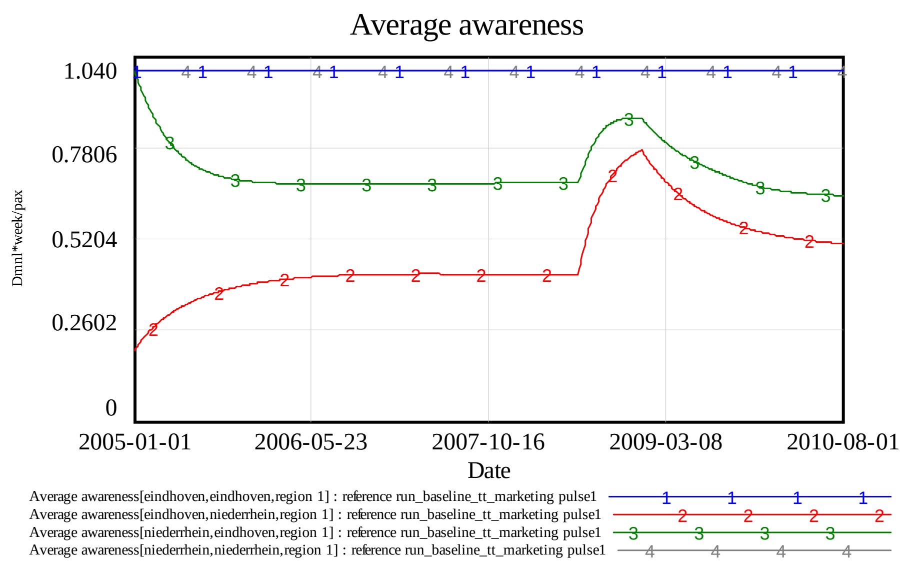
4.3 Effect of over expectancy

While testing the functionality of the model, it was found that deliberately creating over expectancy of the utility of an airport has long term effects on the passenger numbers. Figure 10 and 11 show the effect of a lower perceived price on passenger numbers and annual trend. The trend-line clearly shows that although Weeze airport grows substantially more in the first period compared to the base case, the growth converges towards the normal growth in the base case over time. In terms of users the damage in the early stage to Eindhoven proved to be at such a level that the airport will not be able to retrieve its base case value and Weeze will have a large benefit of the over expectancy of utility.

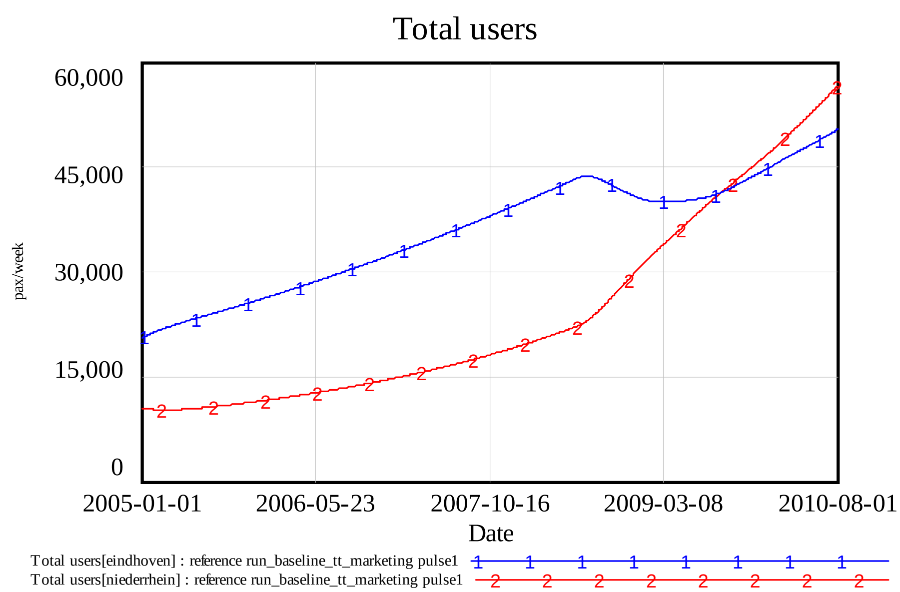
4.4 Policies

Now we have an idea which factors (other than the increase in ticket price in NL) have caused the effects on airport demand, we can try to directly or indirectly influence these factors. A sensitivity analysis is conducted to determine which factors the model is most sensitive to in order to pinpoint where the most effective policies can be taken.

The model proved to be behaviorally insensitive, which means that the shape of the output variables did not change considerably. As all system dynamics models, there is a large degree of numerical sensitivity to the input parameters. The most influential parameters are the determinants of utility, as can be expected. More interesting however is that the factors related with the formation of a habit seem to have a relatively large influence. Also factors that define the effectiveness of communication between groups contribute significantly to the outcome.



