An empirical analysis of airline market concentration

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Abstract

This project was conceived as an extensive empirical analysis of the U.S. domestic airline market, to address the question of why there are so many routes operated by few carriers (e.g. under monopoly or duopoly conditions). Questions about market concentration, entry deterrence and reputation arose later. In particular, we focused on the number of carriers serving a route, their market power and the different levels of competition on a route. The main data source was the Department of Transport's DB1B origin-and-destination database, which contains a 10% random sample of all tickets sold for domestic travel in the U.S. since 1993. The two main tools used in our research have been qualitative (microeconomic) analysis and quantitative (econometric) modelling. Statistical models have been developed in an attempt to explain the main variables of interest as a function of explanatory factors, using the EViews econometric software. Among other results, we have observed considerable stability on the routes over time, as well as a higher probability of presence of a dominant carrier on a route as the route population increases.

1 Introduction

The aim of this project is to perform an empirical analysis of the U.S. airline domestic market. We are interested in examining the number of carriers serving a given route, the concentration of the market, the nature of competition, and all the underlying factors and variables.

Our first step was to develop some insight on the workings of the U.S. domestic market and concepts such as entry deterrence, reputation, market concentration and competition. We knew that the Department of Transport's DB1B database (a freely-available database covering 10% of the tickets sold in the domestic U.S. airline market since 1993) was available to us and it will constitute our main working tool. The database is so large that in order to achieve our objectives the second step was to do some serious thinking about how we wanted to treat the database. We then defined the variables that we would use later. Once we started obtaining some results, we performed various qualitative and descriptive analysis, to verify if our first assumptions on the market were correct. Some surprising findings were obtained. We then built three different empirical models (using econometric theory and EViews skills that we developed for this project), trying to find out which are the main variables influencing the number of carriers and the Herfindahl Index (a way to measure market concentration) on a route. Lastly, we reinterpreted all our analysis taking into account the model results and we came to our final conclusions.

The structure of the report is as follows. Section 2 deals with the treatment of the core data. In Section 3, the variables needed to perform the regressions (models) on the market are defined and explained. Section 4 focuses on routes served in monopoly and features the first model. In Section 5, a similar analysis to that of the previous section (including another model) is performed for routes served by more than one carrier. Section 6 includes an extensive study of market power and competition ,as well as our third and final empirical model. Section 7 and Section 8 are a theoretical study of entry deterrence and reputation: main concepts are explained, and guidelines about how to measure these effects are given. A lack of time to cover these subjects prevented us from going any further. Finally, in the Annexes we can find a part of the work that was not included in the main text. A preliminary empirical model, a study on the heterogeneity of the market, and further plots, EViews codes and regressions are featured.

As for the potential applications of the project, a better understanding of the U.S. market can be very useful for carriers in a process of expansion. Routes that could potentially admit more carriers than they actually have can be spotted, or forecasting future market concentration on a route can be performed with our models. A carrier making a decision about which route to enter may use these results to its own advantage and make more accurate decisions. The project is also useful from a theoretical point-of-view, and can highlight important features of market structure and concentration that realistic empirical and theoretical economic models should satisfy, in addition to the usual econometric diagnostic statistics that are checked.

Contents

2 Core data

Throughout this project, we have used a rich statistical dataset from the **American Bureau of Transportation Statistics (BTS)**[1]. Particularly, we were interested in the **Airline Origin and Destination Survey (DB1B)**. This dataset contains a 10% random sample of the reporting carriers, giving information on the domestic traffic over the past 17 years. This dataset is been updated every 3 months, as a consequence, the available data is quarterly. We use data up to 2009Q1 in our empirical work.

The DB1B database is divided into three main parts: Market, **Coupon** and **Ticket**. For this project, we have used the second and third parts.

2.1 DB1B Coupon and Ticket databases

These databases catch (from each single domestic itinerary report given by the carriers) information regarding: origin and destination of the flight, the nominal itinerary fare, number of passengers per ticket and the travel length, among other relevant variables which will explained below. Figure 1 shows the form of this database, which is constructed using Python code, from the raw DB1B datasets and using U.S. CPI data to deflate nominal fares.

[1] This entity was established as a statistical agency in 1992, and its mission is to create, manage, and share transportation statistical knowledge with public and private transportation communities and the Nation. The BTS data collection program for aviation is authorized under separate legislation enacted when the Civil Aeronautics Board (CAB) was terminated. This program is a mandatory data collection from carriers.

Orig	Dest	Year	Q	Op. Carrier	Average Fare	Total Pas	Route	R. code	C. code	Time	CPI quarter	CPI deflator	Real Average Fare
PHL	PSP	1993	1	AA	722.26	69.0	PHL_PSP	6807	12	1	142.6	1.48	106.94
LAX	MSP	1993	1	UA	456.96	65.0	LAX_MSP	5448	81	1	142.6	1.48	676.61
DAY	MIA	1993	1	DL	293.15	143.0	DAY_MIA	2904	26	1	142.6	1.48	434.06
MSN	ORD	1993	1	AA	22.36	64.0	MSN_ORD	6315	12	1	142.6	1.48	331.16
CAK	DTW	1993	1	NW	343.44	90.0	CAK_DTW	2014	52	1	142.6	1.48	508.52
BOS	ORD	1993	1	CO	249.35	148.0	BOS_ORD	1480	21	1	142.6	1.48	369.21
DEN	RNO	1993	1	UA	269.05	241.0	DEN_RNO	3201	81	1	142.6	1.48	398.37
IAD	OKC	1993	1	AA	524.57	75.0	IAD_OKC	4731	12	1	142.6	1.48	776.71
LGA	ORD	1993	1	AA	541.03	4417.0	LGA_ORD	5608	12	1	142.6	1.48	801.09

Figure 1: DB1B Coupon and Ticket treated data.

2.1.1 Origin and destination airport

This dataset provides us with the departure and arrival destination airport for each route. It is then possible to determine the endpoints of each route, once some assumptions are made.

2.1.2 Year of trip and corresponding quarter

The dataset also provides the date of travel (year) and the corresponding quarter. For example, as it is possible to see in Figure 1, the first row corresponds to year 1993, quarter 1, which means that this flight was performed somewhen during a time period of three months (January - March).

2.1.3 Operating carrier

The operating carrier is the company which actually served the route (transported passengers), not that which sold the ticket (ticketing carrier) or reported the data (reporting carrier) to the Bureau of Transportation. This information is posted as a 3-letter IATA code and such coding is available on the airline codes web page.[2]

2.1.4 Average fares

This is the average price paid by the ticket and due to some problems regarding the current database where some fares seems to be high rather than others which are lower than the normal ones, it is necessary to implement an upper and lower limit, which in our case have been defined as follows:

$$\textit{Upper Limit} = \textit{US\$1000},$$

$$\textit{Lower Limit} = \textit{US\$20}.$$

[2]The Airlines Code Web Side is a web page at which one can quickly find information regarding airlines coding www.airlinecodes.co.uk/airlcodesearch.asp

2.1.5 Total passengers

The numbers of passengers whose bought a ticket for a route at a given price with a specific reporting carrier. An important quantity of buyers does not mean any connection between the travellers, the only relation that could appear is the fact that each of them bought the ticket in the same quarter, for the same route and for a closely related price. This dataset will be one of the most important during whole project due to its direct correlation with demand of the market.

2.1.6 Route, route code, carrier code and time

These values are another means of representing what has been identified previously, to enable easier manipulation of the database. They can be identified in Figure 1.

2.1.7 Inflation

This issue comes up due to the fact that one ticket reported by a carrier to the Bureau of Transport Statistics in 1993 has been reported with the current value of the dollar in 1993, on the other one ticket reported in the last quarter of 2009 had the actual value of the dollar at 2009. Nevertheless, it is not possible to compare those two values because the purchasing power of $1 at that time may be very different to the actual one. As a consequence, it is necessary to implement a method to deal with this matter such as the introduction of the **Consumer Price Index (CPI)**.[3]

[3]The Consumer Price Indexes (CPI) program produces monthly data on changes in the prices paid by urban consumers for a representative basket of goods and services. Further information can be found at this website: www.bls.gov/cpi/

Previous studies have demonstrated that the CPI generally increases in the U.S. Thus, a simple manipulation (least squares estimation) gives an estimated coefficient which is mainly the average increase of **CPI per quarter**. As it is possible to see in Figure 1, the current dataset corresponding to **CPI quarter** has been computed, as well as the value of **CPI deflator** for each quarter, which will be a multiplying factor between the reported fares and the real fare value.

2.1.8 Real average fares

This value has been determined by use of the *"CPI deflator"* as multiplying factor to determine the corresponding value of the average fare, taking into account the inflation rate.

2.1.9 Route

A uni-directional *route* is defined by its two endpoint airports (for instance, LAX – JFK and JFK – LAX are considered to be the same route). The tickets from which the routes are constructed are return tickets, and either direct or non-direct (with a maximum of one plane change per leg, and with no stopover). We consider tickets with a maximum of 4 coupons (a maximum of one stop on one-way tickets and two stops on return tickets).

These assumptions are made in order to avoid unusual cases (as we consider that most of the passengers travel from one airport to another with no more than one airplane change). Information about the airport were the stop-over is made will be lost.

Percentage of omitted tickets From the DB1B database, we compute the percentage of tickets with more than 4 coupons, for two illustrative quarters (2008Q1 and 2009Q1), obtaining 6% and 5.8% of the total number of tickets. This is an acceptable value of missing tickets, as we will be modelling around 95% of the market and we will be leaving out "strange" cases.

2.1.10 Enplanements

An *enplanement* is defined as a revenue passenger boarding an aircraft, and so one-way tickets would be regarded as one enplanement, while return tickets would be considered as two enplanements on the same route.

Airline service on a route The minimum number of enplanements necessary for an airline to be considered as *serving* a certain route is 1000 enplanements per quarter. We set this value by rounding up a minimum of one 50 passenger flight per week. We hope to retain data on smaller regional markets while removing any extraordinary service.

2.1.11 Airports and carriers

We retain routes on all available airports in the DB1B, in order to keep as much heterogeneity as possible in the data. Likewise, we retain all recorded operating carriers. (We will not take ticketing carriers into account). For a carrier to serve a route, we require it to be the operating carrier on every leg of the route.

For instance, if a passenger flies LAX – ORD – LAX, travelling first with CO and then with AA, it would count as 1 enplanement for each carrier on the given route.

3 Modelling markets and competition

The analysis of U.S. domestic air transport market behaviour will depend upon several aspects. This project aims to explain the main important steps in building an econometric model which captures each of them as far as possible, taking into account the available data and the issue of qualitative variable constraints. During the first part of the modelling, variables regarding the **socio-economical** aspect have been determined, such as **route population** which allocates a specific value for population to a given route, the **gross domestic product** which measures the economic "wealth" of an airport's surrounding area, the market power of carriers serving a route is given by the **Herfindahl Index**, the **fare standard deviation** is a variable related to a carrier's underlying cost structure. Secondly, variables concerning **geographical** aspects have also been taken into account, such as **route distance** which will relate to how the route length can influence the number of carriers serving a route. Then, variables related to the intrinsic nature of the carriers itself have been included. These variables are trying to assess the impact of a given **carrier presence** on market structure, and also what happens if they are forming **alliances** with others carriers. After, a variable regard to **fare class** distribution has been covered by gross domestic product data manipulation, and the output information was split into **leisure** and **business** activity. As a consequence, it has came out with a mean to measure the impact of each of them. Finally but not less important, is the influence on the market if a given **carrier** decide to **enter first** to operate a route.

A detailed explanation of each variable will be presented below.

3.1 Context of preliminary model

A preliminary analysis of variables was performed during the first modelling development phase. At that time, our intuition regarding the air transport economy, combined with good knowledge of the availale data, allowed us to come up with a large set of variables and a specific preliminary concept of a model which can be seen in Appendix A.1.

3.2 Socio-economic variables

3.2.1 Route population

In order to determine a correspond variable related to **population** which is directly connected with the objective market, the variable **route population** is interesting. This variable is the **geometric mean of the endpoint cities population** of the corresponding route and is rounded to the nearest person. For example, if we consider the route between Baltimore and Detroit *(BWI - DTW)*, the corresponding route population will be the geometric mean of the population of these two cities.

The specific equation is presented as follows:

$$Pop = \sqrt{PopA \times PopB},$$

where $PopA$ and $PopB$ represent the populations of cities A and B. On the other hand, it is important to mention that this variable has been divided by $1,000,000$ in order to get a scaled value with the same order of magnitude as the other variables.

3.2.2 GDP (Gross Domestic Product)

It seems clear that the carriers' motivation to serve a route depends upon several issues, one of these will be the economical situation of the cities or regions involved in the route. The ***GDP*** works as a good economic growth explanatory variable, which represents how healthy is one city or state. **The Gross Domestic Product** is a measure of overall economic output in a country, state or city. It is the final value of the products and services which are made or offered inside the territory. We use the GDP of the **metropolitan** and **micropolitan** areas with data taken from the **U.S. Bureau of Economic Analysis (BEA)**. The data is split into **Metropolitan Statistical Areas (MSA's)** and **Micropolitan Statistical areas (mSA's)**. As a consequence, we have used the MSA data in this project. At the same time, in order to get a value related to route population, this dataset has been divided by the corresponding route population.

On the other hand, it is also important to note that the GDP variable has been defined only for airports at which Southwest is present (due to data availability restrictions). Future work could expand the GDP data to include all U.S. domestic airports. We would not expect our qualitative results to change significantly, but we must keep this potential limitation in mind.

The **GDP per capita** was also used in the modelling.

3.2.3 Herfindahl Index

The**Herfindahl Index** ***hhi*** or H **index** is a way of measuring the market share of the different carriers on a route in relation to the total market, in a given time period *(quarter)*. It provides information about the **level of concentration/competition** that a carrier willing to enter a given route or airport will face. The H index is a number between 0 and 1. A high H index indicates a **heterogeneous** and concentrated **market** (large size differences between competitors), whereas a low H suggests a more **homogeneous** and less concentrated **market** (several firms of similar size are present).

It is defined as:

$$H = \sum_{i=1}^{n} \alpha_i^2,$$

where α_i is the market share of carrier i.

H index for a route We define the H index for a given route j at time t as:

$$H_{jt} = \sum_{i=1}^{n} \alpha_{ijt}^2.$$

H index for an airport The H index for a given airport at time t is:

$$H_t = \sum_{i=1}^{n} \alpha_{it}^2.$$

It is important to mention that there are three main properties which will be explained in the Appendix.

3.2.4 Fare variation

It seems important to take into account how a given carrier is setting fares on its routes. Companies may reduce their prices either due to the necessity to undercut competitors or due the capability to decrease their current production costs. Concepts of entry deterrence and yield management are relevant here.

To determine this variation, it could be a good idea to use the fare data coming from the ***DB1B* database**. However, this data might generate a problem related to **"endogeneity in econometrics"**, which means that in this econometric model we need the causal effect to run from the independent variables (right side) to the dependent variable (left side), but there may also be an effect the other way. Now, for example, a high price ticket might be related to a high value of the Herfindahl index due to the nature of monopoly power. However, the ticket price might change due to Herfindahl as well.

That is why it has been necessary to find another way to link the fare variable to the model. This variable is the **standard deviation in the passenger – weighted fare/distance** across all carriers on a given route i, calculated using all other routes j served by the carrier on route i, in the same time period. Figure 2 represents the basic principle applied to a specific example.

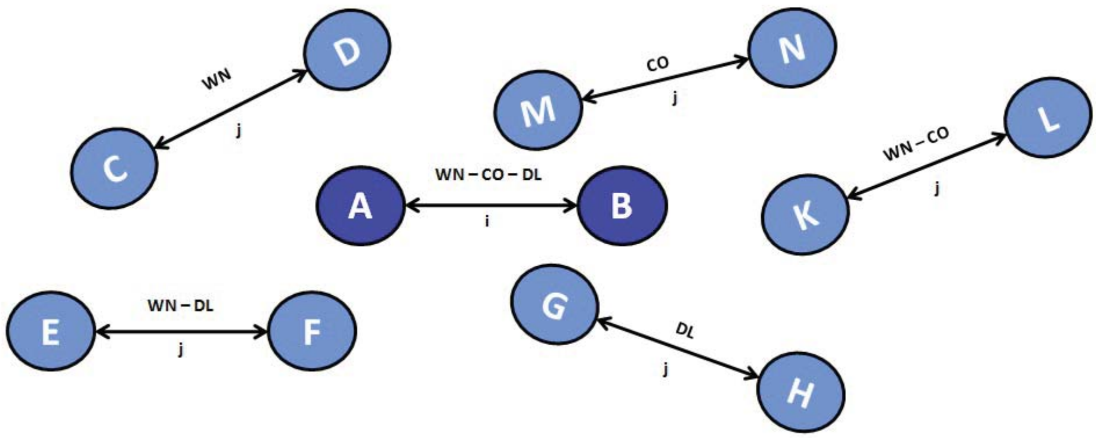

Figure 2: Fare data assumption.

As shown in Figure 2, the fare structure of Southwest (WN) on route i can be calculated using the average price on j routes. This can be applied for CO and DL and finally we get the fare standard deviation of the A – B route.

Why might this method be useful? Because the fare structure reflects more or less how the other routes are charged, and so the production cost behind them. Now, it is possible to say that lower production costs can generate a decrease in the average price of tickets, and so easier undercutting of competitors.

3.2.5 Route distance

It seem reasonable that the distance between two airports determines whether one carrier starts to operate a given route or not. One of the most important reasons is the high operation cost involved with long haul flights, so for some airlines it is better just to operate medium haul routes.

Thus, to determine the influence of **distance** on this model, it was necessary to create a variable based upon the endpoint airport coordinates and the corresponding distance between them ($dist$).

3.2.6 Route distance squared

The term $dist^2$ permits us to determine a specific **level of saturation** in the model. It seems clear that the longer the route, the more interesting it will be for a given carrier. However, this may be true up to certain value when the route distance is too long and it is no longer attractive for the airlines. Figure 3 illustrates this feature.

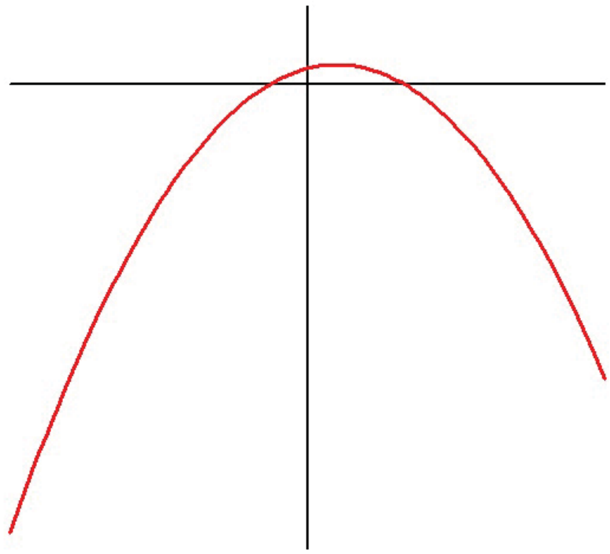

Figure 3: Likely impact of distance.

Consequently, due to the large magnitude of this variable, it is relevant to scale it. We divide the current distance variable by $1,000$. By this method, it is possible to avoid problems due to differences in the orders of magnitude of the explanatory variables.

3.3 Carrier-specific variables

The U.S. domestic market is one of the most important in the world. Commercial air passenger transport has developed since the post Second World War period, and now there are many carriers flying along U.S. strong enough to influence in some market aspects.

Southwest has served an ever-larger number of routes in monopoly, perhaps due to its low cost structure, which can bring it the capability of higher profit margins and easier undercutting strategy against its competitors. The variable of **Southwest presence** has been defined as ***wnpresence*** and takes value 1 when Southwest is serving a route i and 0 otherwise. It is important to mention that the *wnpresence* variable is only useful since quarter 30, when Southwest return ticket data started to be recorded correctly by the **American Bureau of Transportation Statistics (BTS)**.

There are others companies which also have demonstrated strength and a high level of competitiveness, the major carriers **AA**, **CO**, **DL**, **NW**, **US**, **UA**, have proven their ability to deter a competitor trying to serve a new route. These companies are sometimes so powerful, and even when their cost structure is not low cost, that still have the capacity to protect their current market. Now, under this premise, it is more convenient to analyze them with the same method. Thus, the corresponding variables will be shown as follows.

Low Cost Carriers (LCC)

wnpresence

Full Service Carriers or Major Carriers (FSC's)

aapresence, *copresence*, *dlpresence*, *nwpresence*, *uspresence*, *uapresence*

3.3.1 Number of alliances by carriers

Due to the necessity to overcome the legal and financial restriction imposed by some countries, the airlines have decided to enter alliances, especially with foreign carriers. These have been established due to the importance of protecting their own domestic markets. As a consequence, the alliances have come out with the purpose of introducing new routes and services in those regions, increasing their current coverage. The beginning of the global alliances was first the creation of code-share agreements between airlines, then, some of them became alliances, which now have many major carriers as members. Now, it is possible to say that more or less 60% of the world's total air traffic is involved in some alliances.

The variable related to **number of alliances by carriers** ***(alliancesn_ bycarriers)*** might be a good idea to measure what could be the market behaviour if, for instance, two or three carriers as a part of one specific alliance are serving a given route at the same time. In order to explain how this variable works, it is relevant to consider 7 carriers, A, B, C, D, E, F, G, where A and B are in one alliance, C and D in another alliance, and E, F and G not in any alliance. As a consequence, the number of alliances on that route is 2, and so the number of alliances by carriers on a route is 2/7.

$$allianceny carriers = \frac{\text{Number of alliances on a given route } i}{\text{Number of carriers serving a given route } i}.$$

The alliance membership database has been taken manually from the Wikipedia internet web page `http://en.wikipedia.org/wiki/Airline_alliance` and then manipulated in Python. There are 3 alliances: Star Alliance (founded in 1997, 27 members), SkyTeam (founded in 2000, 13 members) and Oneworld (founded in 1999, 11 members).

3.4 Fare class variables

The GDP is used to define the *Leisure-Sector* and the *Business-Sector*. This data is available for the most of the *Metropolitan Statistical Areas* (MSA's). Thus, the ***region-specific ratio*** of the GDP that is contributed by the ***Leisure-Sector*** and ***Business-Sector***, to the total GDP is computed for each airport. We generate two binary variables for each airport. These variables take value 1 when the business ratio is greater than 10% and the leisure ratio greater than 5%, and value 0 otherwise:

$$\frac{GDP_{Leisure}}{GDP_{Total}} > 5\% \rightarrow Leisure = 1,$$

$$\frac{GDP_{Business}}{GDP_{Total}} > 10\% \rightarrow Business = 1.$$

3.5 First carrier on a route

There are some carriers with recognized experience, so it could be possible that such experience would represent a strong ability to control the market. In order to measure whether the serving time on a given route is a relevant value which affect this model, it was necessary to define the ***Inertia_ range*** variable. Consider the following example:

If the carriers DL, AA and CO are serving a route i, using historical data to find the first quarter in which each of the incumbents were present on route i; the corresponding quarter for each carrier is DL 2, AA 15, CO 60. Thus, the correspond value for the variable $Inertia\_range$ in this simple example is explained as follows:

$$\text{Inertia Range} = \text{Maximum Value} - \text{Minimum Value}:$$

$$\text{Inertia Range} = 60 - 2 = 58.$$

Thus, the **Inertia Range** variable is intended to measure the impact of a carrier entering a route before the others; perhaps this carrier will have an advantage over the others due to its first movement (e.g. development of customer loyalty, or economies of scope).

4 Why is there a majority of monopolies?

To better understand the U.S. domestic market is one of the main aims of this project. That being said, the first work done on the treated dataset is to verify if effectively there are a majority of routes served by just one carrier, as was expected before analyzing the data. Figure 4 represents the percentage of routes served by n carriers over time. It can be noticed that around **60% of the routes in the U.S. are in monopoly** throughout all 65 quarters analyzed. This result not only confirms the existence of a high number of monopolies but also reveals considerable **stability over time** (the database covers 1993 to 2009). This stability is remarkable on all the different kinds of routes and not only on monopolies, meaning that if we observe the routes operated under a duopoly or three firms or any n over time, the percentage of routes under each regime is also stable.

