WORKING PAPERS

N° 1482

October 2023

“ Banning short-haul domestic flights: A preliminary assessment for France”

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A preliminary assessment for France

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23/10/2023

Very preliminary version

Abstract:

In the midst of an increasing debate concerning the environmental repercussions of transportation decisions in France, this study employs nationally representative data from the 2018-2019 Mobility Survey to investigate the determinants shaping French citizens' preferences for long-distance travel modes. Emphasis is placed on assessing potential CO2 emissions reductions resulting from government-proposed flight bans when a train alternative with a travel time of less than 2 hours and 30 minutes exists (notably, the Paris Orly - Nantes, Paris Orly - Bordeaux, and Paris Orly - Lyon routes). Descriptive analysis reveals a pre-ban inclination among travellers to favour non-flight modes, with just 4% of trips between these cities relying on air travel. Subsequently, econometric analysis challenges the conventional wisdom that income significantly influences air travel choices, instead highlighting its impact on car trip preferences up to a specific income threshold. Additionally, it underscores the expected inverse relationship between travel distance and train travel adoption, coupled with a corresponding increase in flight preference.

I- Introduction.

In 2019, President Emmanuel Macron announced the creation of a *Citizens' Climate Convention*[1] with the aim of finding common solutions to the climate challenge facing all citizens. This convention led to the promulgation of the *Climate and Resilience Law*[2] in August 2021. This text included a measure considered totally innovative in Europe by the French government: the cancellation of domestic flights for which an alternative rail of less than 2h30 is available. Following the approvals of the European Commission and the Council of State in December 2022, the decree concerning this cancellation entered into force in May 2023. Thus, three air routes are now banned in France: Paris Orly - Nantes, Paris Orly - Lyon and Paris Orly - Bordeaux.

In 2020, Austria had already tried to limit short-haul flights. During the COVID-19 crisis, the Austrian government launched an economic plan for the aviation sector. Specifically, financial assistance was granted to Austrian Airlines, but environmental measures were demanded in return. Chancellor Kurz has set a minimum price of 40 euros for all airline tickets in order to fight against social dumping and avoid "low-cost tickets on the backs of the climate and employees". In addition, a tax of 30 euros has been introduced for all journeys of less than 350 kilometers.

Similarly, Germany increased taxes on domestic and intra-EU flights by 75% in 2020 to "continue efforts to meet decarbonisation targets by 2030". The Spanish government has also announced its intention to cancel flights with an alternative rail of less than 2h30 by 2050. However, this measure could be implemented more quickly and be more important. The political party Unidas Podemos has proposed amending a law to cancel cargo flights of more than 100,000 tons per year when an alternative train exists in less than 6 hours. Train travel time would be reduced to 6 hours for passenger journeys. These measures are therefore more draconian than those adopted by France.[3][4]

We therefore note that some European countries have taken initiatives to limit CO2 emissions from these flights. Indeed, according to the French Environment and Energy Management Agency (ADEME), air travel emits 72 times more CO2 per person than train travel for the same distance. It would initially seem wise to cancel these flights and promote train mobility if the objective is to significantly reduce CO2 emissions and combat global warming.[5]

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[1] Convention Citoyenne pour le Climat.
[2] Loi climat et resilience.
[3] "Short-haul ban: These European countries could soon see the end of domestic flights", Euronews, 01/06/2023. Available ici : https://www.euronews.com/green/2023/06/01/short-haul-ban-these-european-countries-could-soon-see-the-end-of-domestic-flights.
[4] "United We Can Proposes Eliminate short flights when there is a fast train alternative", The Journal.es, 30/03/2023. Available here: https://www.eldiario.es/economia/unidas-propone-eliminar-vuelos-cortos-haya-alternativa-tren-seis-horas_1_10080541.html.
[5] Comparison tool of ADEME. Available here: https://impactco2.fr/transport/avion.

It is therefore necessary to question the effectiveness of this type of measure in terms of mobility and environmental impact. Will this cancellation really lead to a significant reduction in carbon emissions? The debate on the validity of this measure, considered by some as political opportunism, has begun through the press and through various associations.