(a) Average Awareness



(b) Total users

Fig. 9: Awareness and total users

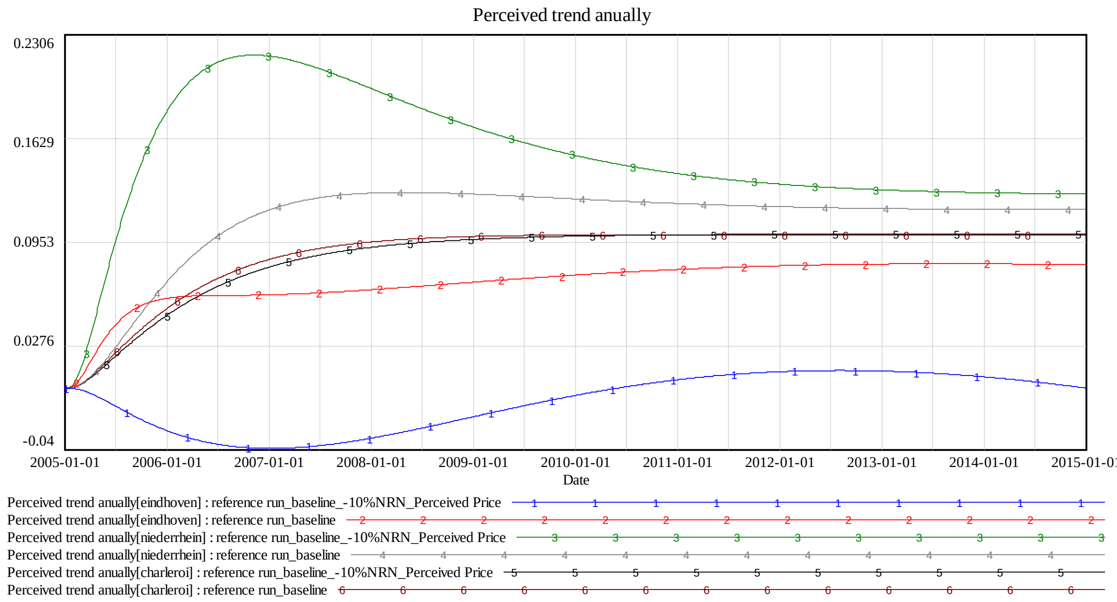


Fig. 10: Over expectation annual trend

5 Conclusion and Discussion

This paper described that in search for insight in mechanisms that have affected the shift of demand after the implementation of the Dutch ticket tax, the traditional models offer limited capabilities. A new, system dynamics model has been developed to complement these traditional models. The development of the model was preceded by a literature study in which in was found that three items of information are required to make a decision. The model is developed to account for the transfer of information between groups of people and incorporates the contribution of learning by direct experience. Furthermore, the supply side of the market is included and interacts dynamically with the demand side.

It is concluded that in the model, Charleroi is not affected by any large amount. Furthermore, the awareness of Niederrhein has structurally changed after the tax compared to the period before. It is also found that creating over expectancy in an early stage of airport development, can result in a significantly different outcomes of passenger numbers. Finally, policies should be targeted at the formation of habits and on information transfer in order to be effective.

The conclusions drawn from the model are affected by the assumptions that underlie the valuation of the parameters and more importantly the chosen structure of the model. The usefulness of the model is therefore highly affected by the validity of these assumptions. The validation of the model is however difficult due to two reasons. First, soft variables that are hard or even impossible to measure empirically have explicitly been used. Second, the structure of the model is not the only structure that can produce the observed behavior. Although proven structures from literature are used as major building blocks, the choice of which mechanism to include and which not is subject to uncertainty. The validity of system dynamics models is therefore more related to how useful the model is given the purpose and objectives of the research.

A final note should be placed on the level of aggregation of the model. The model reflects a simplified reality in which the unique behavior of individuals is averaged out by the group behavior. This is valid for both air travelers as well as for airlines. As a result, the simplification of consumer behavior and airline strategy could influence the results of the model and therefore the conclusions drawn from the model. Additional research is required to assess the impact of these simplifications and to explore the opportunities for more disaggregate modeling methods such as agent based modeling.

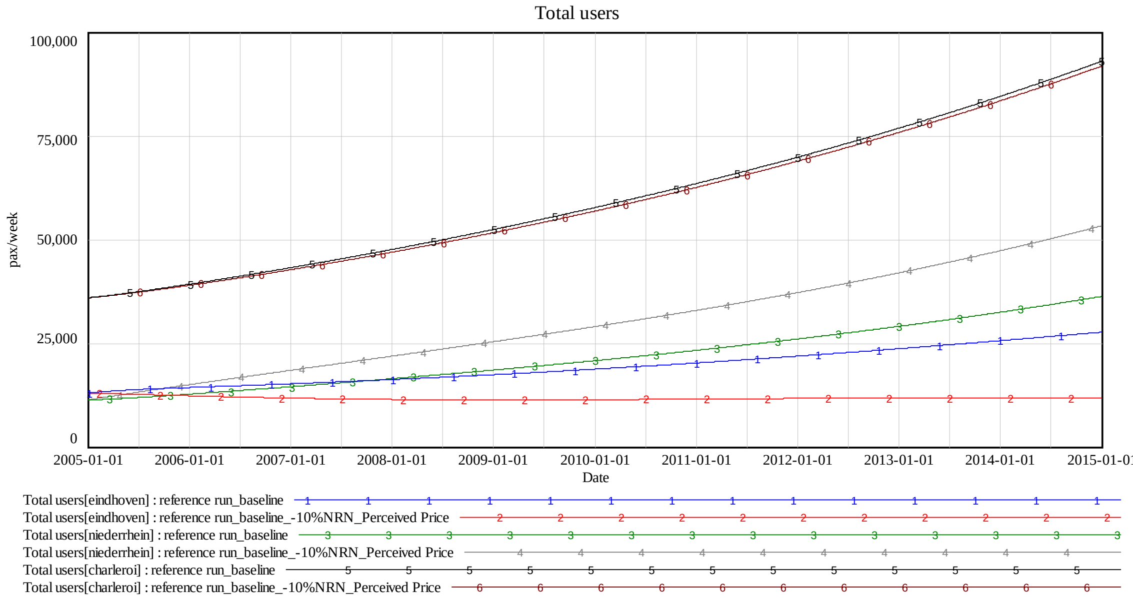


Fig. 11: Over expectations

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