The percentage used in the previous paragraph is defined as:

$$\%RN = \frac{\text{Number of routes served by } n \text{ companies}}{\text{Total number of routes served}} \times 100\%.$$

Looking at the total number of routes instead of the percentage, and aggregating this number for a given quarter, it is observed that the total number of routes served remains nearly constant over the past 15 years. We can observe a slight decrease, but it is not significant. As before, we can affirm there is a stability on the number of routes served by a given number of carriers (see Figure 29).

These results seem logical given the fact that the U.S. domestic market had already been settled in 1993 and continues that way. The airports were already there and the routes were already opened. New needs concerning routes are unlikely and, when

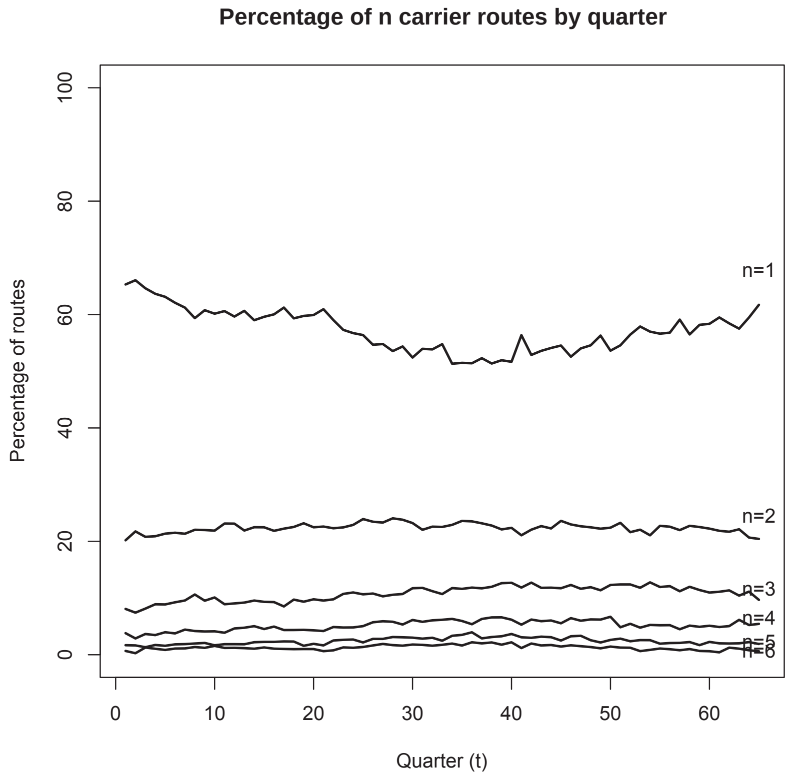

Figure 4: Percentage of n carrier routes by quarter.

appearing, they will be just a low number and they will not have a strong impact on the total or they will be compensated by disappearing routes (also a rare phenomenon). At first sight, the need of a route will be linked to its population and the nature of the destination (for example, hub or tourist), and these factors are not likely to change very much over time. Hawaii is still a tourism destination and Atlanta is still a hub for Delta Air Lines and AirTran Airways and this is not going to change in a short period of time. Comparing the total number of routes served, in quarter 1 (1993Q1) there were 3,156 different routes served whereas in quarter 65 (2009Q1) there were 2,957. There is a slight decrease but the market essentially remains the same.

Looking at the demand, it is not expected to change sharply from one quarter to the next. We look at the demand for a route as the number of tickets sold (passengers) on this route. As the DB1B gives a sample of 10% of all domestic tickets, it is necessary to multiply by 10 the number we get from the database. The demand on a route is limited and a really strong variation of it would be necessary in order to modify the characteristics of the route. For instance, a route from La Guardia to Chicago O'Hare (LGA–ORD) will always have a strong demand whereas another one from Nashville to Oklahoma (BNA–OKC) will not face such a big demand, mainly due to a difference in terms of population of the routes. To further illustrate all this we take the route between Baton Rouge Metropolitan Airport and Detroit Metropolitan Wayne County Airport (BTR–DFW), and we see that the demand was 6,300 pax on the first quarter of 1993, and 6,780 on the first quarter of 2009. It is practically stable.

As for the total number of passengers, in quarter 1 (1993Q1) the database collects 14 million passengers flying in the U.S. domestic network; by quarter 65 (2009Q1) there are 25 million passengers. If the number of routes and the number of carriers per route are both stable we can assume there has been an impact on the capacity of the aircraft fleet or the frequency of the flights. Another explanation may be because the competition has gradually moved towards the more profitable routes (as seems logical), with a lot of carriers providing a large number of flights per day. In the meanwhile, smaller routes are operated by just one carrier, remaining the aggregate number of both stable over time.

Therefore, **the limited demand on a settled market appears to be the reason**

behind this stability. It is also important to remark that some routes cover a basic communication need and they will not disappear even if the demand fluctuates. This is a special characteristic of the airline market. For instance, the aforementioned route BTR–DFW responds to the need of connecting Baton Rouge (the second largest city of Louisiana, around 200,000 inhabitants and 500,000 in its metropolitan area) with the bigger nearby airport of Detroit. The travel takes around one hour and a half. In the present day this route is served in monopoly by American Eagle Airlines, a regional affiliate of American Airlines. Whether the demand fluctuates between quarters American Eagle will continue to provide this service, critical for the population of Baton Rouge. We will see later how important an increase of the demand should be for an additional carrier to be expected to enter the route.

Figure 5: Baton Rouge to Detroit route.

Secondly, the number of carriers present on the U.S. domestic market has increased, as seen in Figure 30. In 1993 there were around 20 carriers and in 2009 there were almost 40. As we have seen, the market has not changed and the number of players has doubled, necessarily in the current market there is more competition than 15 years ago. The market is the same and it must be shared by 20 more carriers. We will continue to analyze the implications of all this later on the project when describing and modelling the Herfindahl index.

From a geographical point of view (see Figure 31), we appreciate that the U.S. domestic market is made up of a whole lot of continental routes plus some extra-continental ones, mainly to Alaska, Hawaii and Puerto Rico. As has been said, there is a high density of routes in monopoly all along the U.S.. The only conclusion we can derive from the map is the existence of an inferior route density in the northwest states. This could be explained because the northwest is less populated than other regions and, as a consequence, the demand will be smaller and there would be fewer routes.

4.1 What exactly is a monopoly?

The U.S. domestic market is a huge network of routes operated by a large number of carriers. It is possible to travel between virtually any two random airports in the domestic U.S. with any of the major carriers. At first sight it would seem there are no monopolies and you can always find an alternate carrier to travel with. The issue is whether this alternative is practical or not. To better understand, the next three examples illustrate what a monopoly on the U.S. really looks like.

4.1.1 Ontario – San Francisco

The route linking San Francisco International Airport and LA/Ontario International Airport (ONT–SFO) is, as today, a monopoly operated by the regional airline Skywest Airlines. It operates the route under the name of United Express and on behalf of United Airlines. Skywest offers a one hour and twenty minutes direct flight, with fares around $300 for a return ticket. The most competitive alternate flights for this route are proposed by US Airways at the same price but with a stopover in Phoenix. The same trip will take around five hours (for location of these airports see Figure 6).

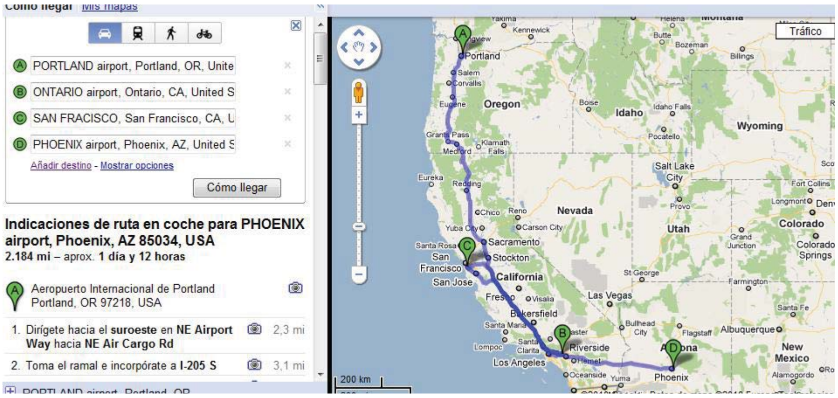

Figure 6: Portland, Ontario, San Francisco and Phoenix locations.

It is obvious that, for the same price, users will prefer to fly the direct flight. In this case Skywest operates the route in monopoly conditions. The only reason for a passenger to fly the route on an alternate way it would because all direct flights are complete or because he benefits from a fidelity discount from the other carriers. However, those cases are not expected to happen often.

The main reason behind the lack of competition on this route seems to be the proximity between Ontario and Los Angeles (one hour by car). There are more than 40 daily flights between LAX (Los Angeles International Airport) and SFO, operated by at least seven different carriers. The competition is inclined to happen in LAX and not in ONT.

4.1.2 Atlanta – New York JFK

The route between Hartsfield–Jackson Atlanta International Airport and John F. Kennedy International Airport in New York (ATL–JFK) is another monopoly, operated in this case by Delta Airlines. Delta offers a six times a day direct flight with fares around \$500. The flight is around two and a half hours. The better alternate to this route is offered by US Airways. It provides a route with one stop over in Charlotte (CLT): the trip takes four and a half hours to be made and with average fares around \$400.

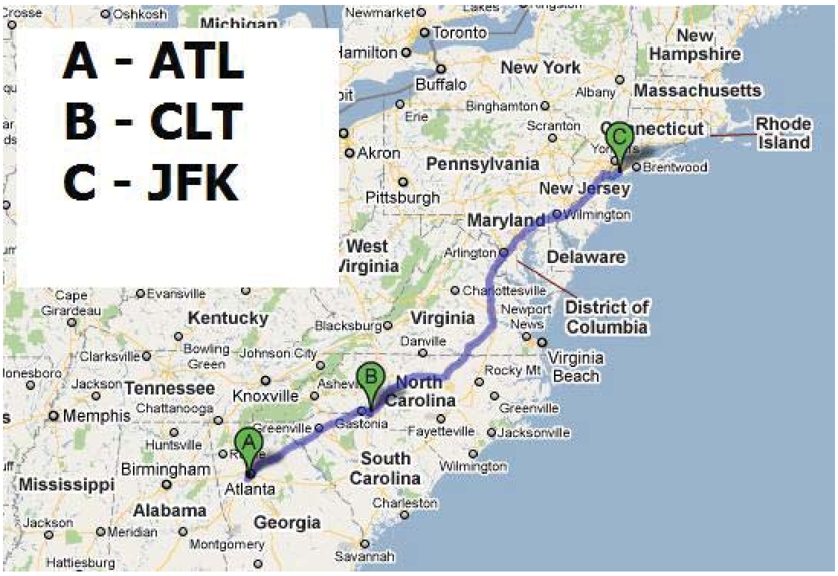

Figure 7: Atlanta, New York and Charlotte locations

In this case, even if the alternative offered by US Airways is a good one (Charlotte is practically in a straight line between Atlanta and New York), the connection time is not very high and the prize is \$100 cheaper than the direct flight, users prefer to take the direct flight, as it is apparent in the database.

4.1.3 Oakland – San Diego

Last, this is an example of a monopoly by Southwest Airlines. As we will later analyze, the number of monopolies held by all U.S. carriers have decreased over the fifteen years covered by the database except for Southwest, that has multiplied its monopolies by three (see Figure 32).

Southwest offers a direct route between Oakland International Airport and San Diego International Airport (OAK–SAN) with an average fare of \$170. The trip takes one hour and a half. Alternatives offered by US Airways and Delta Air Lines are around \$100 more expensive, with one stop-over and the trips takes at least four hours and a half. Thus, Southwest is undoubtedly the only effective carrier operating the route.

From a historical point of view, the route was until 2001 a duopoly with Southwest and United Airlines. Analyzing the data set we see that Southwest managed to displace United from the route. In the quarter before UA left the route (2001Q3), the number of passengers carried by Southwest was higher than the number carried by United. It can be assumed that United deemed this route non-profitable as Southwest was ruling it practically as a monopoly and decided to abandon it. The most remarkable result we can appreciate is that the fares of Southwest were slightly higher than those of United, which is against the basic concept of a low-cost carrier such as Southwest. This results are collected in the table below:

OAK–SAN route at 2001 Q03

Carrier	Fare ($)	Passengers
UA	133	940
WN	166	94740

4.2 An astonishing regularity

In the previous section, we have studied the stability of the U.S. domestic market over time. Taking a step further, the results obtained in Figure 4, we focus on **the percentage of routes served by n carriers on a concrete period of time** (quarter). In Figure 8 these values have been represented for three quarters: quarter 20 (1997Q4), 40 (2002Q4) and 60 (2007Q4). These quarters have been chosen for illustration. However all the computations and verifications have been made for all quarters; they have just not been represented in order to get clear plots.

Due to the stability of the market since 1993, the distribution for the three different quarters approximately follows the same function. When observing these results, one can remark that the functions obtained look closely similar to an **exponential function**. Thus, the next step is to compute the **natural logarithm of the percentages** to verify if the found functions follow indeed an exponential distribution (Figure 9). The results obtained follow accurately a **straight line** if the number of carriers is less than or equal to five. When the number of carriers is more than five, the distribution still

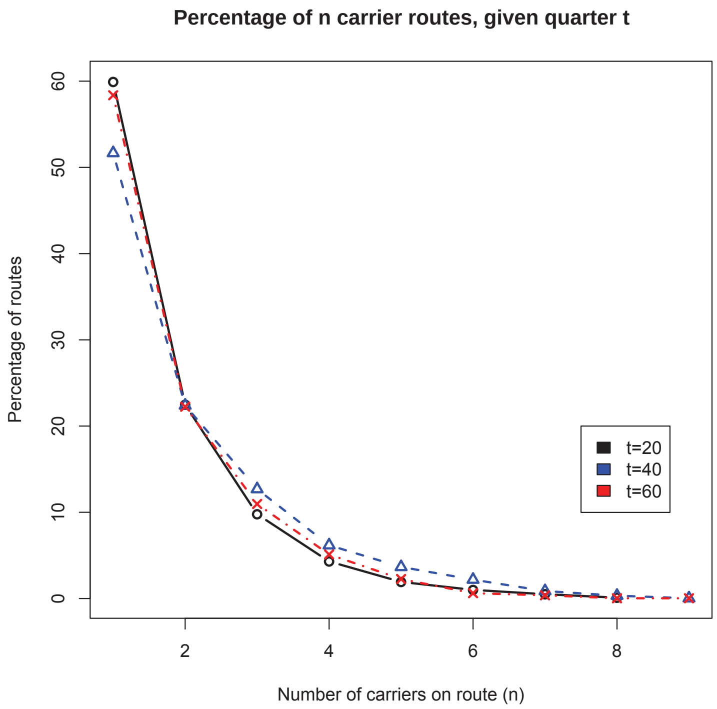

Figure 8: Logarithmic distribution of the percentage of routes served by n carriers.

keeps a certain regularity but the straight line is deformed (there are very few routes with more than 5 carriers). Nonetheless, this deformation does not ruin our reasoning at all. The distortion appears for values of the logarithm closer or less than zero, which means percentages around 1% or smaller (logarithms of numbers between 0 and 1 are negative).

Our next step is to compute the **least squares regression** of this percentage (named $\%RN$) for all quarters and to see if the two coefficients defining the straight line remain on a certain range value over time. Using EViews, we computed these coefficients for the two cases: with all the percentages and imposing n to be equal or less than five. In fact, in Figure 9 one may think that all values are equally important, but the percentages with n equal or less than five represent more than 95% of the routes, so we will be modelling the majority of the market. The routes with a high level of competition on them (n more than five) are usually between highly populated cities, tourism destinations or hubs and they will behave differently. The least squares regressions are as follows:

$$\ln(\%RN/100) = \beta_1 + \beta_2\, n.$$

For example, for quarter 60 we obtain:

$$\ln(\%\widehat{RN}/100) = 4.79 - 0.79\, n.$$

The coefficients obtained are represented in Figure 10 for the case where we consider only routes with 5 or fewer carriers serving them. The value of the coefficients are kept between 4.5 and 5 for $\widehat{\beta_1}$ (the y-intercept of the line) and between -0.66 and -0.95 for $\widehat{\beta_2}$ (the slope). The tables with all the coefficients, the plot for the case where n is greater than five and the code used for computing this on EViews can be found in Appendix D.2.

4.3 Modelling the number of monopolies

In this section we would like to model the probability of a route being served by just one carrier as a function of some of the variables defined in Section 3. A variable y is defined. This variable takes value 1 for a route served as a monopoly and 0 otherwise. A probit model is used. The probit model will forecast this variable as a number between 0 and 1. If the obtained probability is equal or greater than 0.5 we will say that we expect

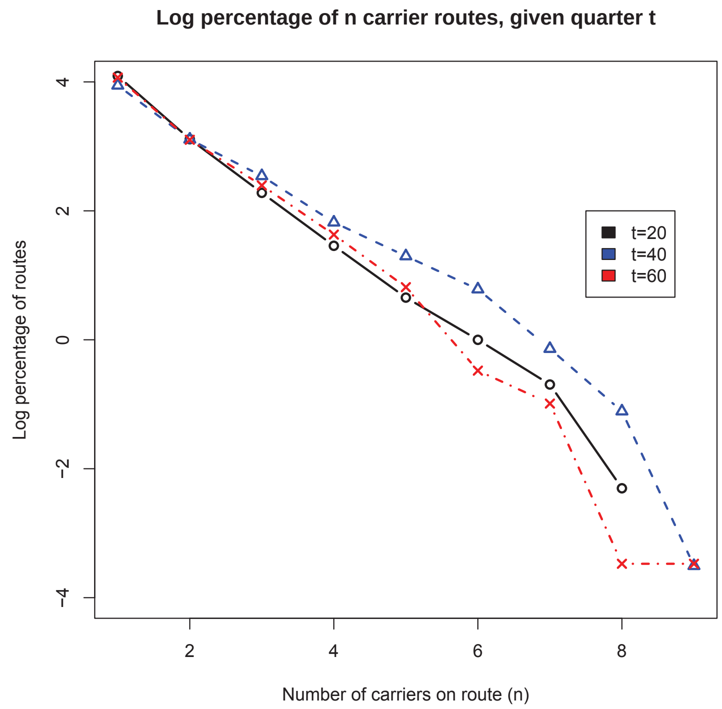

Figure 9: Logarithm of the percentage of the market distribution.

to have a monopoly on that route. Afterwards we will check whether the model works properly using the same routes we took as an example before. For an explanation about how to interpret this kind of model please refer to Section 6.5.

We included 27 variables, 3 of which ended up not being influential on the y variable. These 3 variables are 2 of the route location variables, which is not relevant as we already knew when defining them that not all of them would end up being relevant, and the GDP per capita on a route. This is more surprising as intuition first tells us that the wealth of the two endpoints where the route is will have an impact on the market. This may be a deficiency of our model or it may be explained because routes in monopoly exist all

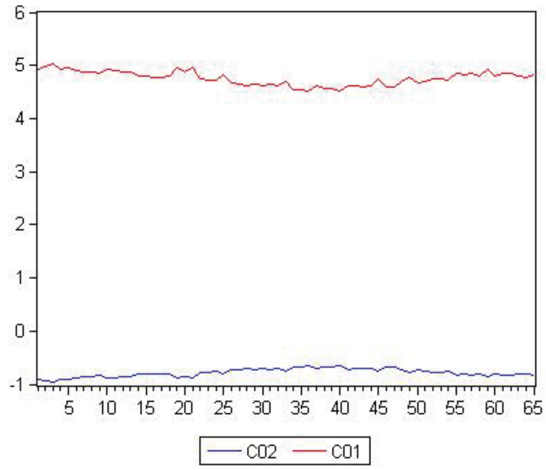

Figure 10: Coefficients of the linear function for each quarter (n<5): $\widehat{\beta_1}$ (C01), $\widehat{\beta_2}$ (C02).

over the country whether the cities served are richer or not, so this variable (which will definitely be a relevant variable on future regressions modelling the number of carriers and the market power) is of no relevance in this case.

Here it is the equation of the regression. The coefficients, standard errors, Z-statistics and probabilities are in the Tables below.

$$\begin{aligned}
\text{Prob}(Y60 = 1) \quad &= \quad \Phi\Big(\beta_1 + \beta_2 \frac{dist}{1000} + \beta_3 \left(\frac{dist}{1000}\right)^2 + \beta_4 \frac{pop}{1000000} + \beta_5\, business + \beta_6 \frac{gdp}{pop} \\
&+ \quad \beta_7\, COpresent + \beta_8\, DLpresent + \beta_9\, NWpresent + \beta_{10}\, UApresent \\
&+ \quad \beta_{11}\, USpresent + \beta_{12}\, rlocMWNW + \beta_{13}\, rlocNESW + \beta_{14}\, rlocSESW \\
&+ \quad \beta_{15}\, rlocSWSW + \beta_{16}\, rlocMWMW + \beta_{17}\, rlocMWNE + \beta_{18}\, rlocMWSE \\
&+ \quad \beta_{19}\, rlocMWSW + \beta_{20}\, rlocNENE + \beta_{21}\, rlocNENW + \beta_{22}\, rlocNEOU \\
&+ \quad \beta_{23}\, rlocNESE + \beta_{24}\, rlocNWNW + \beta_{25}\, rlocNWOU + \beta_{26}\, rlocNWSE
\end{aligned}$$

$$+ \quad \beta_{27}\, rlocNWSW + \beta_{28}\, rlocSESE + \beta_{29}\, WNpresent\Big).$$

As for the remaining variables, we can observe that for short distances (the linear distance term dominates) the probability of a route being a monopoly decreases as distance increases, whereas for longer distances (the quadratic term is more important) the effect is the opposite. This means that when distance increases the route will become more attractive for the different carriers (lower probability of monopoly), but there is a ceiling when this probability starts increasing again (the longer routes will be more likely to be served in monopoly). The Business variable indicates that the higher the business activity in the two areas linked by the route the lower y is. A "business" route is not likely to be a monopoly.

Variable	Coefficient	Standard error	Z-statistic	Prob
DIST/1000	-0.208303	0.097264	-2.141633	0.0322
(DIST/1000)2	0.079358	0.018288	4.339388	0.0000
POP/1000000	-0.067552	0.014530	-4.649240	0.0000
BUSINESS	-0.442601	0.066652	-6.640489	0.0000
GDP/POP	4.655565	4.926151	0.945071	0.3446
COPRESENT	-1.072420	0.111344	-9.631625	0.0000
DLPRESENT	-1.272713	0.091360	-13.93075	0.0000
NWPRESENT	-0.886845	0.102025	-8.692444	0.0000
UAPRESENT	-1.810438	0.130670	-13.85502	0.0000
USPRESENT	-1.951301	0.129690	-15.04591	0.0000
RLOCMWNW	1.448874	0.336449	4.306375	0.0000
RLOCNESW	1.186730	0.233465	5.083124	0.0000
RLOCSESW	1.026027	0.218705	4.691381	0.0000
RLOCSWSW	1.170599	0.267162	4.381603	0.0000

The presence of any major or Southwest on a route reduces the probability of it being in monopoly, which may indicate that these carriers are present on the most competitive routes, being the smallest carriers (often regional carriers code-sharing with majors) the ones often serving small and unprofitable routes as monopolies (for instance, the SFO–ONT route seen in Section 4.1).

Variable	Coefficient	Standard error	Z-statistic	Prob
RLOCMWMW	1.680619	0.501476	3.351347	0.0008
RLOCMWNE	1.362815	0.272263	5.005509	0.0000
RLOCMWSE	1.146114	0.262626	4.364052	0.0000
RLOCMWSW	1.200243	0.294024	4.082126	0.0000
RLOCNENE	1.432660	0.229226	6.249990	0.0000
RLOCNENW	1.312458	0.262669	4.996617	0.0000
RLOCNEOU	-1.064077	0.481232	-2.211151	0.0270
RLOCNESE	1.164341	0.216836	5.369678	0.0000
RLOCNWNW	0.461270	0.279776	1.648712	0.0992
RLOCNWOU	0.893088	0.466538	1.914287	0.0556
RLOCNWSE	0.978831	0.255717	3.827797	0.0001
RLOCNWSW	0.837027	0.235580	3.553048	0.0004
RLOCSESE	1.184161	0.216955	5.458090	0.0000
WNpresent	-0.724781	0.067551	-10.72938	0.0000

The route location dummy variables fit very well in the model. Their effect (except for that of $rlocNEOU$, which we will not pay attention to as it may be a misfit of the model) is always positive, meaning higher monopoly probability. This takes us to the concept of carriers defining their natural operating space, and focusing on concrete geographical routes. The project previously completed by Cobb and Metzger (IENAC06TE) revealed that Southwest (which started as a regional carrier on the southwest of the U.S.) has more presence nowadays on routes in the southwest and between the southwest and other regions. Something similar will happen with the other carriers, having historically placed and specialized themselves in some concrete markets limited by the location.