In this economic note, we will first cover the existing literature, then we will use data from the *Ministry of energy transition and territorial cohesion*[6] to study the effects of the ban of short-haul flights in France as well as the determinants of individuals' mobility choices in France. We seek to understand who, and why, would take the train, plane, car, or other transport methods to make their trips. To "limit" our study to trips where the comparison would be relevant, we will study the trips of individuals over 300 kilometers.

II- Currently literature on our subjects

Short-flight hauls ban

As explained in the introduction, many countries are adopting, or considering adopting, public policies to ban short flights in order to reduce emissions. As the fight against climate change is relatively new, so is the literature. However, there have been some studies analyzing the impact of these bans.

In 2021, a study quantified, at a European level, the impact of banning short-medium flights with high-speed trains. They found that, in France, 27.4% of the domestic offered seats could be replaced by a rail alternative that only increases the duration of the trip by 15%, at maximum (Avogadro, et al. 2021). For example, they argue that cancelling the route Toulouse-Paris would save 136 000 tons of Co2 per year if everyone replaced their flights with train tickets. Similarly, they found that about 26.5 million offered seats (3%) for intra-European flights may be cancelled and substituted with alternative trips without an increase in travel time.

Similarly, a study made with German data on passenger bookings and airline schedule in 2019, estimated a potential reduction in CO2 emissions of between 2.7% and 22% - depending on the ban's level of restriction- (Reiter, Augusto et Suau-Sanchez 2022).

Other studies particularly on young people, since there is a claim that young people show a more positive attitude towards the environment. But, a study found that among university students, having a degree environmentally oriented does not have an impact on the probability of using more sustainable methods of transport when visiting a place different than the one they live, while the distance and the type of destination (rural or urban) played a major role (Maltese et Luca 2023).

[6] Ministère de la transition énergétique et de la cohésion des territoires.

In general, scholars argue that fuel burnt per passenger-km is higher for short flights since take-off and landing consume more and thus banning short flights would help reduce these emissions. However, there are findings that fuel per distance can decrease at the beginning of the flight but re-increase with distance flown, since longer flights might have less seats (more business passengers) and be heavier (Park et O'Kelly 2014). Similarly, another paper from 2022 finds that short flights (under 500km) represent 27.9% of all flights departing from Europe but only represent 5.9% of all the fuel burnt (Dobruzkes, Giulio et Laurette 2022).

Some studies have also considered the impact of having to build a completely new railway and found that "in order to balance the annualized emissions from the railway construction, traffic volumes of than 10 million annual one-way trips are usually required" (Westin et Kageson 2012). It is therefore important to consider how much people would move from flights to trains if a ban were considered when assessing the environmental impact.

Determinants of mobility choices

During our econometric analysis we focus on evaluating the impact of certain characteristics on the probability of choosing the train, the plane, the car or other methods of transportation using a logit regression. One of the main drawbacks of our analysis is that we do not have information on the prices paid by individuals[7].

However, there is a broad existing literature covering these discussions with similar models to ours. For example, a paper from 2015, used a multinomial logit regression to study the transportation mode choices for long-distance touristic travels in Norway (Thrane 2015).

Similarly, the paper that studied the determinants of environmentally oriented degrees also used the same choice of econometric model to understand the determinants of travel choices (Maltese et Luca 2023).

III- Data.

Presentation of the survey used.

The Data and Statistical Studies Service (SDES in French)[8] under the *Ministry of energy transition and territorial cohesion* opened access to the public in December 2021 to the files of the *Survey on the Mobility of Persons 2018-2019*[9]. This survey is part of periodic studies carried out approximately every ten years on mobility transport. It benefits from the

[7] We will delve deeper on the data used and the limits of the model in the next sections.
[8] Service des Données et des Etudes Statistiques.
[9] Enquête sur la Mobilité des Personnes.

recognition of the *National Council of Statistical Information*[10] as a survey of general interest and statistical quality.

The survey is a very comprehensive source of information (although with some limitations that we will discuss later) to understand the mobility of French individuals. It makes it possible to analyse their choice of mode of transport for their journeys as well as their evolution over the last decade.