Now we will check how well the model works taking the routes explained in Subsection 4.1. The results are in the Table below:

Route	Y	$\widehat{Y}$	dist	pop	GDP/POP
ONT–SFO	1	0.73	585	4684205	183423.128397
ATL–JFK	1	0.14	1222	94452325	Not Available
OAK–SAN	1	0.013	3051	4154262	Not Available

Route	NWpresent	WNpresent	Business	rlocNWSW	rlocNESE
ONT–SFO	0	0	0	1	0
ATL–JFK	1	0	1	0	1
OAK–SAN	0	1	1	1	0

We can see that the model only gives us an accurate forecast for the first of the three routes. For the other two routes the model gives us a mistaken forecast. The deficiencies of our model we think are mainly due to some effects determining the U.S. domestic market we were not able to include in our model. We deem that airport fees, availability of slots, the existence of alternate airports or the type of airport (hub or tourism for example) are important variables we thought of but we did not include at the end. A lack of time has been decisive for us not getting further on the improvement of our model.

The results for this model for quarters 1 and 30 can be found in the Appendix.

5 Analysis of routes served by more than one carrier

Up until now our study has been focused on routes operated as a monopolies. Our next step is to get better insight on **routes served by more than one carrier** and on the conditions behind them. Proceeding in a similar way as in the previous chapter, first a qualitative analysis will be done with the help of some plots. The analysis will point out how the routes with more than two carriers work. Afterwards we will try to model the number of carriers on a given route as a function of some variables. We will provide concrete examples and use our model for forecasting.

Firstly, a link will be established between the population of a route and the number of carriers serving them. Figure 33 gives us the frequency of routes with a given population (as defined in 3.2.1) for quarter 60. **Most of the routes (over 50% aggregating the results) have a population around 1.5 million**. Routes with really high populations are a much rarer occurrence. The first remark derived from this plot is that there is a **population threshold for a route to exist**. A route between two small population areas will never occur, mainly because there is no potential market and there will not even be an airport. This also seems to be in accordance with one of our first intuitions linking the existence of a route with a basic need to communicate two endpoint city areas. Therefore most of the routes in the U.S. domestic market are routes between not very big city areas and we can imagine they will be served by a low number of carriers. A greater amount of carriers competing against each other will be observed on the more scarce high populated routes. The following plot will provide more insight on this.

Knowing by now the quantity of routes with a given population, our next step is to go a little further analyzing the number of carriers serving those routes. Effectively, in Figure 11 it is represented the **number of carriers against the route population** for quarter 60. To better comprehend the plot a least square fit has been done. Studying the slope of the least square line very interesting results will be obtained. This plot has also been computed for quarters 20 and 40 in order to compare the effect of population on the number of carriers serving a route over time. They can be found in Appendix C.2

Focusing on quarter 60 (autumn of 2007), the slope of the least squares regression is 0.10. It means that **if keeping all other variables constant on a given route the number of carriers serving it is expected to increase by one if the population of the route increases by 10 million**. The same reasoning can be done for quarters 40 (autumn of 2002) and for quarter 20 (autumn of 1997). The slopes of the least squares fit are 0.173 and 0.1973 respectively. Thus, the increase of route population needed for a new carrier to be expected to enter the route remaining all other variables constant is roughly 5 millon.

The above analysis shows that there has been a considerable **decrease in the influence of route population on the number of carriers serving a route. From 2002 to 2007 this effect has been practically reduced by half**. This may be explained either because nowadays the routes are served by fewer carriers than before, or because population is a less relevant factor compared to other factors. The first assertion is false as it has been seen before that the number of routes remains constant over time. At the moment we cannot say anything about the second assertion. Later a model trying

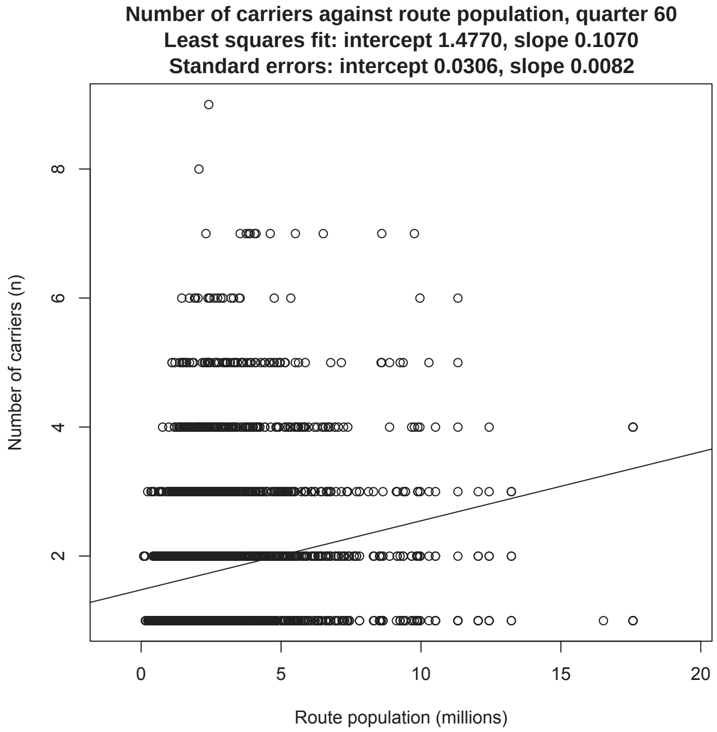

Figure 11: Number of carriers against route population for quarter 60

to capture the effect of route population and other variables in the number of carriers serving a route will be presented. There we will try to get more insight on the reasons behind the loss of importance of the route population.

The maps showing routes served by n carriers give us an idea of geographical barriers and where the spatial nature of competition between carriers is (see Appendix C.3). As it has been stated before, the northwest of the country (states of Minnesota, North Dakota and Montana) presents less air activity. It is also remarkable the already known decrease of density as the number of carriers involved goes up. We also observe that the remaining routes as the number of carriers increase are the longest ones.

Corridors to Alaska, Hawaii and Puerto Rico as well as some corridors inside the continental part of the country can be clearly determined. In quarter 60 the corridor to Alaska has only up to two carriers, the corridor to Puerto Rico holds until four carriers and the one to Hawaii five. The internal corridors are generally routes from one coast to another or some long routes between cities on the East Coast. For instance, both routes between Baltimore and San Diego (BWI – SAN) or between Orlando and Seattle (MCO – SEA) are served by six carriers and nine carriers respectively in quarter 60 and they both connect cities on each coast.

5.1 Modelling the number of carriers on a route

Similar to what has been done for the y variable defining the number of monopolies, now we are interested in developing an empirical model attempting to explain the number of carriers on a route as a function of the variables defined in Section 3. A least squares regression will be performed in order to get a model that will explain n. Later we will verify with some example routes if the model works properly. For an explanation about how to interpret this kind of models please refer to Section 6.5.

Background to the regressions The results presented here are the last ones we obtained. However, the working process we followed was an iterative one where we kept adding new variables as they were available to us and removing those that were not useful to us. In the end, we have used 21 variables for modelling the number of carriers serving a route, however just 15 out of the 21 ended up being relevant on the model.

We have maintained the non-relevant ones to try to explain the reasons behind their not relevance.

As with the y variable, the regressions have been done for quarters 1, 30 and 60. The results commented will be those of quarter 60, the more recent ones. However the regressions for quarters 1 and 30 can be found in the Annex D.4.

$$\begin{aligned} n &= \Bigg(\beta_1 + \beta_2 \frac{dist}{1000} + \beta_3 \left(\frac{dist}{1000}\right)^2 + \beta_4 \frac{pop}{1000000} + \beta_5 \, WNpresent + \beta_6 \, leisure \\ &+ \beta_7 \, business + \beta_8 \frac{gdp}{pop} + \beta_9 \, AApresent + \beta_{10} \, COpresent + \beta_{11} \, DLpresent \\ &+ \beta_{12} \, NWpresent + \beta_{13} \, UApresent + \beta_{14} \, USpresent + \beta_{15} \, STDpother \\ &+ \beta_{16} \, Inertia\_range + \beta_{17} \, AllianceEN_bycarriers + \beta_{18} \, rlocMWNW \\ &+ \beta_{19} \, rlocNESW + \beta_{20} \, rlocOUSW + \beta_{21} \, rlocSESW + \beta_{22} \, rlocSWSW\Bigg). \end{aligned}$$

The coefficients, t-statistics, and standard errors obtained for quarter 60 are:

Variable	Coefficient	Standard error	t-statistic	Prob
Coefficient	1.816	0.122855	14.77828	0.0000
Distance	-0.0421	0.0328	-1.2855	0.1989
Distance2	-0.0035	0.0050	-0.7052	0.4808
Population	0.0023	0.0056	0.4036	0.6866
WN present	0.2074	0.0292	7.0926	0.0000
Leisure	-0.0165	0.1436	-0.1151	0.9083
Business	0.0171	0.0324	0.5283	0.5974
GDP / population	2.6777	2.6547	1.0087	0.3133
AA present	1.2268	0.0328	37.4593	0.0000
CO present	0.9512	0.0360	26.425	0.0000
DL present	1.1330	0.0290	39.0582	0.0000
NW present	1.1955	0.0368	32.5277	0.0000
UA present	1.0774	0.0330	32.6276	0.0000
US present	1.0782	0.0319	33.7560	0.0000

Variable	Coefficient	Standard error	t-statistic	Prob
Standard pother	0.9523	0.3018	3.1559	0.0016
Inertia	0.0078	0.0007	11.0908	0.0000
Alliance by carriers	-2.3759	0.0644	-36.8901	0.0000
Route location MW NW	0.3302	0.0936	3.5292	0.0004
Route location NE SW	-0.1098	0.0486	-2.2578	0.0241
Route location OU SW	0.3357	0.1787	1.8787	0.0605
Route location SE SW	-0.1166	0.0466	-2.5014	0.0125
Route location SW SW	-0.1956	0.0921	-2.1248	0.0338
R-squared	0.8554			

The results The first remark we can see in the regression is the high *R-squared* value. The *R-squared* value measures how well the model fits the observed data. In this case **the model fits with an accuracy of 85%**. In Figure 12, we computed a new variable nf giving us the number of carriers according to the model for all the data on quarter 60, and we compared them to the real number of carriers as a way of measuring the accuracy of our model. We can see that the result is very good.

As before, the presence of a major or Southwest increase the probability of having competition. They will be placed in the most profitable and competitive routes, competing against each other. The *Alliances by carrier* variable has a negative influence on the number of carriers, meaning that **carriers within an alliance are less likely to compete against each other**. The *Route location* variables are sometimes positive

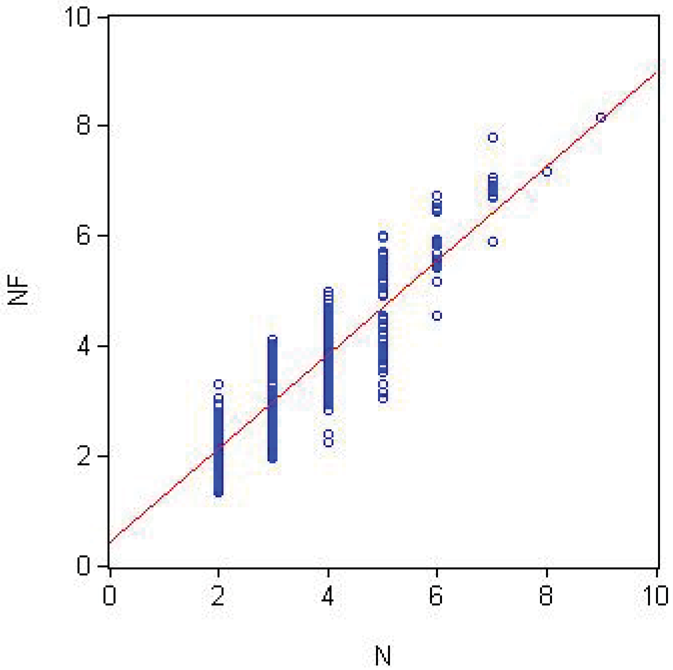

Figure 12: Real against forecasted variable for number of carriers

and sometimes negative. This gives us the regions where competition is inclined to happen. Routes between the midwest and the northwest and between the southwest and the regions outside the continent have positive coefficients, thus routes between this routes are inclined to have more carriers on them. However, routes between the northeast and the southwest, the southeast and the southwest and within the southwest have negative coefficients, meaning less carriers per route. It is remarkable how, **according to the model, distance, route population and gross domestic product have no influence on the number of carriers operating a route**.

For instance, the route between LaGuardia Airport in New York and Chicago O'Hare

International Airport (LGA – ORD) was served by two carriers in quarter 60 (now it is served by three, as delta started operations recently) and the model predicts 1.88. The route between Detroit Metropolitan Wayne County Airport and San Francisco International Airport (DWI – SFO) is served by five carriers and the model predicts 5.39. This are both fine examples of the nice working of the model.

6 The importance of market power

In this section, we analyze market power and its importance into the U.S. airline market. First this concept is considered in general terms, then it is explained how market power is measured in this report and finally some interesting plots are provided and commented upon.

Market power is known as the **extent to which a firm can influence the price of an item by exercising control over its demand, supply, or both**. On one hand, there can be lots of firms in the market in a perfectly-competitive framework, thus all firms are assumed to have zero market power. Nevertheless, this economic concept is not frequently found in the U.S. airline market.

On the other hand, when there are just a few firms in the same field, each of them is able to exercise some control over its own market price, which means we are far from a perfectly-competitive situation. Besides, in the environment of U.S air transport some firms have varying levels of market power.

As has been explained in the previous part, just a few carriers are serving the majority of the routes in the U.S. Therefore, those firms are believed to have a high market power and this report attempts to measure this particular economic ability. Consequently, in the next Section, **the H index has been chosen as the proper variable to determine the power each particular firms have in the market**.

6.1 Current situation in U.S air transport market

In this Section, we are going to study the H index and its importance. The H index is determined by the market share of each company. In the following points, we try to measure the variables that have an influence on the H index by studying the H index of each route.

Since we are going to work with market share and routes, it is important to have an idea of the current situation of the U.S air transport market. So that, following subsections shows the data of the market from April 2009 to March 2010.

6.1.1 Airline Domestic Market Share April 2009 - March 2010

Figure 13 shows the ten strongest firms in the domestic airline market, measuring this strength in terms of market power.

It is notable that just four airlines (American, Southwest, Delta and United) have the 50% of the whole market. 25% is shared by US Airways, Continental, Northwest and Jet Blue, and 25% by the other 30 airlines in the market.

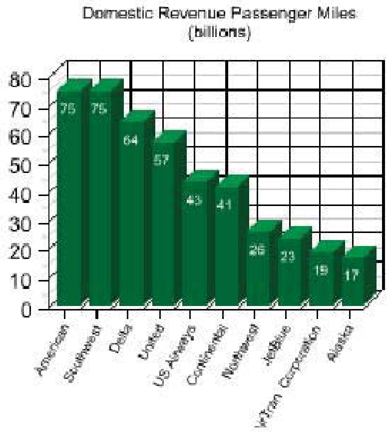

Figure 13: Market share based on Revenue Passenger Miles April 2009 - March 2010.

Airline	Share
American	13.8%
Southwest	13.8%
Delta	11.8%
United	10.4%
US Airways	8.0 %
Continental	7.6 %
Northwest	4.8 %
Jet Blue	4.3 %
AirTran Corporation	3.4 %
Alaska	3.1 %
Other	19 %

6.1.2 Top Domestic Route April 2009 - March 2010

In Figure 14, we can see the 10 most demanded routes. At is it shown the route Chicago - New York is the one which has the most enplaned passengers. This leader route is followed by Los Angeles - San Francisco.

We are studying the factors that make an influence on competition on all the routes U.S. routes, which nowadays is 3,000 routes. The examples provided in the following subsections are not 10 top listed.

Figure 14: Routes based on enplaned passengers of all airports for a city pair April 2009 - March 2010.

6.2 The Herfindahl index over number carriers on a route

The Herfindahl index is influenced by several variables, nevertheless in this Section we see the dependence of H according to the number of carrier that operate a route. In the next Sections, it will be explained how the other variables affect the H index.

In Figure 15, it is represented the Herfindahl index (H) against the number of carriers for quarter 60 (last quarter of 2007). This plot has also being done for quarter 20 and 40, nevertheless it is not included in the report because the results are very similar.

First of all, as with the other plots, in order to present the results in a clear way, a least squares fit is presented. It can be say that the slope remains constant along the quarters, the obtained values are: -0.1766 for quarter 20, -0.1584 for quarter 40 and -0.185 for quarter 60.

Secondly, it is clear that plots start with the value $H = 1$ for a monopoly. Besides, what it is really interesting is that the majority of the duopolies are in perfect competition, since $H = 0.5$. As can be observed for the routes with three airlines, most of their H indexes are around $H = 0.33$, which means the same market share for each firm.

Then, **as the number of carriers per route increase the value of H goes away from perfect competition**. For example, for $n = 6$ the perfect competition value of H is $H = 0.166$ and in the plots it is seen that all of the routes with 6 firms have a higher value of H.

Finally, it can be say that the more the number of carriers in the same routes increases, the more the average value of H goes away from the perfect competition value. It meas that **the differences among the markets share of the firms increase if the route**

is served for a higher number of carriers. Thus, if there are six or more carriers serving the same routes, in most of the cases, few firms have a high market share power. Consequently, a **few leader carriers exist on congested routes**.

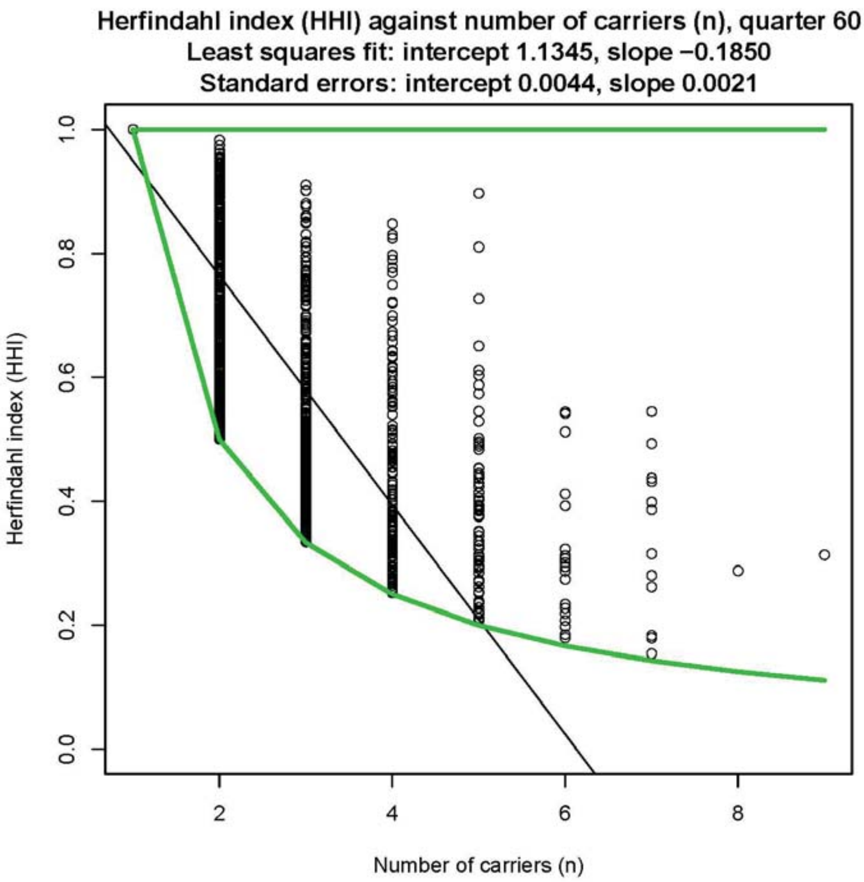

Figure 15: Herfindahl index plot.

6.3 Working on the data

The data we have used to study the U.S. air transport market were just composed of **several columns of values**, then with the help of EViews, we have computed the coefficients of the variables in the equations. First, the variables have to be defined, it meas that **a name have to be given to each column of data**, obviously depending on what each column represents. Then, we have to choose one dependent variable which in this section is H. As well, the independent variables have to be established; in the cases analyzed during our research some of these variables are: distance, route population, number of carrier and presence of Southwest. Finally, **EViews provides the particular coefficient** for each independent variable. This coefficient **measures the way that a change in its associated independent variable affect to the dependent variable**. It has been already mentioned that in this Section the independent variable is H. Once we get the coefficient, its influence has to be analyzed taking into account the other parameters given by the software, as a t-statistic and probability of rejection of the null hypothesis.

6.4 How to model competition

To better understand and study the competition in the U.S airline market it is necessary to build a model. This model must **take into account several variables and must be submitted to some restrictions according to the data and the values the variables can take**. From here on, we refer to H in our models as hhi.

First, a basic model was built, but soon we found it was not accuracy, due to the fact that the high quantity of monopolies ($hhi = 1$) disturbed the coefficients of the variables. The only condition that impose this model is that hhi should be in the interval $(0, 1]$.

Then, a second model was constructed removing from the data all the monopolies. On one hand, the coefficients seems to be represent better the influence of a change in the variables. On the other hand, the hhi domain should be corrected, without monopolies the interval is no longer $(0, 1]$. In fact, the lower limit depends on the number of carriers in each case.

Finally, a model that covered all the previous requirements is developed. This model imposes an suitable hhi upper limit depending on the number of carriers that are being analyzed. The model is based on the transform function.

In the next Section each model is explained. The best one for our study of competition in U.S airline market is the third.

6.4.1 Model 1

In order to model competition hhi is written as a function of a vector of some variables x_i:

$$hhi = {x_i}'\beta \rightarrow hhi \in \mathcal{R}.$$

At the beginning these values are in the real number domain, nevertheless this domain should be corrected and restricted because it is known that hhi can only takes values between zero to one.

6.4.2 Model 2

This second model has been built by deleting all the monopolies, because as it is known that hhi for a monopoly is always 1. The paradox is that we are trying to build a model that detects which variables will have an influence on hhi, nevertheless in case of monopoly hhi will not change and will always take value one whatever the change of the variable is. Consequently, monopoly cases are not the suitable ones to measure hhi changes, so that these cases are neglected.

In this second model the hhi still being a function of the same variables, but the constant value ($hhi = 1$) is not taken into account. It allows us to detect in a more representative way which are the variables that influence hhi. As before, the limits are for hhi values are $(0, 1]$.

$$hhi = \Phi(x_i\beta) \rightarrow hhi \in (0, 1]$$

This model is not accurate enough because of the limits for the hhi domain, this domain changes depending on the number of firm considered.

6.4.3 Model 3

This third model provide a huge and accuracy analysis of the variables that will affect to hhi and as before monopoly cases are neglected.

Once monopoly cases has been removed, the minimum value that can be found for hhi is $hhi = 1/2$, which corresponds to perfect duopoly competition. Therefore the new values for hhi limits are $[0.5, 1]$. Besides if there are three firms present in the market, the previous limits are reduced to $[0.33, 1]$. Furthermore, for four firms the limits are $[0.25, 1]$.

As has been explained **the boundary for hhi depends on the number of firms in the market. Our aim is to find a function that imposes in each case the**

suitable limits.

$$hhi_i \in \left[\frac{1}{n_i}, 1\right].$$

Since the length of the interval is variable, some changes must be introduced to reach a interval of length one. First the variable is scaled and the interval is stretched.

$$\frac{n_i}{n_i - 1} hhi_i \in \left[\frac{1}{n_i - 1}, \frac{n_i}{n_i - 1}\right].$$

Once the length of the interval is one, the variable is shifted.

$$\frac{n_i}{n_i - 1} hhi_i - \frac{1}{n_i - 1} \in [0, 1]$$

$$\frac{1}{n_i - 1}(n_i hhi - 1) \in (0, 1); n_i \neq 1. \tag{1}$$

It is clear that n cannot be one, but this condition is already fulfilled since the monopoly case has been deleted from the data. The variable depends on the route. And for each route the variable depends only on hhi. Equation (1) can be written as:

$$g_i(hhi_i) \in (0, 1)$$

which can be modelled using

$$g_i(hhi_i) = \Phi(x_i'\beta).$$

In order to work with a variable and not with a function of a variable, we have to invert the function. To find the inverse function:

$$hhi \longrightarrow \frac{1}{n_i - 1}(n_i hhi_i - 1) = z_i$$

z_i is the transform function, thus, if we transform z_i we get the hhi:

$$z_i \longrightarrow \frac{n_i - 1}{n_i}(z_i + \frac{1}{n_i - 1}) = hhi_i.$$

hhi is the inverse function of the argument of the explanatory variables.

$$hhi = \frac{n_i - 1}{n_i}\left[\Phi(x_i'\beta) + \frac{1}{n_i - 1}\right]; n_i \neq 1.$$

At that moment, we are able to do the regression and get the estimated hhi:

$$\widehat{hhi} = \frac{n_i - 1}{n_i}\left[\Phi(x_i'\hat{\beta}) + \frac{1}{n_i - 1}\right].$$

6.5 Interpretation of an H index regression

In this Section we explain **how to read the result for the *hhi* equations**. To better understand the reading the presented equation is **a simple one, containing few variables**. In the next Section it is presented the whole final equation taking into account all the variables we have been able to measure. Previously, we have identified how some competition models work as well as the mathematical theory behind them. After that it should be explained **the criteria to identify if a variable has a relevant effect on the model or not**. Back to Model 3 which has been explained before, then starting from data removal process, particularly (monopoly, $hhi = 1$) and dealing with data manipulation, it is possible to come out with Figure 16. First, the **coefficient** of each variable can be identified (see Figure 16). As well, the **standard error** and the ratio between the coefficient and standard error, which is called the **t-statistic**. The last column is the probability of the t-statistics, which indicates the probability of get a

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.971803	0.087220	-11.14192	0.0000
C(2)	0.310114	0.081479	3.806075	0.0001
C(3)	-0.086180	0.018034	-4.778680	0.0000
C(4)	0.043038	0.007405	5.812214	0.0000
C(5)	-0.012899	0.012960	-0.995351	0.3197
R-squared	0.335410			

Figure 16: Equation information related to Model 3 - Herfindahl Index Q60.

relevant difference between the coefficient and their respective error. In other words, it tells us if the previous correlation is big enough. Now, it will be necessary to analyze the t-statistics. The expression below show that if t-statistics is bigger than 2 consequently their probability will be less than 0.05.

$$|t - statistics| > 2 \longrightarrow Probability < 0.05.$$

Thus, we will take the first and fifth rows from Figure 16, as it is possible to see along the first row, the absolute value of t-statistic is more than 2, as a consequence the probability is almost zero, however in the fifth row the absolute value of t-statistic is less than 2, so the probability is no longer less than 0.05, which means that the error compared to coefficient β_5, which is the presence of WN, is quite big.

As a result, it seems clear that this statistical model implies that Southwest presence in an evaluated market does not have any effect in terms of competition (regarding quarter 60 of the database). In other words, the presence of WN does not influence the market. But, what is the reason? It could be possible that the market power is still so large that operation of one specific carrier does not have any effect on it, or it might be that the market power of Southwest is not as big as we thought. Not so far from this point, come out another question: Is it the same behaviour for all carriers? This will be explored further with the inclusion of more variables inside this model.

The corresponding equation computed in EViews is:

$$hhi = \frac{n_i - 1}{n_i}\left[\frac{1}{n_i - 1} + \Phi\left(\beta_1 + \beta_2\frac{dist}{1000} + \beta_3\left(\frac{dist}{1000}\right)^2 + \beta_4\frac{pop}{1000000} + \beta_5 WN\right)\right].$$

and

$$\begin{aligned}\widehat{hhi} &= \frac{n_i - 1}{n_i}\left[\frac{1}{n_i - 1} + \Phi\Bigg(- 0.9718 + 0.3101\,\frac{dist}{1000} - 0.0861\left(\frac{dist}{1000}\right)^2 \\ &+ 0.0430\frac{pop}{1000000} - 0.0128 WN\Bigg)\right].\end{aligned}$$

The previous expression is determined by the function Φ, which regarding its nature, modifies the values of the coefficient so the whole parenthesis will have a value between $(0, 1]$.

It is important to determine the variation of the **competition, explained by the variation of the Herfindahl Index**. The way this mentioned dependent parameter varies in function of independent variables, focusing of the sign of the corresponding coefficient. The **coefficients** β_2 and β_3 measure the corresponding behaviour of the **distance variable**, but each coefficient is then adjusted by the **function** Φ giving the expected value of the Herfindahl index so level of competition itself. Those two coefficients are preceded by the signs $(+)$ and $(-)$ respectively, which means the first behaviour of the dependent variable will be linear with positive slope and then it will become exponentially negatively sloped. In others words, it said when the route distance is too small, there is not enough competition due to the small demand; when the distance increases, there is still not enough demand to hold up competition; just until a distance of 1,799 km the demand is good enough to maintain more a more competition gradually.

On the other hand, different results have been found using other models which are not as accurate at the third one. For instance, **Model 1 shows in Figure 17, that sometimes the results do not have any sense**, perhaps due to a problem coming from the data. In this sample, it is easy to identify that the majority of probabilities of t-statistics are more than 0.05. Thus, in this model the variables distances and population can not be considered as an influent variables in the *hhi* values. This result seems quite illogical according to intuition. **Therefore this model was replaced by Model 3**.

	Coefficient	Std. Error	t-Statistic	Prob.
C	1.126843	0.006986	161.2981	0.0000
DISTANCE	5.46E-06	5.27E-06	1.036066	0.3003
(DISTANCE)^2	-9.18E-10	8.88E-10	-1.034084	0.3012
POP	1.35E-09	1.02E-09	1.322234	0.1862
NUMBER	-0.186053	0.002226	-83.56725	0.0000
WN	0.000211	0.005013	0.042013	0.9665
R-squared	0.717536			

Figure 17: Equation information related to Model 1.

6.6 Factors that influence competition

First of all, two examples of two different routes are presented. It has already been shown that the H index depends on the number of carrier serving a route. Nevertheless with the examples it can be noticed that there are more several factors that must be taken into account.

6.6.1 Boston - San Francisco

This route (Figure 18) is between two high population cities, with population of around 4.5 million inhabitants [3], thus a high traffic of passengers is expected. As can be appreciated in the map those cities are on the coast, the distance between the two endpoint cities is 4,344 kilometers.

In the 2007Q4, five different carriers were operating this route: United Airlines, US Airways, American Airlines, Delta Air Lines and Jet Blue.

To see whether there is high or low competition between the firms in this route the market share of each firm has to be taken into account, and this one has been computed according to the number of passengers flying which each airline.

- United Airlines: 57.6 %

- American Airlines: 29.3 %

- Jet Blue: 10.3%

- US Airways: 1.97 %

- Delta Air Lines: 0.76 %

In this route we can observe that United Airlines has a dominant position respect to

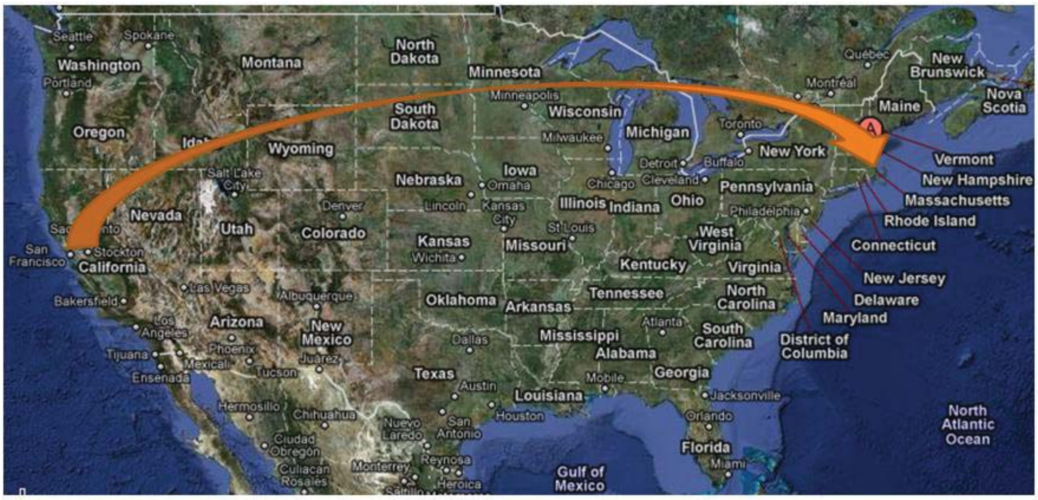

Figure 18: Boston - San Francisco.

the others, since that is has more than the half of the market share. The H index on this route is 0.429, as it is two high it means that there is a high competition between the carriers in this particular route.

6.6.2 Baltimore - Seattle

The route (Figure 19) between Baltimore and Seattle is not expected to have as much traffic as the previous one. Since the population of the cities is lower than in the previous example. The characteristic of this route are studied for 2007Q4 and by that time Baltimore had around 2.6 million inhabitants and Seattle approximately 3.5 million passengers [3]. As before, the route is between coastal cities and the distance is 3,749 kilometers.

In 2007Q4, five different carriers were operating this: United Airlines, Southwest, AirTran Airways and Northwest.

The routes Baltimore - Seattle and Boston - San Francisco seem to have many issues in common, same number of carriers, coastal cities, same distance, high population, nevertheless the competition in those two routes are not the same. Thus, it makes us believe that there are many others factors to take into account when we try to model competition.

The market share of each airline in this route is as follows:

- United Airlines: 27.1 %

- Southwest: 24.3 %

- Delta: 8.7%

- AirTran Airways: 10.6 %

- Northwest: 29.1 %

Contrary to the previous example, all the airlines seems to have approximately the same market share. So it can be said that the competition in this route is low, and the H index is 0.237.

Those two examples show that competition and in particular the H index is a variable that depends on many factors. Thus, it is very difficult to measure and, even more, to model. In this report we try to model competition with Model

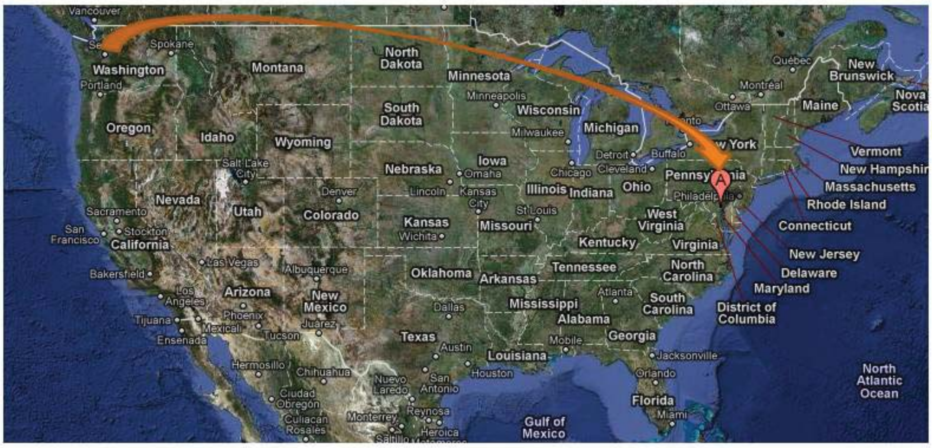

Figure 19: Baltimore - Seattle.

3, which has already been explained. In the next Section, we will present all the routes from Q1, Q30 and Q60, with all the variables that we have defined before, and we will analyze the influence on hhi.

6.7 Analysis of H index regression

In the examples of the previous section it shown that the H index takes different values for each route, it is due to the fact that each route is defined by some especial characteristics. The influence of these characteristics in the H index is what we are trying to measure with our model. A total number of 20 variables have been introduced in our method and after doing the regression with EViews the results for quarter 60 are shown in Figure20. To see how to interpret a regression see the Appendix.

$$
\begin{aligned}
hhi \;=\; & \frac{n_i - 1}{n_i}\Bigg[\frac{1}{n_i - 1} + \Phi\Bigg(\beta_1 + \beta_2\,\frac{dist}{1000} + \beta_3\left(\frac{dist}{1000}\right)^2 + \beta_4\,\frac{pop}{1000000} + \beta_5\,WNpresent \\
+\; & \beta_6\,leisure + \beta_7\,business + \beta_8\,\frac{gdp}{pop} + \beta_9\,AApresent + \beta_{10}\,COpresent \\
+\; & \beta_{11}\,DLpresent + \beta_{12}\,NWpresent + \beta_{13}\,UApresent + \beta_{14}\,USpresent \\
+\; & \beta_{15}\,STDpother + \beta_{16}\,Inertia\_range + \beta_{17}\,AllianceEN_bycarriers + \beta_{18}\,rlocMWNW \\
+\; & \beta_{19}\,rlocNESW + \beta_{20}\,rlocOUSW + \beta_{21}\,rlocSESW + \beta_{22}\,rlocSWSW\Bigg].
\end{aligned}
$$

The coefficients that have an influence on the H index are going to be explained. First, as was expected, the distance of the route affects the level of competition on that route. From the results we can get that if the distance is low and increases the H index will increase, nevertheless if the increment of distances is too high the H index

QUARTER 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-2.028451	0.255640	-7.934790	0.0000
C(2)	0.468245	0.104462	4.482425	0.0000
C(3)	-0.126619	0.022821	-5.548242	0.0000
C(4)	0.038399	0.008637	4.446086	0.0000
C(5)	0.024344	0.050109	0.485827	0.6272
C(6)	0.124222	0.242053	0.513203	0.6079
C(7)	0.125052	0.060002	2.084134	0.0374
C(8)	19.86647	4.662358	4.261034	0.0000
C(9)	-0.161256	0.055214	-2.920570	0.0036
C(10)	0.001853	0.058862	0.031478	0.9749
C(11)	-0.073271	0.048525	-1.509968	0.1313
C(12)	0.012095	0.058305	0.207447	0.8357
C(13)	-0.119313	0.053899	-2.213658	0.0270
C(14)	0.195202	0.051063	3.822732	0.0001
C(15)	0.002959	0.578919	0.005110	0.9959
C(16)	-0.003579	0.001224	-2.925074	0.0035
C(17)	0.155014	0.113975	1.360068	0.1741
C(18)	-0.253944	0.179693	-1.413208	0.1578
C(19)	0.071783	0.081886	0.876615	0.3809
C(20)	0.709464	0.316004	2.245109	0.0249
C(21)	0.189036	0.075965	2.488453	0.0130
C(22)	0.368822	0.153347	2.405141	0.0163
R-squared	0.384292			

Figure 20: H index regression for Q60.

will decrease. This result seems intuitive since that **medium-distance routes will be served by a high number of carriers, nevertheless if the distances is very long a few carriers are expected to be serving that particular route**.

Another variable that influences competition is the population on the route. The results tells us that if the population increases the H index will increase as well, which means less competition. In other words, if the population on the route increases, it is expected that the differences between the market share of the firms increase. It has to be said that the market share of each firms has been defined in terms of passengers. Therefore, **if more passengers began travel in this route, is more likely that one or few of the companies in the route take all of them**. It cannot be specified it will be due to a increase on capacity of the aircraft, increase on the frequency of the flight, etc.

The presence of one particular airline can be expected in some cases to influence competition, nevertheless for this particular quarter the presence of Southwest on a route does not seems to made any difference in terms of competition. In the following paragraph it will be study if the present affect to the level of competition.

The leisure variable is not considered to contribute to a H index change because the t-statistic, in absolute value, is not above 2. For the business variable, it can be considered that if the business increase the H index will increase. Also a factor to be taken into account is the gross domestic product. In the regression analysis the variable that has been taken is GDP/population. Studying the regression we get that an increase on this variable gives an increase of H index. For a route, it can be said that **the richer the two end point regions becomes, the more competitive the route will be**.

The next six variables are related with the presence of six different carriers on a route. Among those, the presence of Continental Airlines, Delta and Northwest can be neglected in terms of competition. It seems that if American Airlines or United Airlines are present on the route, the H index of this route is expected to decrease. On the contrary, the presence of US Airways provokes and increase of the H index, which means that the competition will decrease. Taking into account that the present of US Airways is the only variable that increase the H index, it could be said that US Airways might have the ability to increase its market power or to provoke a high difference between the market power of the firms serving the same route.

Then, after analyzing the presence of one particular carrier on a route, we study "inertia", which is a variable related to the time that carriers have been present on that route. For a wide explanation see the section of modelling competition. In our model if the inertia increase the H index decrease. According to this result it can be said that **if a carrier has been present in a route for a long time and another one has entered just few time ago, it might not be a sufficient condition to achieve a high differentiated leader position in terms of market power**.

Finally, the geographic zone where the route is settled seems to have an influence. The results for Q60 show that routes in the south west region seems to increase H index. It can be say that there **is likely to appear a low level of competition in the routes on south west region or routes which have one end point airport in that region**.

For the other quarters (Q1 and Q30) the results of the regressions are presented in the Appendix E.2.

6.8 Accuracy of our model for H index

To check the accuracy of our model we have use *forecast* EViews tool. This tool give us the H index for each route according to our defined model. As it can be seen in Figure 21 the model is not *perfect* because the least square regression has an slope different to

45^o.

To better understand this tool we are going to compute the forecast the H index for the two given examples

Route: Boston - San Francisco

For this route the real H index is

$hhi = 0.429$,

and the forecast H index is

$\widehat{hhi} = 0.3$.

Route: Baltimore - Seattle

For the second example the real H index is

$hhi = 0.237$,

and the forecast H index is

$\widehat{hhi} = 0.337$.

As it is shown there is a difference on 0.1 between the H index our model provides and the real H index. That can be explained due to any missing variable we are no able to measure or we are not able to model. Time has been a restriction in this research project, we have try to measure and model as many variables as possible.

7 Further topics: entry deterrence

Entry deterrence refers to any action taken by a firm already operating on a route or market (incumbent) to prevent potential competitors (entrants) from entering this market. Such actions are referred to as barriers of entry. These barriers, their effectiveness,

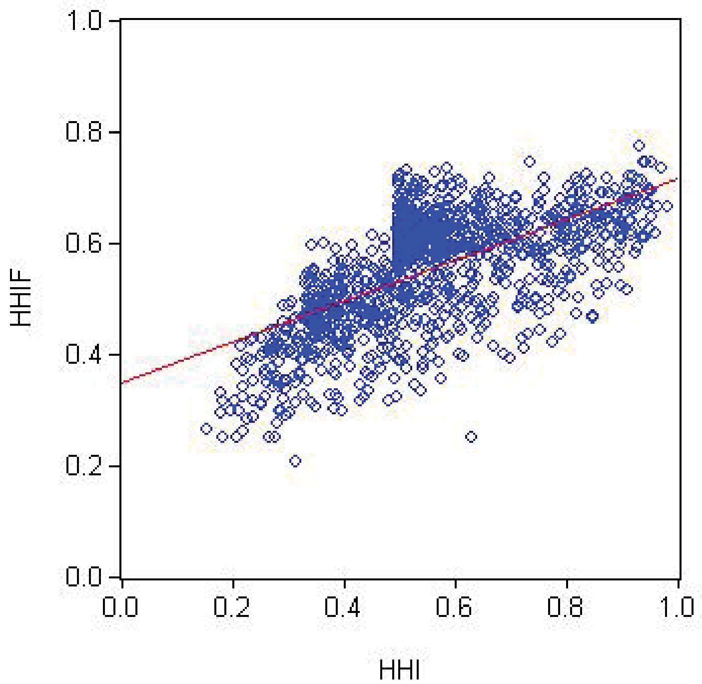

Figure 21: H index forecast over H index for Q60.

and the means by which they are implemented are some of questions we would have liked to address but we finally did not have time. Entry deterrence is a wide enough theme to constitute a project by itself.

7.1 Introducing entry deterrence into our model

It is known that the probability of a carrier entering a route when being present at one endpoint airport of the given route is small but significantly higher than the probability when the carrier it is not at all present (the latter being close to zero). When having a presence in both endpoint airports the probability of a carrier entering the route increases significantly, as Goolsbee and Syverson [5] analyzed for the specific case of Southwest entry. We will go one step further by focusing not only on a single carrier as the entrant but on all carriers present on the U.S. domestic market. We will also take into account the different level of threat faced when the entrant is a low cost carrier (for instance Southwest or JetBlue) addressing a potentially different market, an expanding carrier or a steady one. We think the threat will be higher if the carrier is in expansion (if it is currently opening new routes and increasing his market) than if the carrier is steady (if it has not created new routes or if it has not increased its market share lately).

Thus, we will consider that a route served by a carrier is facing a threat of entry when another carrier establishes itself on both endpoint airports of the route.

To measure entry deterrence from the data, a Python code may detect the two endpoint airports of a given route and the different routes served from both of them. Once a carrier is operating on both endpoint airports we will consider that the route is being threatened, and the code must extract the fares of the two quarters before and the four quarters afterwards. Finally, the code must look for the entrant finally getting to serve the route or not.

It would also be interesting identifying different ways other than price of deterring entrance, as frequency or capacity augmentation. Therefore, the code may get also the total passenger from two quarters before and after the entry would be nice. The problem we may encounter is that if fares decrease and an increase on the number of passengers is observed, it will be unknown whether this is due to a higher frequency or capacity measure or to a higher demand now the prices have lowered, being the capacity

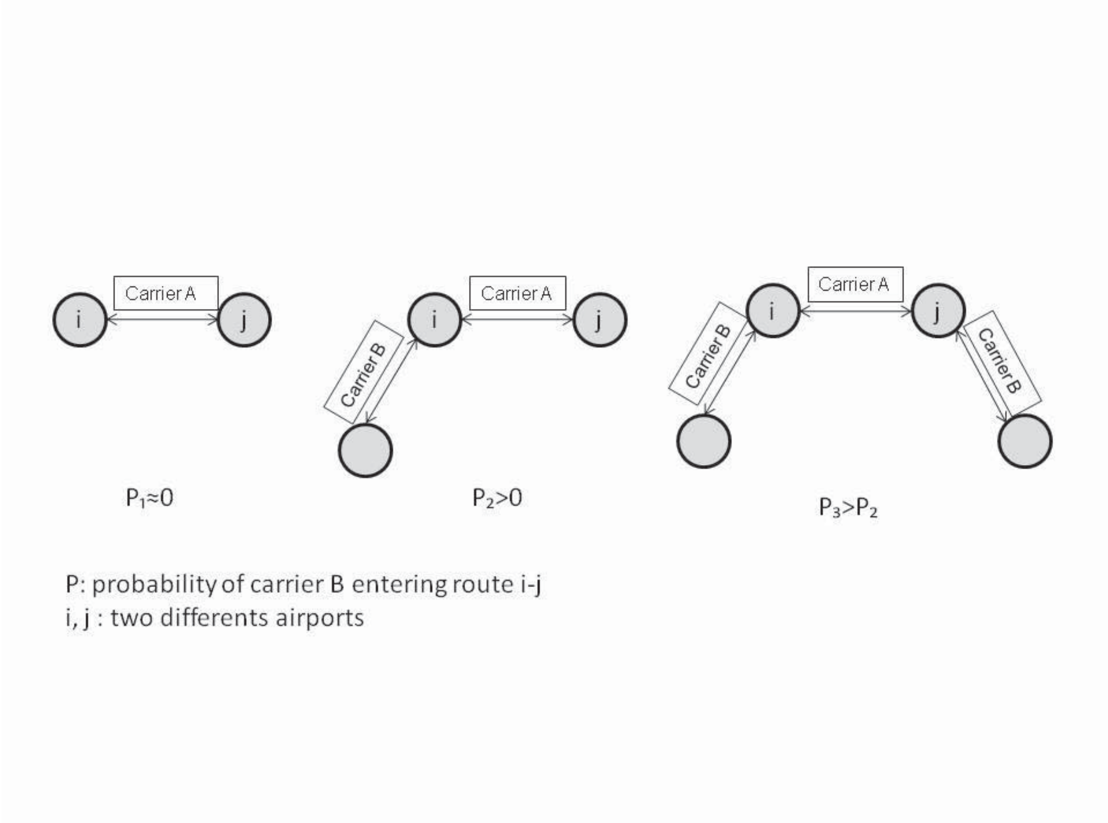

Figure 22: Probabilities of a new carrier entering a route.

and the frequencies the same. A further study on the fleet mix of the carriers from a historical point of view will be needed to avoid this problem, which will not be easy to do. Another problem is not to know which airplane is serving which route. Differences in seat distribution may come up, too. Another solution is just to study all this for Southwest, which we know has a fleet mix composed exclusively of B-737s.