This study was conducted face-to-face by interviewers from the *National Institute of Statistics and Economic Studies (INSEE)* between May 2018 and April 2019, among more than 20,000 households throughout France. To ensure representativeness of the results, participating households were randomly selected. Within each household, one individual was selected using the Kish survey method to answer questions in an interview lasting approximately 1 hour.[11]

According to INSEE data, the survey obtained an overall success rate of 75.6%, or 13,825 households that responded to the questions. During this survey, a total of 10,252 trips involving 22,291 movements were recorded for all households surveyed. To preserve the anonymity of the data, the publicly available database does not provide precise variables regarding the exact places of origin and destination of each trip.[12]

Topics covered by the survey.

The survey provided a large amount of data covering more than 850 variables. These data cover various topics, including:

- The fleet of vehicles available for each household, as well as the characteristics of these vehicles such as the *"puissance fiscale"*[13], year of purchase, number of cars available, etc.
- Transport-related subscriptions, allowing the analysis of travel preferences and habits.
- Detailed socio-economic information of individuals and/or households, such as gender, age, employment, income, etc. This essential data makes it possible to understand mobility behaviors according to social profiles.

[10] Conseil National de l'Information Statistique.

[11] An individual Kish is one who is shot randomly to answer questions. In this investigation, officials asked which person was the next to celebrate his birthday. Each individual therefore has the same probability of being chosen.

[12] A trip is composed by several movements (at least two). Indeed, this database only lists trips that return to their initial point. Therefore, a trip « Paris-Toulouse » necessarily implies that the individual leaves Paris, stops in Toulouse for a particular reason, and then returns to Paris at the end of his journey (two movements). We can also observe trips with more than two movements: the individual could leave Paris, stop at Toulouse, then also go through Bordeaux before his final return to Paris. So, we would count a trip with three movements.

[13] This is a measure used to estimate the amount of emissions for each car.

- Comprehensive details of each movement made by individuals, including dates, distances travelled, means of transportation used, etc. This information provides an in-depth insight into travel patterns and transportation preferences.
- Obstacles to mobility, shedding light on the constraints and obstacles that can influence individuals' travel choices.

In short, this survey provides a wealth of crucial data to analyze and understand in depth the different facets of mobility at the individual level in France. This information is essential for developing appropriate public policies and promoting sustainable and efficient mobility.

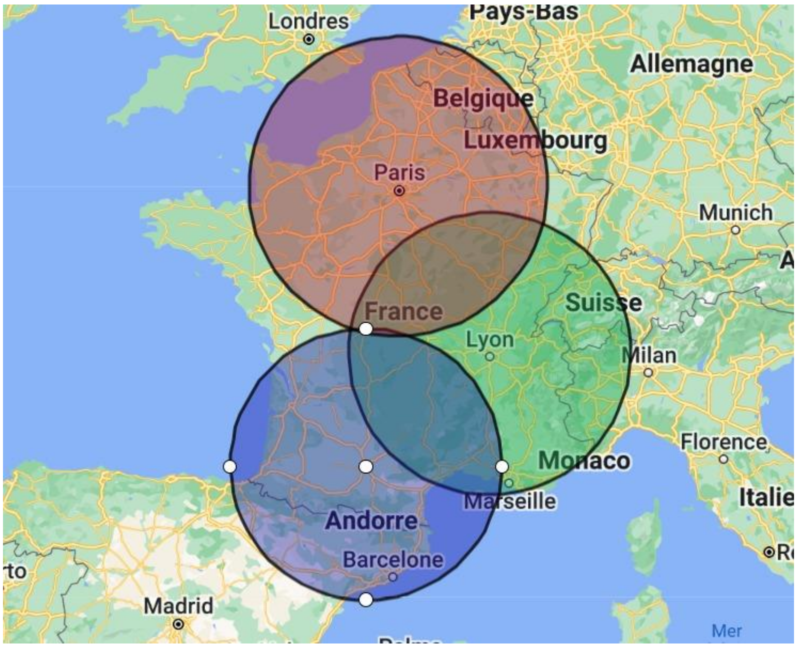
Long-distance mobility.