7.2 Mechanisms used to deter entry

The following pages describe the main mechanisms generally used to try to deter entrance. Lack of time has prevented us from getting further on this matter. Defining how to measure all this mechanisms on the database available and the implications of all this remain to be done.

Price Price is supposed to be the main tool used by every incumbent to try to deter entry.For instance, the article published by Goolsbee and Syverson [5] (in which they study the particular case of Southwest entering a new route) proves that incumbents cut fare significantly when threatened by Southwest's entry. The fare declines appear to be accompanied by an increase in passenger traffic on the incumbents threatened routes. So we can say that it is a very simple but effective mechanism. By reducing price decreasing, companies hope to increase their sales and make it less attractive to other carriers to enter the route. On the contrary incumbents does not seem to have a strategic investment in excess capacity.

Product differentiation, capacity and frequency. An increase of capacity or the frequency of the route can also be seen as an entry deterrence measure. It is a way of product differentiation, as the incumbent tries to provide a higher quality service than the potential entrant (usually a low cost). Higher frequency, ability to change tickets, better in-flight service, alternative routes (if problems occur) and a high level of customer service are also product differentiation measures. However, it is a less frequent tool than price decrease and, given the database available to us, not easy to measure.

Pre-emptive deterrence Another way to deter entry is to build up an image for the carrier or to create a loyal customer base. Through marketing strategies and advertising campaigns, a carrier can be perceived as safe and reliable. Customer loyalty can be rewarded with flight points, free flights or several different prizes.

7.3 Entry deterrence in duopolies

As all the theory papers available about entry deterrence we have found concern only monopoly routes threatened by an entrant, we have thought it would be really interesting but difficult also to analyze the behaviour of carriers serving a route on duopoly (or n more than two) when they are threatened by another carrier (again, threat means the entrant is serving routes in the two endpoint airports). The Python code necessary would be similar to the one used above.

Will they behave different than when being threatened in monopoly? Will the incumbents ally among them? Will they plan a common strategy? Will they take advantage of the situation to try to recover a monopoly status? Trying to give an answer to all this questions would have been really interesting.

To analyze these last questions will also be needed some historical information (news) to try to give some weight to our argumentations (as just price and number of passengers seems scarce resources to model all that).

7.4 A closer look at entry deterrence theory

Entry Deterrence is a very useful business strategy since it is not a direct approach. It is not an attack strategy to gain possession of market share neither is a defense strategy to keep market territory from being damaged. Deterrence gives carries (incumbents) the chance to achieve success in the marketplace excluding an encounter between opposition competitors (entrants). As B.G.James [4] says in his article there are key deterrence factors and strategies.

7.4.1 Key factors for effective deterrence

There are four key elements to achieve a successful deterrence strategy:

Credibility It means that the incumbent is able to convince the entrant that it is willing to deal important losses on the on the entering firm. The entrant is also persuaded it has something to obtain from restraint. In the market it can also be observed a non credible threat, it is when the entrant is ready to face the possibility of suffering a punishment.

Capacity The incumbent uses this key element when it convince the entrant that it is not only being willing but also it has the resources to take further the threat of punishment.

Communication It allows to show to the entrant the incumbent's intention to further its targets or keeping its market position. Moreover, it makes the entrant fully aware of the benefits of cooperation and the punishment that may be meted out for noncompliance.

Rationality This is what guides the behaviour of the incumbent instead of taking arbitrary action. A incumbent uses rationality to avoid arousing emotion on the part of a entrant.This key element drives the entrant to a disadvantage position since that, to avoid forgoing the benefits of cooperation, the entrant has been persuaded to act rationally, reasonably and objectively.

7.4.2 Strategies designed for deterrence

There are substrategies that are defined in different fields to avoid the disturbance competitors can cause in the market equilibrium. Moreover, this strategies are the origin of entry barriers. The five different mentioned fields are: Marketing, production, financial technological and managerial deterrents.

Marketing deterrent strategies: distribution, promotion, franchise, customer relations, services, quality and pricing.

Production deterrent strategies: capacity, utilization and equipment.

Financial deterrent strategies: cost and economics.

Technological deterrent strategies: innovation and information.

Managerial deterrent strategies: acquisitions, mergers and alliances.

7.4.3 The importance of deterrence

To adopt any of these strategies a company has to reflect very carefully on its own situation.

"If a company is not prepared to fight a war in the marketplace, it cannot rationally or credibly threaten another company, and its own survival will be threatened if it adopts a deterrent strategy" [4].

The previous sentence shows the importance of a carefully incumbent reflection before adopting a deterrent strategy. If the incumbent wants to adopt a any of these strategies, first of all, its hast to be sure that it is able to battle and threat a competitor. And once, it is convinced of being able to follow those two first steps, it will be able to face a threat.

To sum up, first the incumbent is able to threat and then and only then it will have the ability to repel an entrant's threat.

8 Further topics: reputation

The same way as entry deterrence, when first planning the project we thought that looking at reputation of the carriers and how this reputation influences on future routes and the decision making of the carriers would be really interesting, but again we did not have time to develop this subject.

8.1 Defining reputation

When trying to enter a new route, previous successes or failures of en entrant when trying to enter on different routes in the past can modify the level of threat perceived by the incumbent. Being aware of the current status and previous strategies undertaken by the entrant on similar situations may cause the incumbent to act one way or another.

8.1.1 A points system for reputation

A good starting point to try to measure reputation from our Core data would be a point system game. A Python code may assign a point to each "Won battle" to a winner carrier. A point will be assigned to a carrier succeeding to enter on an already existing route (obviously, the route must already exist), establishing a minimum time (one year and a half seems reasonable to us) the carrier must stay on the route for considering the carrier has successfully entered the route and, therefore, won. We will also assign one point to a carrier succeeding in deterring an entrant to enter the route it is serving (also a time margin will be needed). The problem we encountered here is that we may find some carriers serving the two endpoint airports but not really posing a threat, so assigning a point to the incumbent for succeeding in deterring entrance will be incorrect. So, how do we make the difference? Maybe if the incumbent does not significantly decrease its fares it will not be consider as threatened. Concerning the payoffs for a carrier losing a battle, maybe a loss of two points seems reasonable.

Later with a model we can check if this Reputation we have created has some influence on the number of battles won in the future or on the routes a carrier succeeds to enter.

For example, if the route with more points is the route that succeeds to enter more routes, our model would be correct.

9 Conclusion

The purpose of this research project was to explain why the majority of the routes in the U.S market are served by so few companies. This market distribution is explained by the competition between airlines and it is measured by the H index. First, we had to increase our knowledge in the economy and econometric field, learn a lot about the U.S air market and acquire the skills to use EViews, software that has helped us to do the regressions. The data was filtered from the U.S Department of Transportation, which gives us a sample of the 10% of the tickets bought by passengers during .one quarter since 1993. Treating the data and its subsequent descriptive analysis has been a key step in our research.

The main remark we can do concerning the structure of the market is the totally unexpected regularity in the percentage of routes served by a given number of carriers. From it we can conclude that even though the market has suffered enormous changes over the last fifteen years (the number of carriers has been multiplied by two and the number of passengers has increased sharply), when we look at the aggregate of the whole market it remains essentially the same. This is due to, though the number of players may vary over time, the basic needs the air transport responds to are the same. The market on the U.S. in 1993 (where the DB1B database started) was already settled and continues that way.

Then we consider the variables that might affect competition. Medium-distance routes seems to have a low H index value and to be served by a hight number of carriers. We though also about population and we get that there is a low level of competition high populated routes, it means that a few carriers are expected to have a leader position on those routes. Besides, the richer the two end points regions are, the more competition we have. Further, thinking about the effect that can cause the prolonged presence of a particular firm on a route we get that it is not a sufficient condition to achieve a leader position in that particularly route. And finally, the geographical is a relevant matter since that a low level of competition appear in routes on south west regions or routes which have one end point airport in that region.

Our project has not been absent from some problems, too. First, time has been definitely a major constraint for us. We started answering ourselves a very general question and from there a few interesting branches were born. Thus, we were obliged to focus on just two of them (number of carriers and market power). Then, when building our empirical models we have found that they are far from perfect and there is still a lot of improvement that can be performed on them. Adding more variables and treating more carefully the existing ones will surely provide a more perfect model. We think we have settled the basis upon that future students may use to go further on this concepts and build more perfect models. And we are proud of that.

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[2] B. Vasigh, K. Fleming, T. T. Introduction to Air Transport Economics.

[3] Bureau, U. C. State Resident Population — Projections: 2010 to 2030.

[4] G.James, B. Deterrence - a strategy that pays.

[5] Goolsbee, A., and Syverson, C. How do incumbents respond to the threat of entry? evidence from the major airlines.

[6] S. Kim, R. M. Historical Perspectives on U.S. Economic Geography.

A Appendix A

A.1 Building the empirical model

Before the well understanding of how the U.S. domestic traffic works and in order to build a proper and accurate econometric empirical model, it has been important to thought from the general point of view, what are the possible aspects which are going to influence on what it is called **numbers of carriers on a given route**. This, as a possible way to answer the question **why there are so few companies on given route?**. Thus, in the coming paragraphs it will be possible to see some of the preliminary assumptions that have been used.

A.1.1 Numbers of carriers on a given route

The quantity of firms on a given route depends on a lot of factors, since income per capita through airports fees until the population of the evaluated area. Those factors are going to be analyzed and measured as follows. Below we have defined a general empirical model taking into account all possible variables.

$$\begin{aligned} Y_j(t) &= f(GDP, hab, D_jt, GE, ALR, F_jt, AF_jt, Al/Airport, \\ &\quad Pax_jt, Satur/level, N/comp_jt, H_j(t), TKTT), \end{aligned}$$

where GDP is the gross domestic product, hab is the population, GE is the geographical emplacement of either the route or the airport, D_jt is the route length, ALR alternative route variable, F_ijt are the fares charged by an specific carrier on a given route in a period of time, AF_jt are the airport feed charged, $Al/Airport$ is alternative airport variable, Pax_jt is the number of passenger, $Satur/level$ is the level of saturation of the existing infrastructure, $N/comp_jt$ is the nature of the competition inside a given route, $H_j(t)$ is the Herfindahl index and $TKTT$ is the fare class. Nevertheless all of this variables are going to be explained properly in the next section.

A.1.2 GDP (Gross Domestic Product) of a given city, region or state

The **Gross Domestic Product (GDP)**, is a way to measure the overall economic output of the country and it is mainly the market value of goods and services made inside the country. This measurement is also a correlated value of the standard of living so it is related with the capability of the potential customers to buy a specific product or service. Under this assumption, it is possible to say that the more standard of living the population could have the more capacity to travel they will have. As a consequence, seem clear that the U.S air domestic traffic between large economic centers of development, which have an important contribution to overall country's GDP, will be greater than traffic in other parts of the country where the economy is not developed enough.

It has thought to take this information form the official web page of the Bureau of Economic Analysis of U.S. Department of Commerce and it is given in U.S.$ million.

A.1.3 Population

United States has a total resident population of 309,284,664. It is a very urbanized population, with large quantity of people residing in the urban areas and suburbs. The most populous states are California and Texas respectively [3] as a consequence the mean center of U.S. population is located westward and southward every year more and more.

This tendency appear thank to migration of the people from the east to west specially from the twentieth century due to the appearance of new ways of transport and technology, this behavior can be seen in the next figure where the mean center of U.S. population moves toward west. However, the general concentration is located still in the east half of the country as the figure number XX shows where the increase of population per square mile is represented by the change from light to dark color.

Refer to Figure 23 (.jpg)

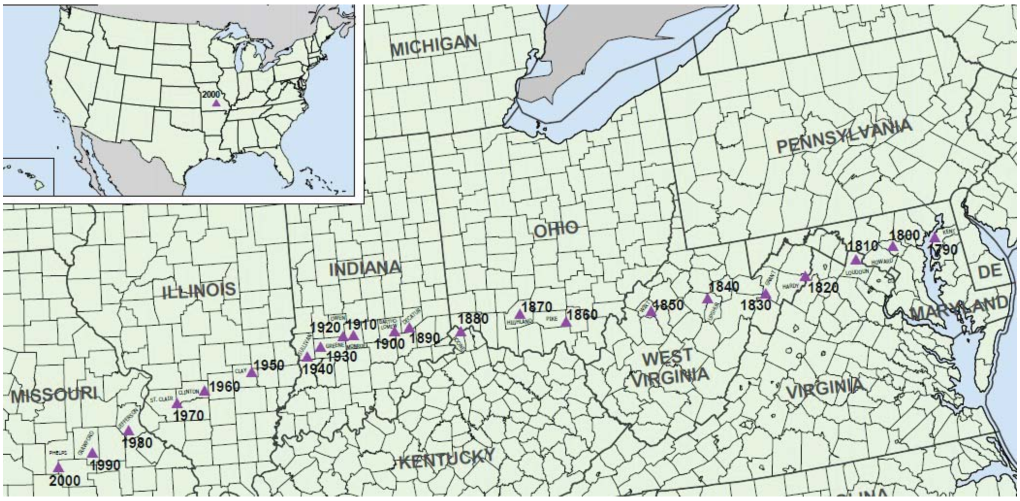

Figure 23: Mean center of U.S. population 2000.

Refer to Figure 24 (.jpg)

Now, this behaviour concerning population seems to be important in terms of potential customer numbers: what that is mean that the more population a given area would have

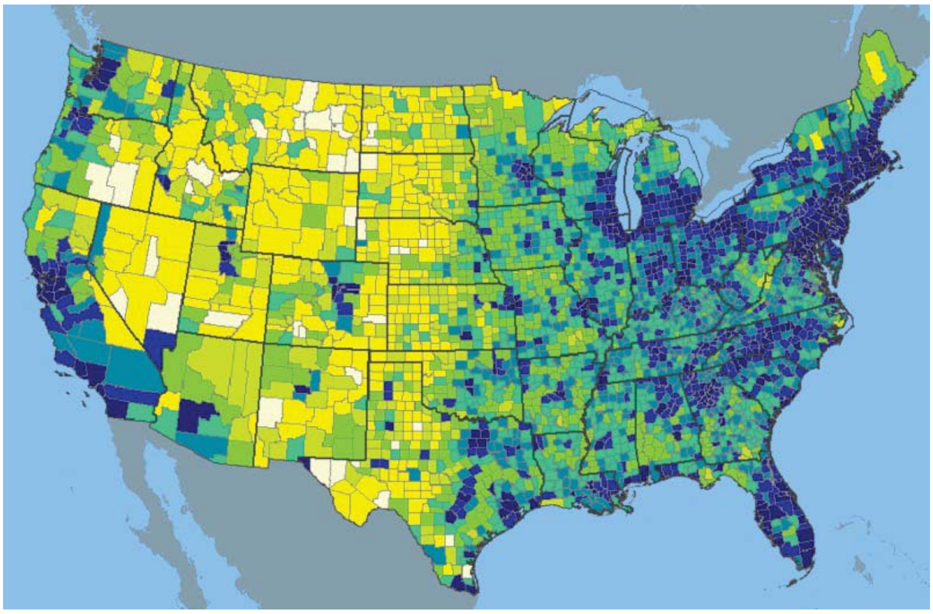

Figure 24: U.S. population density 2000.

the more potential customers on given route will be. Nevertheless, we do not yet know whether this tendency is always true. As consequence the population must be measured and included as a variable (hab) which will be reported in numbers of habitants by geographical area.

Another relevant issue is the relationship between the population and the GDP of each state or region and how those factors affect the emplacement of an airport what we are going to explain further.

A.1.4 Route length

The route length could be another factor that is involved in the quantity of carriers flying on a given route, themes like high production cost concern to long hauls, different profitability of an airline regard long flight time, etc.; might be factors that affect the answer of our main question. Thus, taking into account that the dataset has information about geographical coordinates, it is possible to calculate the distance between different points, even when the flight paths of the airplanes are not completely straight, we are going to assume that. This values is going to be brought in kilometers and the variable will be $(D_j t)$.

Figure 25: **Principle of route distance**

In the previous Figure 25, it is possible to see how we are going to work concerning distance between airports. In this example, the variable $(D_j t)$ will show up the geographical distance (presented as red line) between DFW (Dallas/Fort Worth International) and ORD (Chicago O'Hare International) taking into account their respective geographical coordinates XY and X'Y'.

A.1.5 Geographical emplacement (e.g. coastal or central location)

The U.S. is divided mainly in 9 regions as is presented in the Figure 26, even when there are many classifications defined by law and regulation; each region has historically developed its own economic behaviour, so taking into account their regional comparative advantage based on soil, weather and geography have generated a specific source of economical growth as industrial, agriculture, services, non-renewable resources exploitation, export and many other sources of economic growth.

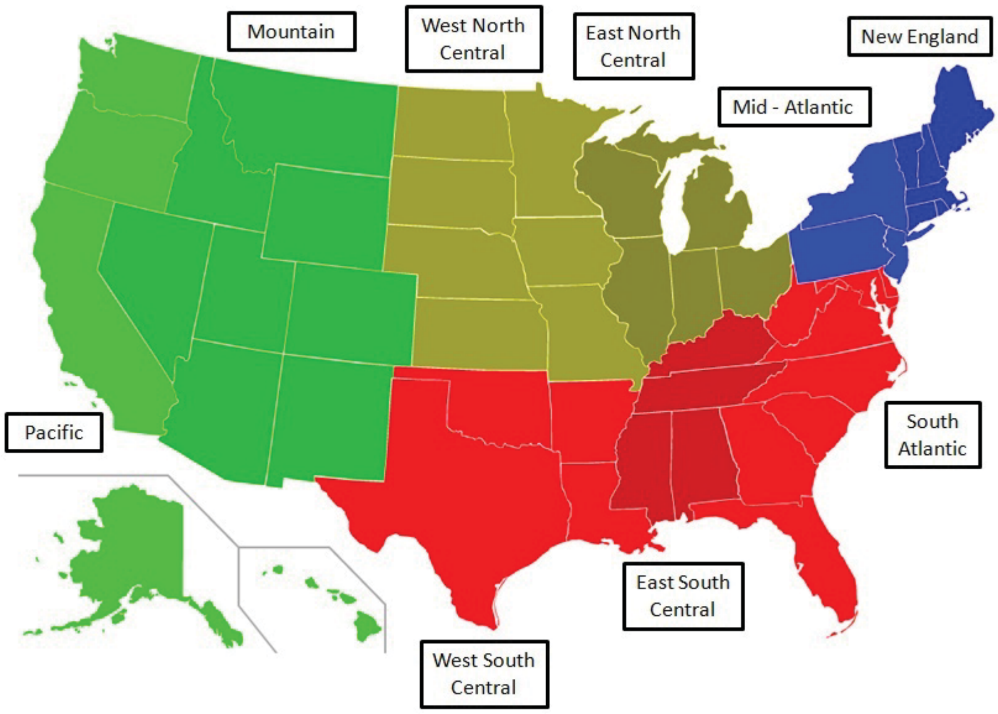

Figure 26: **Regional political distribution of U.S.**

For example, the U.S. has presented an increasingly industrial development in the northern regions, especially New England and Mid-Atlantic, now that past reflects the enormous concentration of capital and economic growth. On the other hand the South – East region had well known agricultural progress which reflects differences compared to the north's regions in terms of economy. Thus, it seems reasonable to think that the north east regions of the U.S. could have important air transport flows compared to the south east. However, some cities such as Atlanta and Miami, which emerge as one of the most important hubs in U.S., and a relevant tourist destination, respectively, might represent different cases.

Also, the East North Central region now represents an important centre of economic development, because at that time, manufacturing spread from the Northeast to form the manufacturing belt . That is one of the reasons why the area surrounding the great lakes has large air transport traffic and also many airports with a huge quantity of movement per year (e.g. Chicago O'hare International Airport). Krugman (1991) said that the U.S. manufacturing belt emerged when economies of scale in production rose and transportation costs fell. Also, Kim and Margo (2003) propose that firms, to minimize transportation cost, chose to locate in one region – the manufacturing belt [6]. This is made of these three regions: New England, Mid – Atlantic and East North Central, so powerful in terms of economic growth.

On the other hand, the south has also undergone a special process of economic growth, either by agricultural factor but mainly due to non-renewable resources exploitation as oil and gas, which are places specially in the South East and South West regions, these factors sum to many other have permitted population growth as well as developing of big cities.

Finally, the Pacific region did not take its place as an important region in term of economy and growth in the population until the twentieth century when population from the east migrated westward more and more. Now this region has reached an important place in the economic development of U.S. until even has almost the same GDP in the private sector compare to Mid-East and South East (See Figure 27).

State	2004	2005	2006	2007	2008
New England	584,984	605,828	638,579	668,83	687,621
Mideast	1,867,410	1,974,764	2,107,412	2,222,447	2,295,976
Great Lakes	1,570,019	1,621,747	1,681,604	1,738,865	1,770,705
Plains	668,211	695,652	722,908	766,975	799,347
Southeast	2,232,275	2,406,689	2,561,479	2,646,074	2,699,843
Southwest	1,114,115	1,219,451	1,332,272	1,418,673	1,499,509
Rocky Mountain	321,844	351,375	377,959	400,132	418,903
Far West	1,835,415	1,977,589	2,107,058	2,202,617	2,252,721

Figure 27: **Growth of GDP's regions from 2004 to 2008**

A.1.6 Alternative routes

As a general idea, this variable measure the influence on the route's market if there are different routes capable to reach the final destination. For example, the traffic between **LGA (La Guardia International Airport)** placed in New York and **LAX (Los Angeles International Airport)** placed in Los Angeles, can be split in different ways, first a direct flight but also a given route using airport connection. The variable concern to **alternative routes** measure how the direct flight route market can be affected by the connection flight route's market.

A.1.7 Fares

A preliminary assumption regard to how the fares affect a given route's market is based upon several aspect. Some of them like, airlines fare structure which is related with means to adjust the final price of the tickets, nature of competition which regard either the number of competitor serving the same route but also what are the main characteristics of those competitors; and the fact if the route is serving in monopoly, duopoly or by many carriers; Thus, it is possible to say that **fares variable** must be measured and analyzed, and at the same time it must find the way to measure it without further compromise of the other variables. This value will be measure by the preliminary variable (F_ijt).

A.1.8 Airport fees

Airport fees could be an important value to define if one firm is going to enter in a specific route. Seems clear that **the quantity of firms on a given route will be indirectly proportional to variable (AF_jt)**. Nevertheless, this variable will depend upon some factors likely defined as airport's importance, current airport slots and so on. That is why, it must be careful when this variable is going to be defined due to its complexity and correlation with some others issues.

A.1.9 Alternative airport

It seems clear that airline presence on a route also depends on airport characteristics, however apparently if the quantity of airports increase in specific city, the numbers of airlines flying on this route will decrease as a consequence of that. Of course, the airline strategy is to maximize their fleet, staff and infrastructure, that is why apparently an airline prefers to entry just in one market, but some of this is not completely true, when there are some factor which can influence in an opposite way, like the importance of arriving flight to an airport close to the downtown or not; as a result we could have one airline flying more than one route to different airports in the same city.

A.1.10 Numbers of passengers that takes the planes (Demand)

In order to measure the route's market behaviour, one of the main factors that come out as relevant one, it is the **numbers of passenger** using a specific carrier which serve a given route. This variable catch mainly the **demand** along all quarter of the database that it will be able to analyze and it will show up how is the market of the route itself. The preliminary variable is presented as (Pax_jt).

A.1.11 Level of saturation

Infrastructural limitations: The demand of air transport have grown rapidly in the last few decades, while the size of airports have not been developing so fast, in particular due to a high cost of investment and long payback period to get back some profit margin. Of course the airport must face this matter, while the airlines as participants in the air transport industry had to come up with some kind of remedy [2].

Large airports from capital cities, business centers and large airline hub airports are quite congested and their capacity could be limited, that is why some airlines might face problems when they try to enter taking into account the flight schedule allowed and also the high fees regarding these kinds of airports.

On the other hand, there are some airports which still have some capacity, in this context its seems apparently the increasing possibility of new airlines on that market perhaps accompanied with less fees expenses.

Therefore, could be difficult to try to involve this matter as relevant variable due to the lack of information and the complexity of this issue itself.

A.1.12 Nature of competitors

As it knows, there are several kind of carriers with different economic models regarding their cost structure, that is why is important to understand and identify them, for example, carriers like South West (WN) which has a low cost structure so different ways to face competition compare to majors ones, when their strengths regard competition strategy are perhaps based upon reputation. As a result, this variable try to measure the presence of some of the most important carriers serving the U.S domestic market split mainly into two groups: LLC's (Low Cost Carriers) and FSC's (Full Service Carriers). However, this variable will be expressed preliminarily as $(Ncomp_ij)$.

A.1.13 Herfindahl index

Taking into account all a above explained, it has been thought that the numbers of companies on a given route is related with the **concentration of firms** on that route, in other words, if there are two companies on a route it might be possible that **one of them get most of the market share** of that route, so the market is likely to be a **monopoly** otherwise the concentration is well split and the market tends to be a **duopoly**.

Under this assumption, the **Herfindahl Index** come out a good explanatory variable regarding this matter, thus preliminarily the variable will be presented such as $(H_j(t))$.

A.1.14 Fare class

Fare class or **ticket type** appear as a **variable** which assess if the evaluated routes are likely to have more capacity allocated to **business** or **leisure** class. it has thought that one route good enough to holdup some quantity of carriers between two economic centers will have more revenues related to business market than other route which joint two small cities and less important in terms of business opportunities. On the other hand, it could exist one route which is more likely to sustain a leisure market than the business one. This variable can be defined as preliminary way as $(TKTT)$.

B Appendix B

B.1 Heterogeneous market

The world market for air transport of passengers and cargo has been essential for the development of trade. Moreover, it has been a measure of technological advances. With the aim of achieving high quality, by meeting passengers' needs, large companies all around the world work to develop strategies to achieve this target, either through on-board service, discount or promotion. All these strategies have a common goal; to provide the best flying conditions and encourage the implementation of the service. If we study air passenger traffic in the U.S. we will notice a huge variety of customers (coach, business, work trips, holidays trips). The air traffic market is extremely heterogeneous and we will give some details about these heterogeneity factors.

B.1.1 Business/leisure (frequent flights)

On one hand, there are some employees that are often forced to take a flight because they reside in one city and work in another. On the other hand, there are passengers who take flights to visit family who reside outside of the passenger city.

B.1.2 Business/ leisure (not frequent flights)

Some employees take an exceptional flight just to meet their working week, attend a congress or give a presentation. These meetings are not recurrent and many companies send their employees to those business activities. On the other, tourists take an exceptional flight for one or two weeks per year (normally holiday period).

B.1.3 Direct/Indirect

Some passengers prefer direct flights. It might be because they need to reach the destination city quickly or for personal preference against stopovers.

B.1.4 Price concerned/not price concerned

On one hand, we have people who are unable or unwilling to spend much money on a flight so that they are just focused on the airlines offers, without giving importance to other factors. On the other hand, we have those who just buy the ticket without looking at the price because there are other factors that they consider more important.

B.1.5 Coach (economy)/business

There is a minor group of passengers that belongs to the highest rank of business, which demand all the luxury and comfort that the airline can provide. On the other hand, the majority of passengers are included in coach (economy) class since they are not sufficiently comfort sensitive. Airlines dedicate less on-board services to coach class passengers.

We take *"Virgin atlantic"* on-board services as an example [1]:

- Economy:

Free lunch is provided and every seat has its own seatback TV (also channels and video game for children).

-Premium Economy:

Preflight drinks and after dinner liqueurs, more space in the seats to stretch out and more reclinable.

- The Upper Class Suite:

On-board bar, long fully flats beds, stunning clubhouses and complementary ground transfers.

B.1.6 Flight schedule

Some passengers have an extremely restricted office routine so they are just able to travel at a specific time of the day. For example, very early in the morning, before the working day start (for those who work full-time) or in the afternoon, after finishing the working day (for those who work part-time).

B.1.7 Frequency

There are some passengers who are only able to travel on weekends so flight demand might increase on weekends. Those passengers will demand a higher frequency of flights on specific days.

C Appendix C

C.1 Monopoly plots

In figure 28 it is shown that the majority of cities houses less than 5 millions of habitants. To have an idea, cities as Atlanta, Boston, Detroit, Miami and Washington have a population around 5 million. Over this quantity it can only be found New York, Los Angeles, Chicago, Philadelphia and Houston.

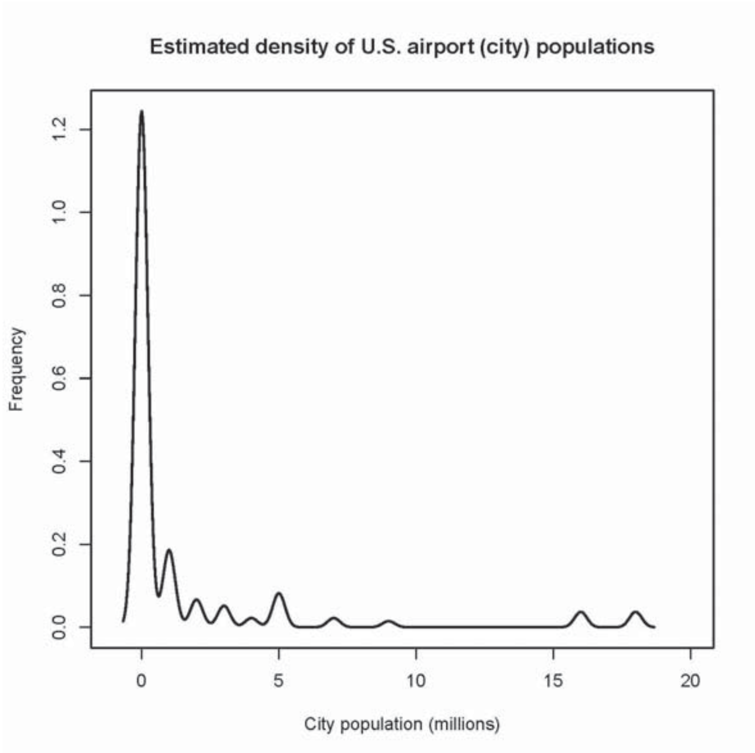

Figure 28: Route population frequency.

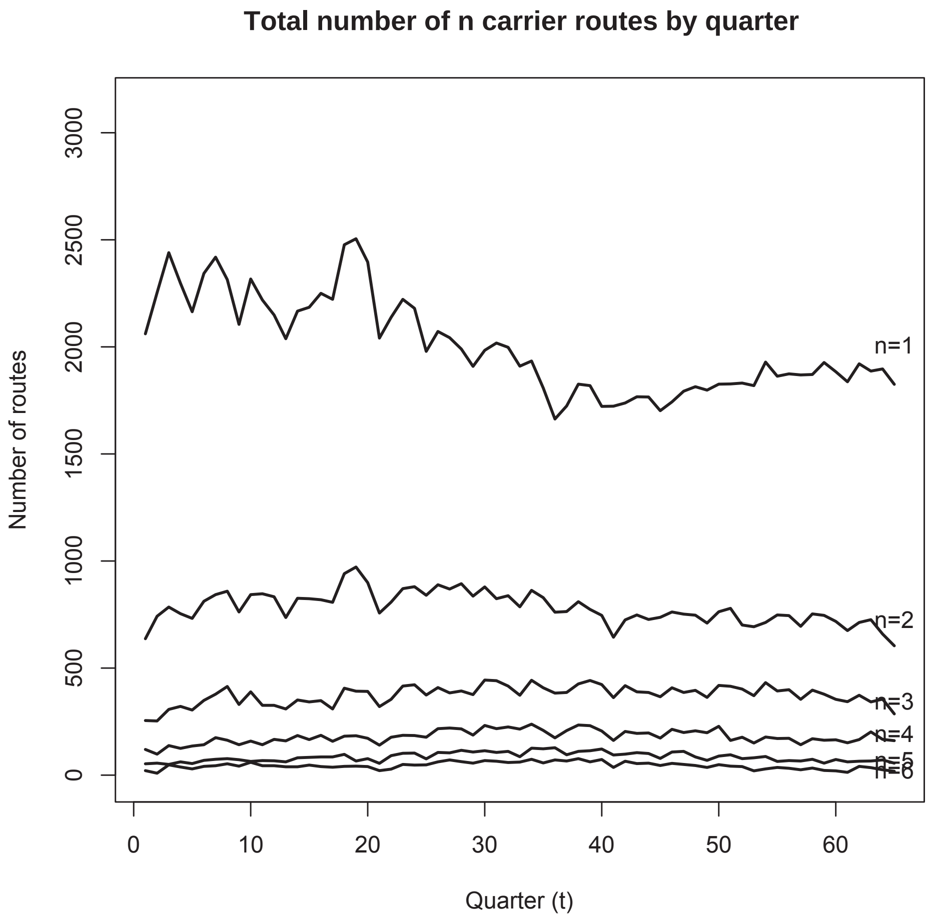

Figure 29: Number of n carrier routes by quarter.

C.2 Routes served by several carriers plots

C.3 Maps

The following U.S. maps are plotted showing the routes served by a given number of carriers.

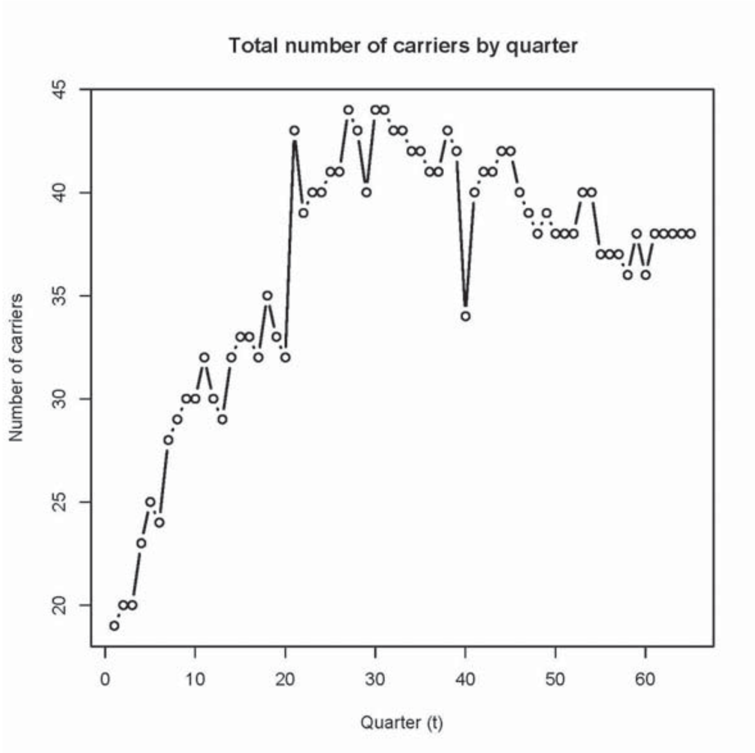

Figure 30: Evolution of the number of carriers since 1993.

D Appendix D

D.1 EViews code for automated estimation

```
for !i=1 to 65 equation eq!i.ls log(q!i) c obs

    series b!i = eq!i.@coefs(1) series c!i = eq!i.@coefs(2)

    next
```

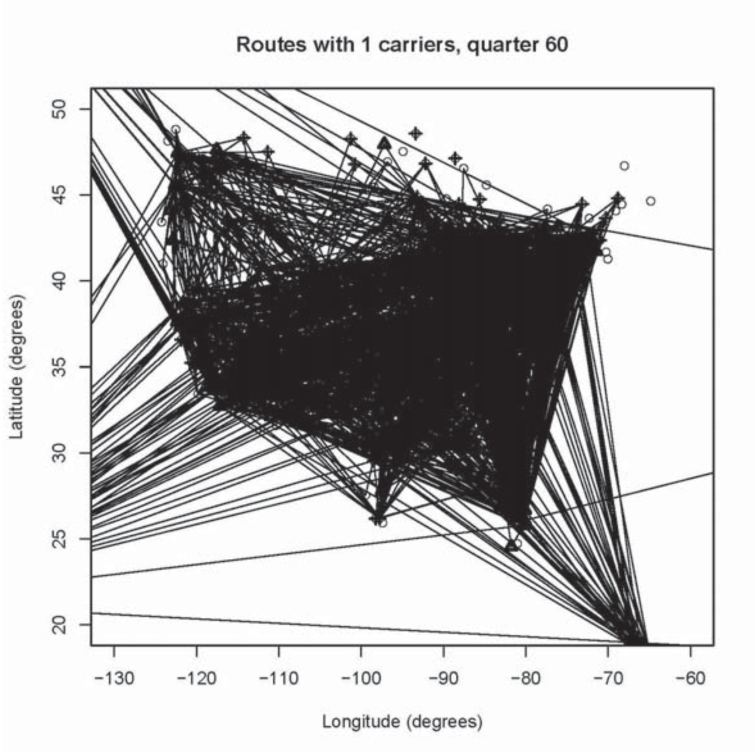

Figure 31: Density of routes in monopoly.

D.2 Further results on the percentage of routes served by n carriers

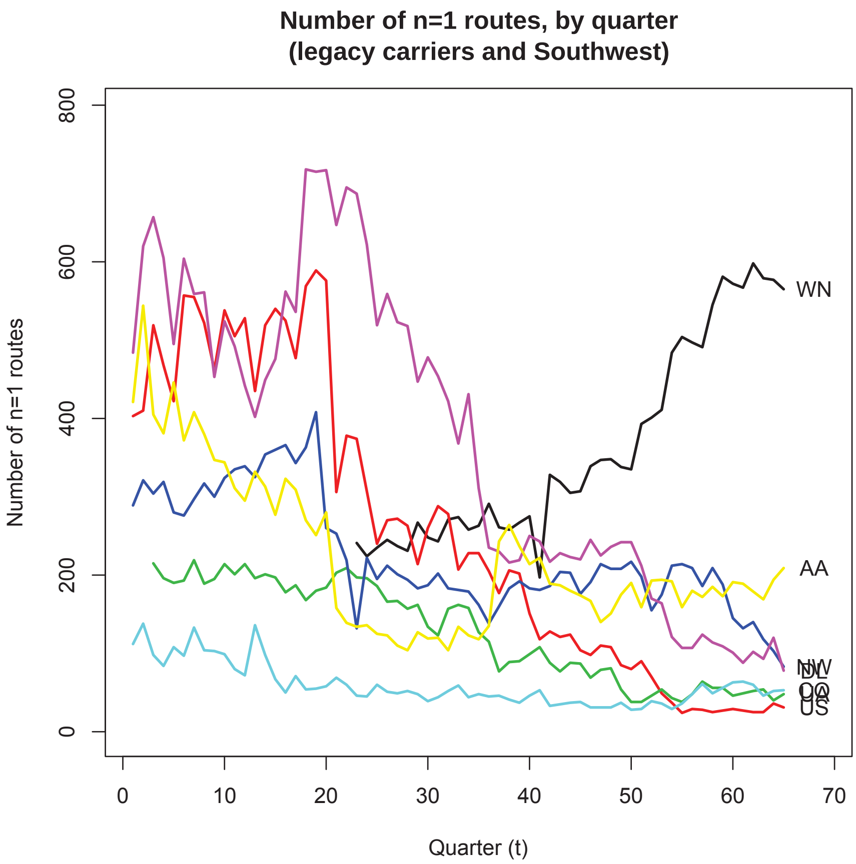

Figure 32: Number of monopolies held by the major carriers and Southwest over time.

Quarter	$\widehat{\beta_1}$	$\widehat{\beta_2}$
01	4.922638	-0.899059
02	4.989139	-0.941371
03	5.029494	-0.951389
04	4.939048	-0.902153
05	4.963646	-0.906458
06	4.908169	-0.879384
07	4.873691	-0.854627
08	4.870498	-0.846787
09	4.848190	-0.843093
10	4.938001	-0.884635

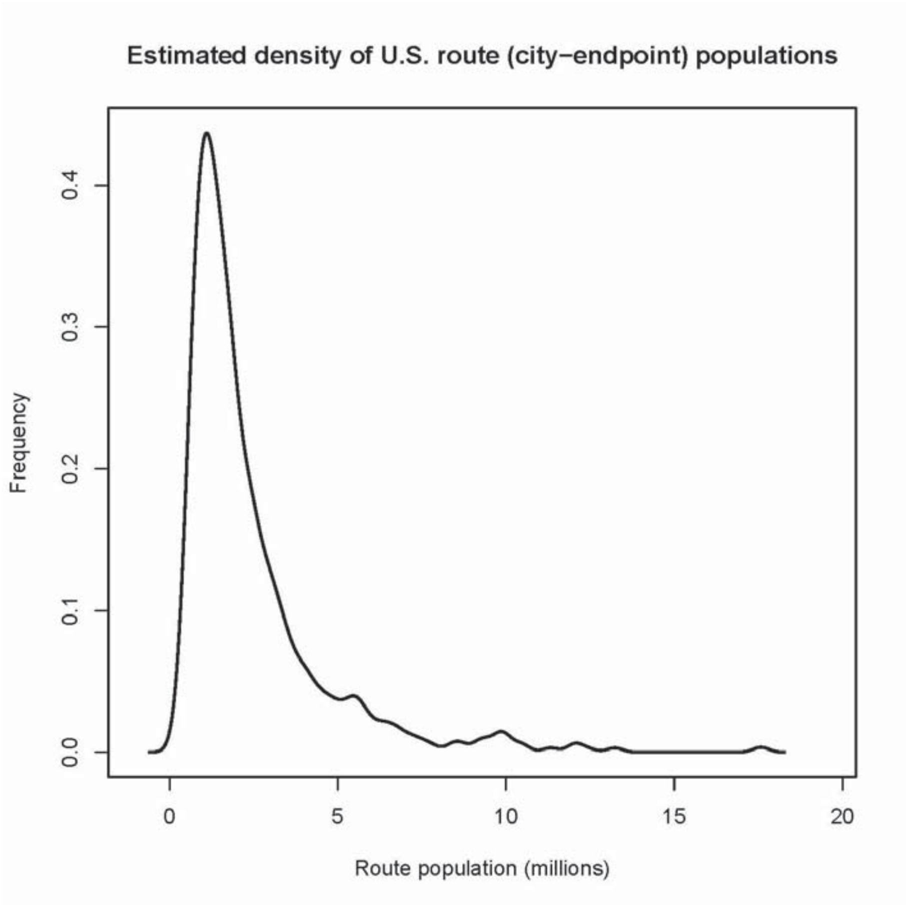

Figure 33: Route population and its frequency.

Quarter	$\widehat{\beta_1}$	$\widehat{\beta_2}$
11	4.908372	-0.875648
12	4.880074	-0.854317
13	4.870165	-0.851124
14	4.791925	-0.806954
15	4.795123	-0.814324
16	4.775988	-0.803441
17	4.783398	-0.815775
18	4.794600	-0.812312
19	4.961647	-0.893720
20	4.878727	-0.852929
21	4.956958	-0.891544

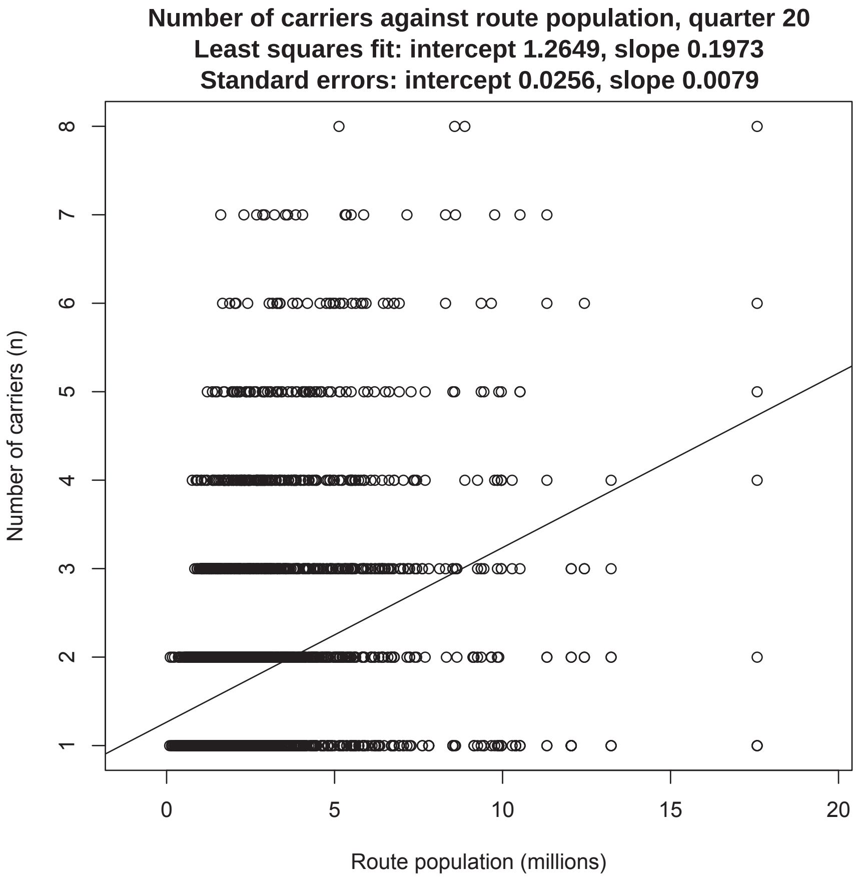

Figure 34: Number of carriers against route population for quarter 20.

Quarter	$\widehat{\beta_1}$	$\widehat{\beta_2}$
22	4.743671	-0.783195
23	4.725420	-0.770628
24	4.723861	-0.766427
25	4.815720	-0.807648
26	4.668491	-0.735586
27	4.655964	-0.732928
28	4.615130	-0.710503
29	4.639251	-0.724193
30	4.610069	-0.704539

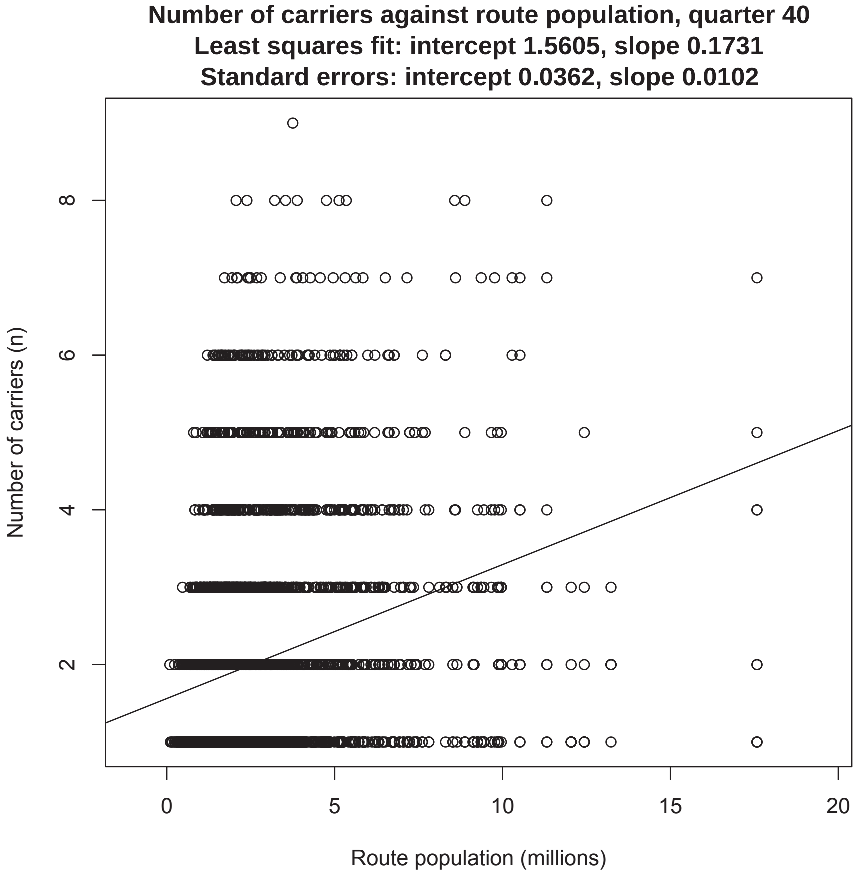

Figure 35: Number of carriers against route population for quarter 40.