The *SDES* distinguished two categories of travel in its survey: local mobility and long-distance mobility. The first covers all trips made within a radius of less than 80 km as the crow flies around the home, while the second concerns trips made beyond that distance. To collect data on "long-distance" travel, the investigators asked individuals selected using the Kish method to list all trips made in the last 6 weeks, whether personal or professional. In addition, this survey considers international travel, beyond the borders of France, which gives it a high representativeness.

Our study focuses specifically on the second type of journey. However, as our objective is to study trips where the plane can be a relevant and competing mode of transport, we only consider trips of more than 300 km. Indeed, planes cannot be considered serious competitors for trips shorter than this distances as it is not very realistic to assume that passengers will fly for 100 kilometers, for example. By analyzing these journeys of more than 300 km, we will be able to better understand the transport choices of individuals when they must travel longer distances.

As an illustrative example, Figure 1 shows circles with a radius of 300km starting from Paris, Lyon and Toulouse (three of the main cities in France in terms of transport flows). These circles delineate the distances considered in our study and will allow us to better understand the mobility flows over longer distances from these urban centers.

Figure 1 300km-radius of major cities in France



Observational level of data.

In our consolidated database, each movement is recorded as an observation. Thanks to the extensive details provided by the survey, it is relatively easy to associate each movement with one's trip, and then with the individual and the corresponding household. This approach allows us to correlate the personal characteristics of individuals and households with the specificities of each trip made.

After excluding movements of less than 300 km, our database now contains 6,358 observations (movements) corresponding to 3,093 trips made by 2,415 individuals. Figure 2 shows that on average, each individual made 1.28 trips, and each trip corresponds to 2.05 movements (Figure 3).

Since the survey tracks trips made in the past 6 weeks, it is possible that the same individual has made several trips, especially in the case of regular business trips. However, it is important to note that the vast majority of individuals (84.4%) have only completed one trip of more than 300 km.

Similarly, as expected, almost all trips involve at least two movements (91.2%).[14] However, it is also possible to find trips with up to six trips.

[14] In the original survey, all trips have at least two movements. We observe in Figure 2 that 2.6% of trips would have only 1 trip but this is due to our initial sorting (remove trips of less than 300km) since a trip with 3 movements could have 2 of its movements removed from our final base. For example, if an individual travels from Toulouse to Bordeaux (>300 km) but on his return he decides to stop to visit his family in Agen before returning on Toulouse, then the two trips of the return will not be considered in our base.

These results give us an in-depth view of the mobility patterns of individuals over long distances, while considering the particularities of each trip and establishing significant associations with the individual and family characteristics of travelers.

Figure 2 Number of trips per individual

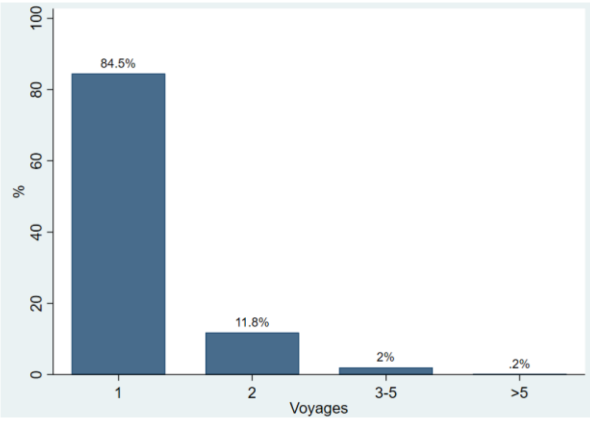
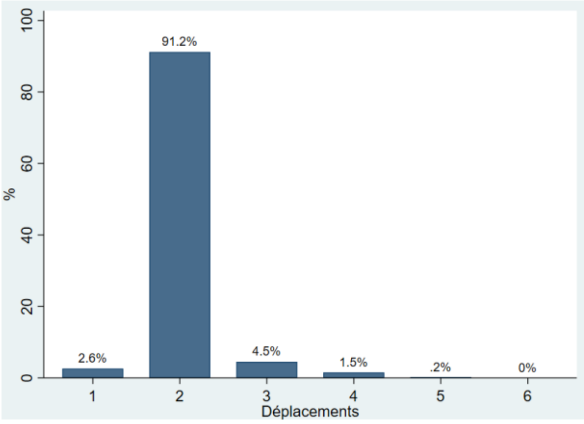


Figure 3 Number of movements 3 per trip



IV- Statistical analysis of trips banned by the government measure.