Quarter	$\widehat{\beta_1}$	$\widehat{\beta_2}$
31	4.637748	-0.722712
32	4.612529	-0.709566
33	4.691251	-0.749734
34	4.541929	-0.675027
35	4.544467	-0.675347
36	4.506695	-0.660427
37	4.621774	-0.709808
38	4.567027	-0.684242
39	4.554241	-0.674884

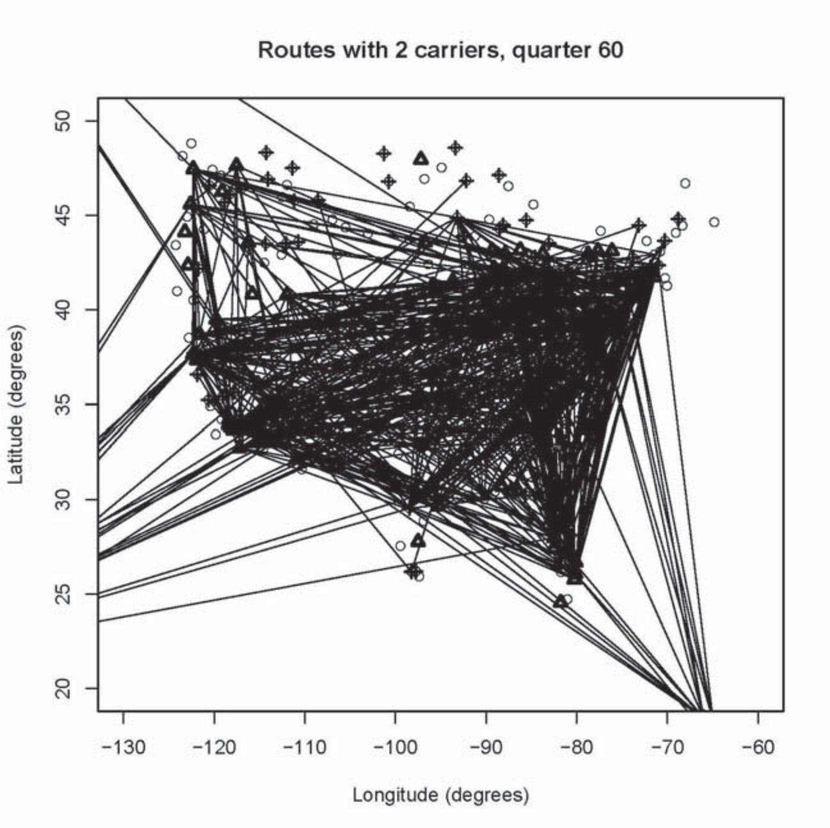

Figure 36: Density of Routes in Duopoly

Quarter	$\widehat{\beta_1}$	$\widehat{\beta_2}$
40	4.516977	-0.658129
41	4.627539	-0.719716
42	4.610215	-0.701910
43	4.598566	-0.699056
44	4.606902	-0.702843
45	4.734717	-0.761500
46	4.580123	-0.683243
47	4.580461	-0.689366
48	4.692861	-0.740462

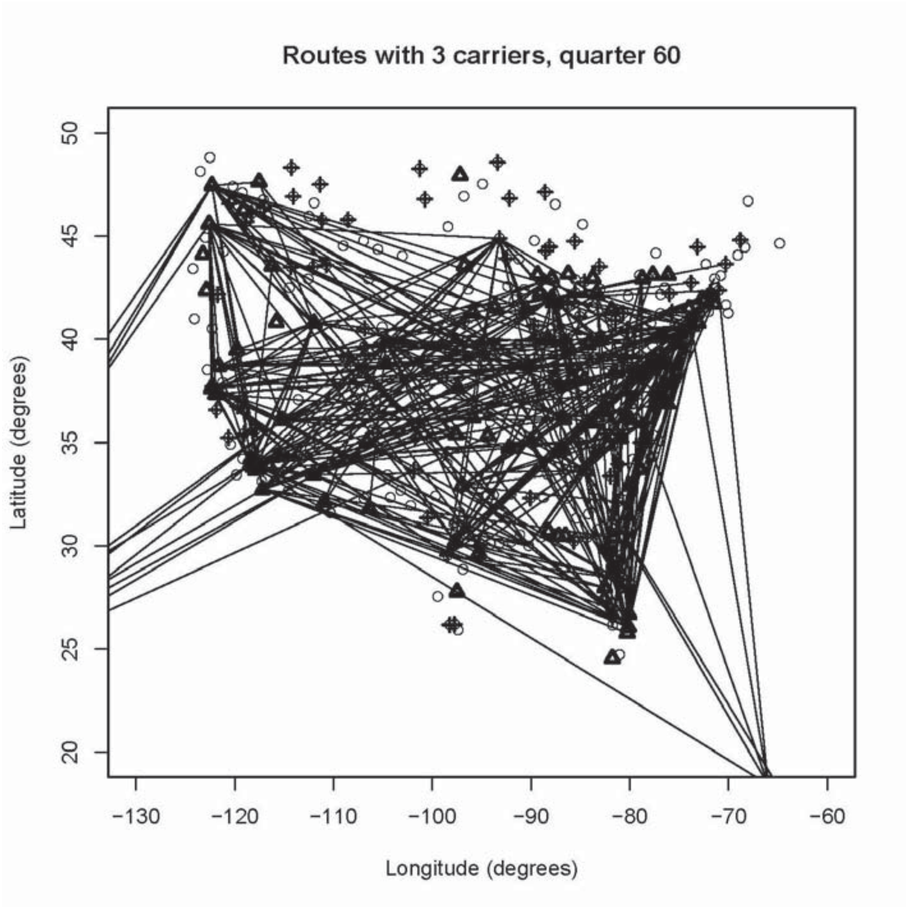

Figure 37: Density of routes served by three carriers.

Quarter	$\widehat{\beta_1}$	$\widehat{\beta_2}$
49	4.770729	-0.779765
50	4.667891	-0.725041
51	4.701747	-0.748352
52	4.751417	-0.771398
53	4.752301	-0.775358
54	4.723751	-0.758540
55	4.856226	-0.821786
56	4.834392	-0.809854
57	4.847108	-0.827509

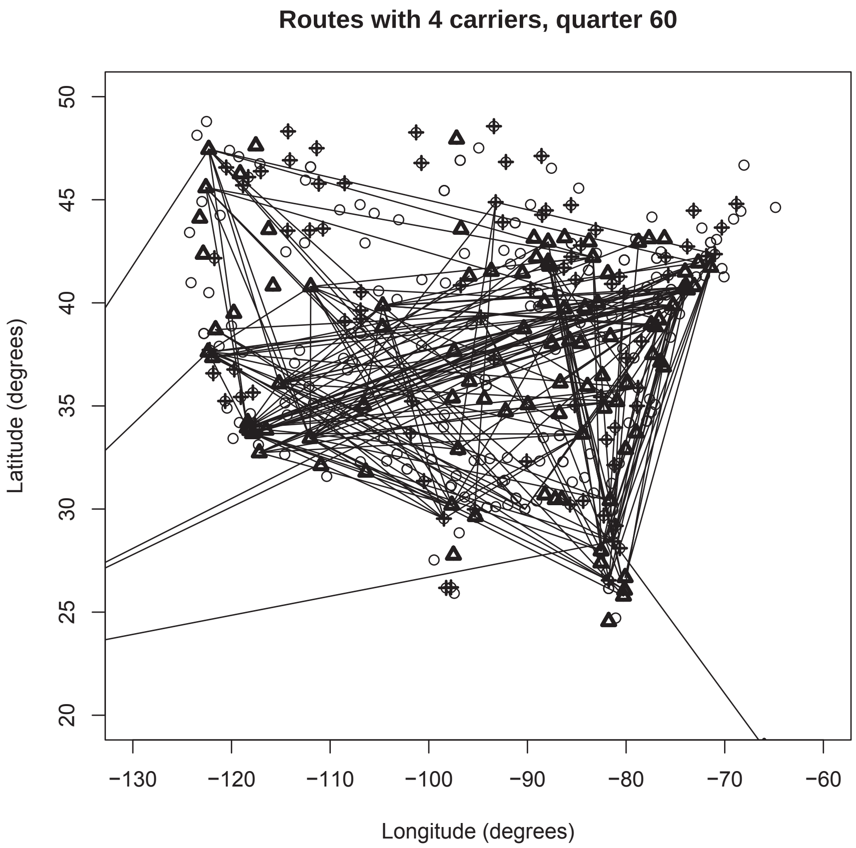

Figure 38: Density of routes served by four carriers.

Quarter	$\widehat{\beta_1}$	$\widehat{\beta_2}$
58	4.800859	-0.794859
59	4.925664	-0.859771
60	4.793790	-0.797191
61	4.854923	-0.827494
62	4.844023	-0.822992
63	4.797510	-0.798546
64	4.779045	-0.794343
65	4.835412	-0.829014

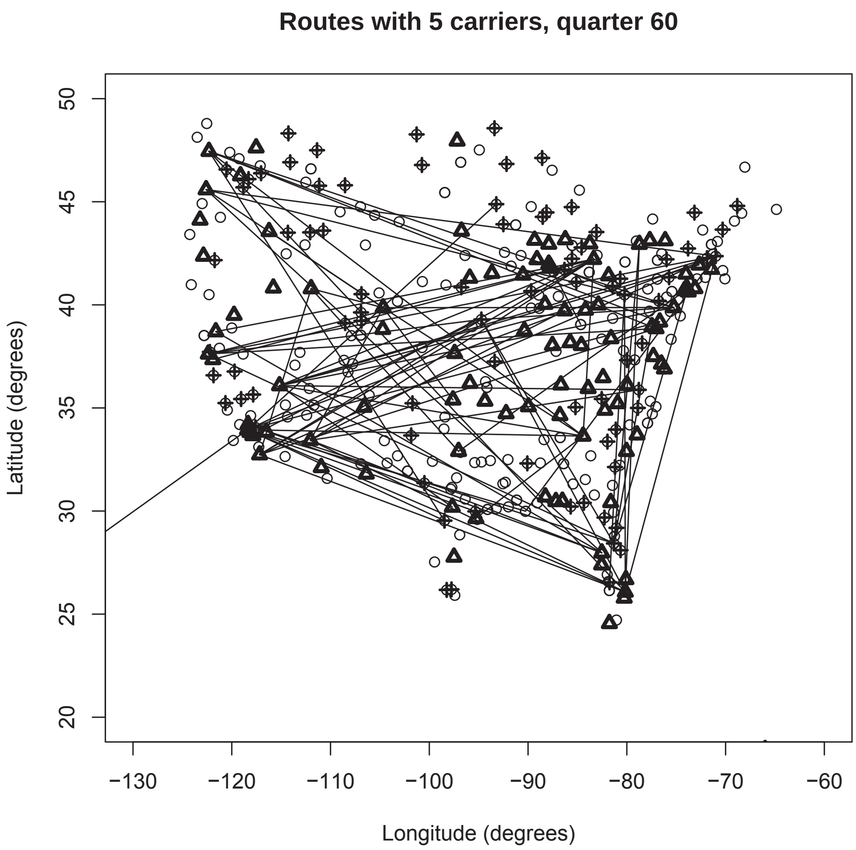

Figure 39: Density of routes served by five carriers.

D.3 Number of monopolies estimation model for quarter 1 and 30

For quarter 30 see the equation below and Figure 42:

$$\begin{aligned}
\text{Prob}(Y30 = 1) \quad &= \quad \Phi\Big(\beta_1 + \beta_2\,\frac{dist}{1000} + \beta_3\,\left(\frac{dist}{1000}\right)^2 + \beta_4\,\frac{pop}{1000000} + \beta_5\,business + \beta_6\,\frac{gdp}{pop} \\
&+ \quad \beta_7\,COpresent + \beta_8\,DLpresent + \beta_9\,NWpresent + \beta_{10}\,UApresent \\
&+ \quad \beta_{11}\,USpresent + \beta_{12}\,rlocMWNW + \beta_{13}\,rlocNESW + \beta_{14}\,rlocSESW
\end{aligned}$$

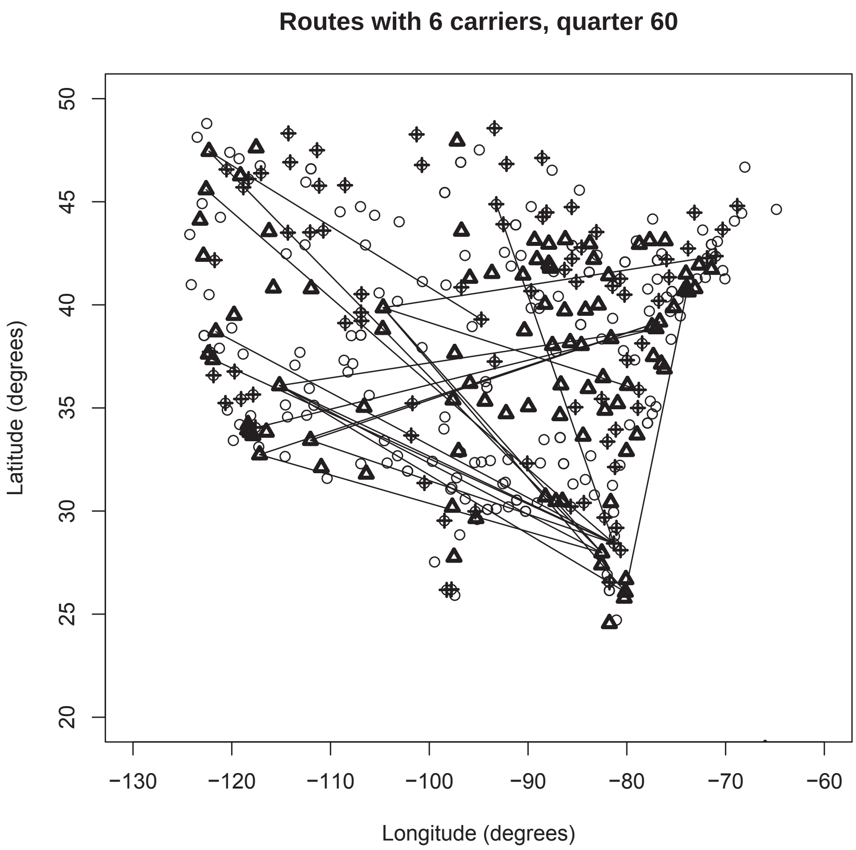

Figure 40: Density of routes served by six carriers.

$$\begin{aligned}
&+ \quad \beta_{15}\, rlocSWSW + \beta_{16}\, rlocMWMW + \beta_{17}\, rlocMWNE + \beta_{18}\, rlocMWSE \\
&+ \quad \beta_{19}\, rlocMWSW + \beta_{20}\, rlocNENE + \beta_{21}\, rlocNENW + \beta_{22}\, rlocNEOU \\
&+ \quad \beta_{23}\, rlocNESE + \beta_{24}\, rlocNWNW + \beta_{25}\, rlocNWOU + \beta_{26}\, rlocNWSE \\
&+ \quad \beta_{27}\, rlocNWSW + \beta_{28}\, rlocSESE\Big).
\end{aligned}$$

For quarter 1 see the equation below and Figure 43:

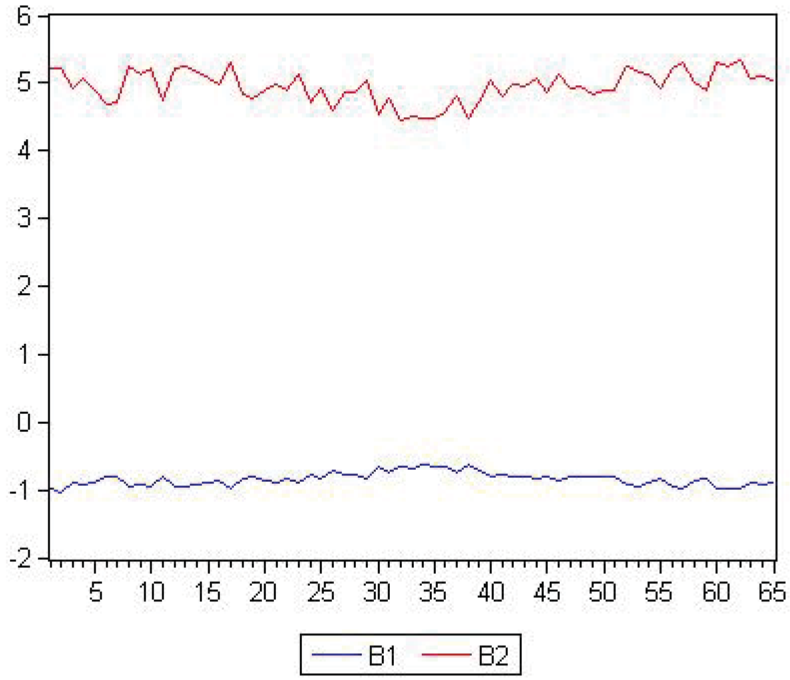

Figure 41: Coefficients of the square linear regression for each quarter (taking into account all data)

$$
\begin{aligned}
\mathrm{Prob}(Y1=1) &= \Phi\Bigg(\beta_1 + \beta_2\,\frac{dist}{1000} + \beta_3\,\left(\frac{dist}{1000}\right)^2 + \beta_4\,\frac{pop}{1000000} + \beta_5\,leisure + \beta_6\,business \\
&+ \beta_7\,\frac{gdp}{pop} + \beta_8\,COpresent + \beta_9\,DLpresent + \beta_{10}\,NWpresent \\
&+ \beta_{11}\,UApresent + \beta_{12}\,USpresent + \beta_{13}\,rlocMWNW + \beta_{14}\,rlocNESW \\
&+ \beta_{15}\,rlocSESW + \beta_{16}\,rlocSWSW + \beta_{17}\,rlocMWMW + \beta_{18}\,rlocMWNE \\
&+ \beta_{19}\,rlocMWSE + \beta_{20}\,rlocMWSW + \beta_{21}\,rlocNENE + \beta_{22}\,rlocNENW \\
&+ \beta_{23}\,rlocNEOU + \beta_{24}\,rlocNESE + \beta_{25}\,rlocNWNW + \beta_{26}\,rlocNWOU
\end{aligned}
$$

	Coefficient	Std. Error	z-Statistic	Prob.
DIST/1000	0.257956	0.123744	2.084589	0.0371
(DIST/1000)^2	-0.023577	0.026261	-0.897778	0.3693
POP/1000000	-0.146276	0.019549	-7.482372	0.0000
BUSINESS	-0.334939	0.075774	-4.420224	0.0000
GDP/POP	-13.23981	7.293572	-1.815270	0.0695
COPRESENT	-2.468943	0.171758	-14.37454	0.0000
DLPRESENT	-2.046099	0.097968	-20.88527	0.0000
NWPRESENT	-1.967534	0.135679	-14.50138	0.0000
UAPRESENT	-2.389124	0.132369	-18.04896	0.0000
USPRESENT	-1.896343	0.106472	-17.81069	0.0000
WNPRESENT	-1.946113	0.107169	-18.15921	0.0000
RLOCMWNW	3.481552	0.456083	7.633590	0.0000
RLOCNESW	2.904389	0.380438	7.634332	0.0000
RLOCOUSW	1.637298	0.632488	2.588660	0.0096
RLOCSESW	3.025692	0.339024	8.924704	0.0000
RLOCSWSW	2.354345	0.345401	6.816258	0.0000
RLOCMWMW	3.254824	0.527720	6.167704	0.0000
RLOCMWNE	3.428411	0.397874	8.616825	0.0000
RLOCMWOU	3.596729	1.198180	3.001826	0.0027
RLOCMWSE	3.512964	0.386585	9.087173	0.0000
RLOCMWSW	2.870617	0.432492	6.637384	0.0000
RLOCNENE	3.522047	0.327427	10.75675	0.0000
RLOCNENW	3.339542	0.440417	7.582680	0.0000
RLOCNEOU	2.912993	0.811945	3.587673	0.0003
RLOCNESE	3.268913	0.334432	9.774511	0.0000
RLOCNWNW	2.840011	0.407715	6.965675	0.0000
RLOCNWOU	2.500423	0.723816	3.454501	0.0006
RLOCNWSE	3.316878	0.420991	7.878743	0.0000
RLOCNWSW	3.290574	0.355918	9.245304	0.0000
RLOCOUSE	2.474767	0.806521	3.068448	0.0022
RLOCSESE	3.367655	0.319676	10.53458	0.0000

Figure 42: Coefficients and statistics for y model on quarter 30

$$+ \quad \beta_{27}\, rlocNWSE + \beta_{28}\, rlocNWSW + \beta_{29}\, rlocSESE\Big).$$

	Coefficient	Std. Error	z-Statistic	Prob.
DIST/1000	-0.324231	0.138771	-2.336442	0.0195
(DIST/1000)^2	0.076563	0.030021	2.550271	0.0108
POP/1000000	-0.096455	0.019198	-5.024289	0.0000
LEISURE	0.234401	0.445042	0.526693	0.5984
BUSINESS	-0.303416	0.080074	-3.789210	0.0002
GDP/POP	-17.07022	7.199203	-2.371126	0.0177
COPRESENT	-2.495483	0.143192	-17.42751	0.0000
DLPRESENT	-2.291714	0.110966	-20.65245	0.0000
NWPRESENT	-1.940270	0.138097	-14.05009	0.0000
UAPRESENT	-2.618723	0.136128	-19.23726	0.0000
USPRESENT	-1.987175	0.120554	-16.48370	0.0000
RLOCMWNW	5.287462	0.518715	10.19339	0.0000
RLOCNESW	3.473331	0.374615	9.271747	0.0000
RLOCOUSW	2.689135	1.008954	2.665271	0.0077
RLOCSESW	3.814472	0.363981	10.47987	0.0000
RLOCSWSW	3.466687	0.475930	7.284033	0.0000
RLOCMWMW	5.149117	0.665787	7.733882	0.0000
RLOCMWNE	4.946603	0.416173	11.88594	0.0000
RLOCMWOU	3.625277	1.815661	1.996671	0.0459
RLOCMWSE	4.498874	0.395115	11.38623	0.0000
RLOCMWSW	4.453193	0.414253	10.74993	0.0000
RLOCNENE	4.621868	0.337595	13.69058	0.0000
RLOCNENW	4.662563	0.439371	10.61189	0.0000
RLOCNEOU	1.791505	1.051497	1.703766	0.0884
RLOCNESE	4.257227	0.343764	12.38417	0.0000
RLOCNWNW	3.919520	0.420227	9.327147	0.0000
RLOCNWOU	1.509364	0.682815	2.210501	0.0271
RLOCNWSE	4.465292	0.427041	10.45635	0.0000
RLOCNWSW	3.736122	0.346053	10.79638	0.0000
RLOCOUSE	3.180420	0.926304	3.433451	0.0006
RLOCSESE	4.316296	0.334387	12.90807	0.0000

Figure 43: Coefficients and statistics for y model on quarter 1

D.4 Number of carriers estimation model for quarter 1 and 30

For quarter 30 see the equation below, Figure 45 and Figure 47:

$$
\begin{aligned}
n &= \Big(\beta_1 + \beta_2\, \frac{dist}{1000} + \beta_3 \left(\frac{dist}{1000}\right)^2 + \beta_4\, \frac{pop}{1000000} + \beta_5\, WNpresent + \beta_6\, leisure \\
&+ \beta_7\, business + \beta_8\, \frac{gdp}{pop} + \beta_9\, AApresent + \beta_{10}\, COpresent \\
&+ \beta_{11}\, DLpresent + \beta_{12}\, NWpresent + \beta_{13}\, UApresent + \beta_{14}\, USpresent \\
&+ \beta_{15}\, STDpother + \beta_{16}\, Inertia\_range + \beta_{17}\, AllianceEN_bycarriers + \beta_{18}\, rlocMWNW \\
&+ \beta_{19}\, rlocNESW + \beta_{20}\, rlocOUSW + \beta_{21}\, rlocSESW + \beta_{22}\, rlocSWSW\Big).
\end{aligned}
$$

For quarter 1 see the equation below, Figure 47 and Figure 47:

$$
\begin{aligned}
n &= \Big(\beta_1 + \beta_2\, \frac{dist}{1000} + \beta_3 \left(\frac{dist}{1000}\right)^2 + \beta_4\, \frac{pop}{1000000} + \beta_5\, leisure \\
&+ \beta_6\, business + \beta_7\, \frac{gdp}{pop} + \beta_8\, AApresent + \beta_9\, COpresent \\
&+ \beta_{10}\, DLpresent + \beta_{11}\, NWpresent + \beta_{12}\, UApresent + \beta_{13}\, USpresent \\
&+ \beta_{14}\, STDpother + \beta_{15}\, rlocMWNW \\
&+ \beta_{16}\, rlocNESW + \beta_{17}\, rlocOUSW + \beta_{18}\, rlocSESW + \beta_{19}\, rlocSWSW\Big).
\end{aligned}
$$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.421934	0.109221	13.01884	0.0000
C(2)	0.039443	0.029099	1.355467	0.1755
C(3)	-0.007595	0.004693	-1.618407	0.1058
C(4)	0.025303	0.004947	5.114381	0.0000
C(5)	0.242285	0.028712	8.438578	0.0000
C(6)	-0.070731	0.117293	-0.603026	0.5466
C(7)	0.024262	0.024772	0.979412	0.3275
C(8)	0.886893	2.240060	0.395924	0.6922
C(9)	1.642956	0.031965	51.39897	0.0000
C(10)	0.393023	0.029761	13.20616	0.0000
C(11)	1.744796	0.030789	56.66859	0.0000
C(12)	0.459727	0.028844	15.93848	0.0000
C(13)	1.734747	0.029762	58.28754	0.0000
C(14)	0.395678	0.026136	15.13899	0.0000
C(15)	0.769536	0.142339	5.406363	0.0000
C(16)	0.012249	0.001194	10.26303	0.0000
C(17)	-3.510642	0.091285	-38.45801	0.0000
C(18)	0.181034	0.079321	2.282303	0.0226
C(19)	0.197541	0.040738	4.849031	0.0000
C(20)	0.443076	0.159904	2.770881	0.0057
C(21)	0.056369	0.039730	1.418815	0.1562
C(22)	0.011035	0.083866	0.131582	0.8953
R-squared	0.930770			

Figure 44: Coefficients and statistics for n model on quarter 30

E Appendix E

E.1 Properties of the Herfindahl index

We are going to explain and give examples about the three main properties of the H index.

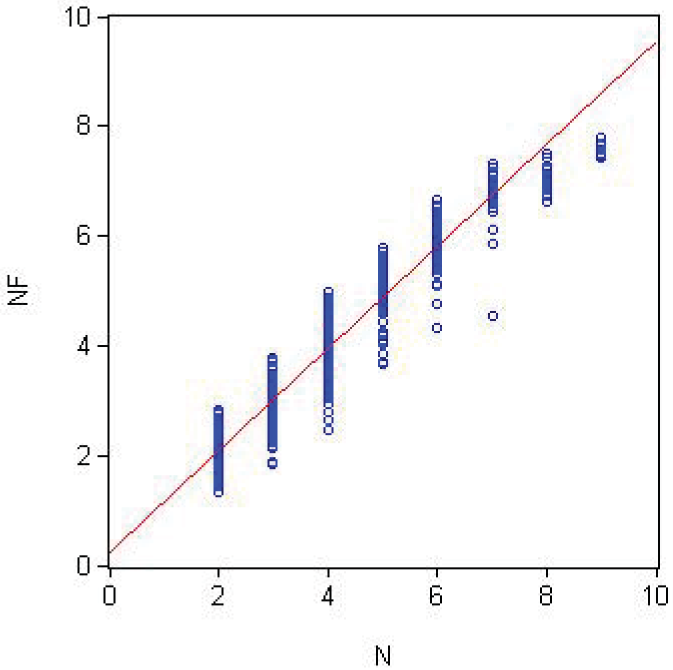

Figure 45: Forecasted n against n for quarter 30

First property Symmetry between firms: H index is a sum of squared terms, so the order of the addends does not change the result.

example:

market share of firm A = 10%

market share of firm B = 90 %

$$H = \sum_{i=1}^{2} \alpha_i^2 = 0.1^2 + 0.9^2 = 0.82$$

market share of firm A = 90%

market share of firm B = 10%

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.115947	0.056415	2.055249	0.0400
C(2)	-0.008257	0.016757	-0.492775	0.6222
C(3)	-0.002268	0.002953	-0.768146	0.4425
C(4)	0.007839	0.003229	2.427841	0.0153
C(5)	0.065276	0.071972	0.906965	0.3645
C(6)	0.028286	0.014465	1.955503	0.0506
C(7)	2.601122	1.344922	1.934032	0.0532
C(8)	0.818100	0.014988	54.58236	0.0000
C(9)	0.973512	0.018474	52.69667	0.0000
C(10)	0.803494	0.014298	56.19605	0.0000
C(11)	0.919754	0.018190	50.56357	0.0000
C(12)	0.984563	0.018013	54.65892	0.0000
C(13)	0.661829	0.017215	38.44590	0.0000
C(14)	3.305125	0.124897	26.46281	0.0000
C(15)	-0.120053	0.053515	-2.243352	0.0250
C(16)	0.082499	0.028049	2.941191	0.0033
C(17)	0.921263	0.110450	8.340968	0.0000
C(18)	0.101787	0.027273	3.732159	0.0002
C(19)	0.616787	0.055709	11.07155	0.0000
R-squared	0.909303			

Figure 46: Coefficients and statistics for n model on quarter 1

$$H = \sum_{i=1}^{2} \alpha_i^2 = 0.9^2 + 0.1^2 = 0.82$$

Second property Concentration for symmetric firms decreases when the number of firms increase:

It means that every firm has the same market share and this value is 1/n (n is the number of firm in the market).

The formula becomes

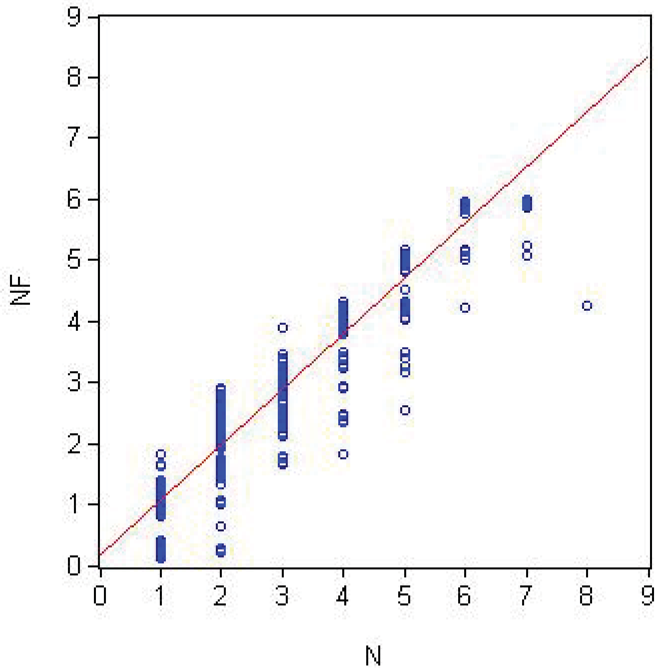

Figure 47: Forecasted n against n for quarter 1

$$H = \sum_{i=1}^{n} \alpha^2 = (\frac{1}{n})^2 \times n = \frac{1}{n}$$

example:

Three firms in the market.

$$H = \sum_{i=1}^{3} \alpha^2 = \frac{1}{3} = 0.333$$

Six firms in the market.

$$H = \sum_{i=1}^{6} \alpha^2 = \frac{1}{6} = 0.167$$

Ten firms in the market.

$$H = \sum_{i=1}^{10} \alpha^2 = \frac{1}{10} = 0.1$$

Third property A further spread of distribution of market share towards tails increase concentration.

We are going to give three different examples. In each example there are four firms and we are going to spread the distribution towards the tails so we will see how the H index increase.

case 1: market share of firm A = 10%

market share of firm B = 25 %

market share of firm C = 25%

market share of firm D = 40 %

$$H = \sum_{i=1}^{4} \alpha_i^2 = 0.1^2 + 0.25^2 + 0.25^2 + 0.4^2 = 0.295$$

case 2: market share of firm A = 10%

market share of firm B = 20 %

market share of firm C = 30%

market share of firm D = 40 %

$$H = \sum_{i=1}^{4} \alpha_i^2 = 0.1^2 + 0.2^2 + 0.3^2 + 0.4^2 = 0.3$$

case 3: market share of firm A = 10%

market share of firm B = 15 %

market share of firm C = 35%

market share of firm D = 40 %

$$H = \sum_{i=1}^{4} \alpha_i^2 = 0.1^2 + 0.15^2 + 0.35^2 + 0.4^2 = 0.315$$

E.2 H index regressions

E.2.1 H index regressions for Q01

$$\begin{aligned} hhi &= \frac{n_i - 1}{n_i} \Bigg[\frac{1}{n_i - 1} + \Phi\Bigg(\beta_1 + \beta_2 \frac{dist}{1000} + \beta_3 \left(\frac{dist}{1000}\right)^2 + \beta_4 \frac{pop}{1000000} + +\beta_6\, leisure \\ &+ \beta_7\, business + \beta_8 \frac{gdp}{pop} + \beta_9\, AApresent + \beta_{10}\, COpresent \\ &+ \beta_{11}\, DLpresent + \beta_{12}\, NWpresent + \beta_{13}\, UApresent + \beta_{14}\, USpresent \\ &+ \beta_{15}\, STDpother + \beta_{16}\, rlocMWNW \\ &+ \beta_{17}\, rlocNESW + \beta_{18}\, rlocOUSW + \beta_{19}\, rlocSESW + \beta_{20}\, rlocSWSW + \beta_{21}\, rlocNEOU \Bigg]. \end{aligned}$$

E.2.2 H index regressions for Q30

$$\begin{aligned} hhi &= \frac{n_i - 1}{n_i} \Bigg[\frac{1}{n_i - 1} + \Phi\Bigg(\beta_1 + \beta_2 \frac{dist}{1000} + \beta_3 \left(\frac{dist}{1000}\right)^2 + \beta_4 \frac{pop}{1000000} + \beta_5\, WNpresent + \beta_6\, leisure \\ &+ \beta_7\, business + \beta_8 \frac{gdp}{pop} + \beta_9\, AApresent + \beta_{10}\, COpresent \\ &+ \beta_{11}\, DLpresent + \beta_{12}\, NWpresent + \beta_{13}\, UApresent + \beta_{14}\, USpresent \\ &+ \beta_{15}\, STDpother + \beta_{16}\, Inertia\_range + \beta_{17}\, AllianceEN_bycarriers + \beta_{18}\, rlocMWNW \\ &+ \beta_{19}\, rlocNESW + \beta_{20}\, rlocOUSW + \beta_{21}\, rlocSESW + \beta_{22}\, rlocSWSW \Bigg]. \end{aligned}$$

QUARTER 1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-2.176784	0.266720	-8.161313	0.0000
C(2)	0.183436	0.100409	1.826877	0.0680
C(3)	-0.076958	0.022591	-3.406585	0.0007
C(4)	0.062732	0.008693	7.216100	0.0000
C(6)	-0.186704	0.410665	-0.454638	0.6495
C(7)	0.155383	0.063937	2.430238	0.0153
C(8)	21.61368	5.265339	4.104898	0.0000
C(9)	-0.053045	0.051209	-1.035866	0.3005
C(10)	0.056249	0.047796	1.176853	0.2395
C(11)	0.037592	0.049608	0.757783	0.4488
C(12)	0.071961	0.052367	1.374164	0.1697
C(13)	-0.097772	0.051402	-1.902102	0.0574
C(14)	0.061684	0.067472	0.914222	0.3608
C(15)	-0.178803	0.539026	-0.331715	0.7402
C(16)	-0.071208	0.186107	-0.382617	0.7021
C(17)	-0.076849	0.098833	-0.777561	0.4370
C(18)	0.242336	0.535533	0.452513	0.6510
C(19)	0.068700	0.096038	0.715345	0.4746
C(20)	0.053035	0.272191	0.194846	0.8456
C(21)	2.642756	0.820833	3.219604	0.0013
R-squared	0.431462			

Figure 48: H index regression for Q1.

F Appendix F: DB1B data treatment

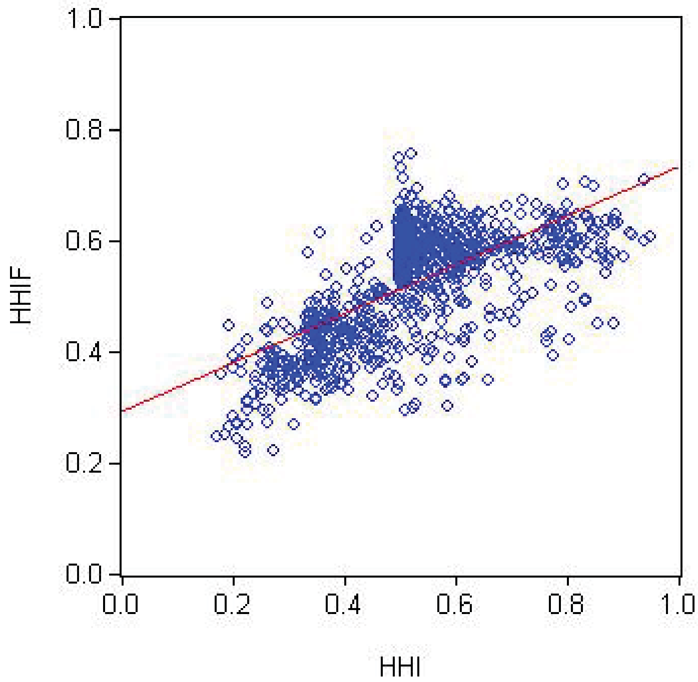

Figure 49: H index forecast over H index for Q01.

QUARTER 30

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-2.213688	0.226498	-9.773521	0.0000
C(2)	0.125449	0.086353	1.452743	0.1465
C(3)	-0.070349	0.018910	-3.720144	0.0002
C(4)	0.030643	0.007344	4.172508	0.0000
C(5)	-0.076551	0.047876	-1.598944	0.1101
C(6)	0.079899	0.222738	0.358714	0.7199
C(7)	0.056757	0.046156	1.229669	0.2190
C(8)	35.51789	4.073197	8.719905	0.0000
C(9)	-0.016257	0.053690	-0.302795	0.7621
C(10)	0.004192	0.045354	0.092427	0.9264
C(11)	0.107766	0.052808	2.040729	0.0415
C(12)	-0.132655	0.047284	-2.805472	0.0051
C(13)	-0.042586	0.048817	-0.872363	0.3832
C(14)	0.046749	0.042301	1.105156	0.2693
C(15)	-1.208187	0.313002	-3.860000	0.0001
C(16)	-0.000284	0.002090	-0.136095	0.8918
C(17)	-0.326746	0.162715	-2.008089	0.0448
C(18)	-0.121456	0.131952	-0.920459	0.3575
C(19)	0.161620	0.072712	2.222729	0.0264
C(20)	0.594535	0.307195	1.935367	0.0531
C(21)	0.168125	0.066903	2.512942	0.0121
C(22)	0.390910	0.144719	2.701168	0.0070
R-squared	0.485804			

Figure 50: H index regression for Q30.

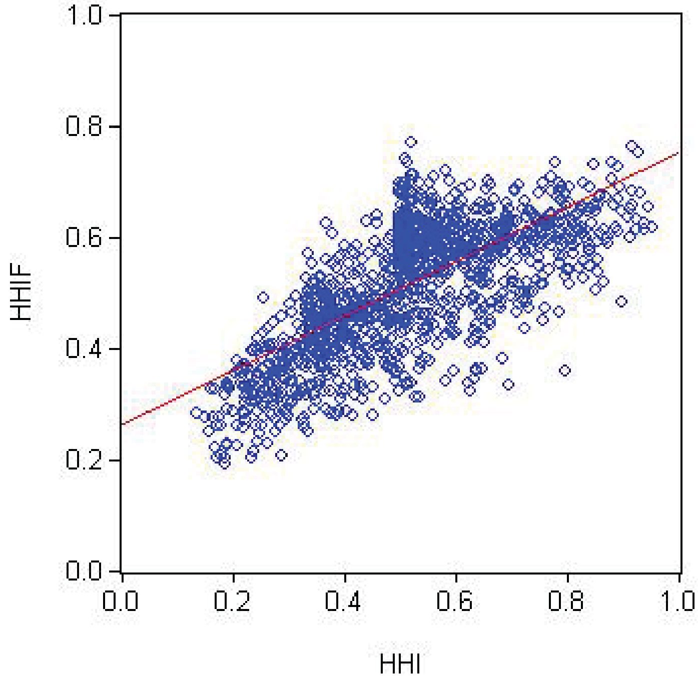

Figure 51: H index forecast over H index for Q30.

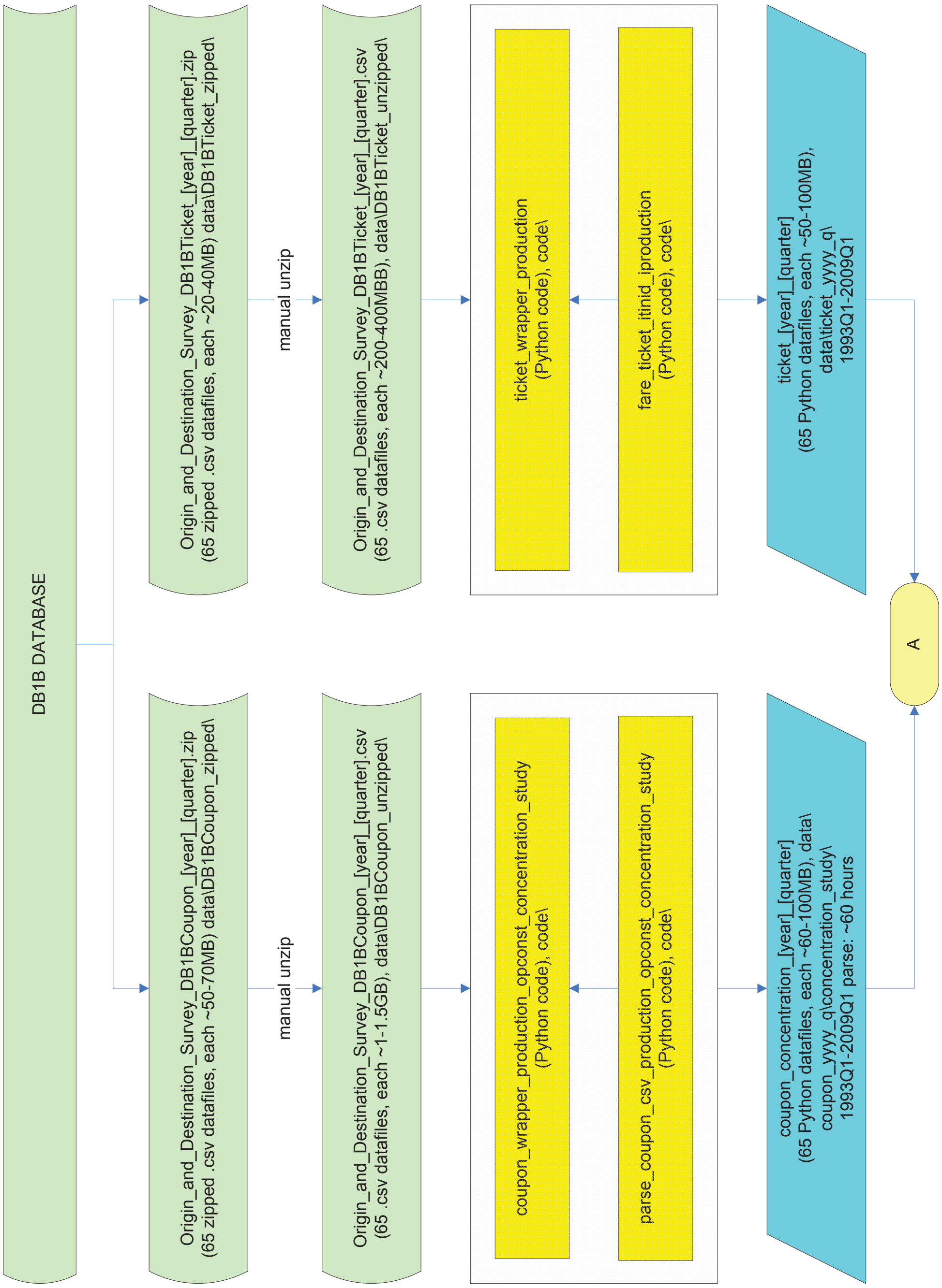

Figure 52: Python DB1B data treatment 1.

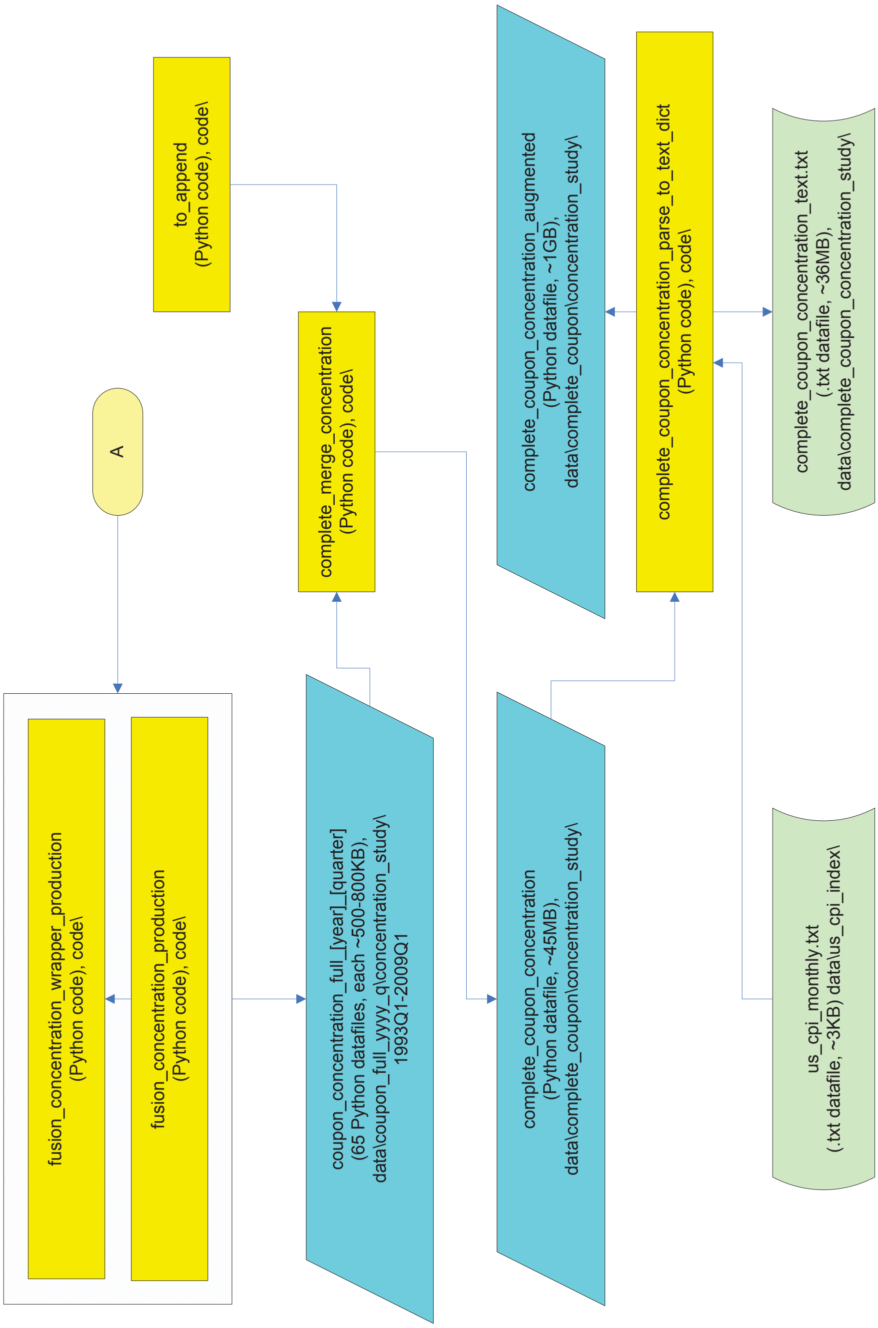

Figure 53: Python DB1B data treatment 2.