The measure.

As previously stated, the current government has taken the decision to *permanently*[15] suspend three aviation routes that were operated by the Air France group. These routes were: Paris Orly - Nantes, Paris Orly - Bordeaux and Paris Orly - Lyon.

These three air links were suspended because there was a high-speed rail alternative of less than 2h30 that met several specific criteria, namely:

- The rail link connected the two points directly, using stations located in the same cities as the airports.
- It did not require a change of train, thus offering continuity in the journey.
- Trains were available at several hours of the day, allowing some flexibility in departure and arrival times.
- The traveler had the opportunity to spend more than 8 hours in the same day at his destination.

On the other hand, other shorter routes than Paris Orly – Bordeaux (498km), such as Lyon - Paris CDG[16] (400 km), Rennes - Paris CDG (328 km) or Lyon - Marseille (277 km), are not suspended because they do not meet all these specific criteria.

[15] The decree will be examined in two years by the French government and in three years by the European Commission.
[16] Charles de Gaulle Airport.

For example, the European Commission has stated that the Paris CDG airport cannot be located in Paris, instead considering Roissy-Charles-de-Gaulle station when implementing the analysis. According to the Commission, there were no journeys of less than 2.30 hours that allowed sufficient early morning access to Paris CDG airport or leaving it late enough in the evening. A similar argument has been put forward for the Lyon-Marseille route.

Figure 4 below shows all routes in France, including those that have been banned and those that have exemptions to continue operating. This illustration provides an overview of the various air and rail connections in the country.

Figure 4 Routes banned in France by the government measure (May 2023)

Source: Le Monde[17]

[17] Full article available here: https://www.lemonde.fr/les-decodeurs/article/2023/05/24/l-interdiction-des-vols-interieurs-courts-en-france-une-mesure-videe-de-sa-substance_6174641_4355770.html

Identification of banned journeys in our database.

In order to measure the effectiveness of this measure, we can use data from the mobility survey focusing only on trips made in 2018-2019, i.e. before the Covid period, when passenger flow levels were "normal". Our aim is to compare the different modes of transport used for travel on these three suspended routes.

To do this, we undertook to identify all the journeys made between these three cities in order to be able to make a relevant comparison between the different means of transport used. This will allow us to analyse travellers' mobility habits on these specific routes before the suspensions have been put in place.

By examining travel data made in 2019, we will be able to better assess the impact of the suspension measure on travellers' travel preferences, as well as on the modal split between air and rail links. Such an analysis should help us to better understand how this measure could affect passengers' transport choices and whether it could contribute to further promoting the use of rail links as an alternative to air flights for these specific routes.

Our travel sorting process went as follows (we will use the example of the city of Paris, but the same steps were followed for the cities of Nantes, Bordeaux and Lyon):

- In general, the public inquiry does not provide accurate data on the places of origin and destination of travel. The nearest level available is that of the region. So, we started by taking into account all the trips leaving or arriving in the region Île-de-France.
- Thanks to the variables of the survey that identify the places of change of means of transport, we were able to identify all the journeys that passed through Paris (in its train stations or airports) at a given time, if there was a change of means of transport. However, it is important to note that the survey is not exhaustive in this regard, as there are trips for which we do not have all the information on the places of changes of means of transport.
- To identify routes passing through places of change of means of transport in Paris, we used a statistical software that took into account the following keywords in the variables: "PARIS," "PARIS 75," "PARIS GARE [...]," "PARIS AEROPORT [...]," "CHARLES DE GAULLE," "ORLY," "BEAUVAIS," or if the departmental code of the place of change began with "75."
- In addition, the survey also includes a variable indicating the station or airport of arrival of the trip. However, this variable is also not complete, and there is a significant proportion of trips for which this information is missing. To be conservative and include even more air trips, we made the following assumption for trips with two movements: if one of the movements arrives, for example, at Orly airport, then the second movement (the return of the trip normally) will also depart from that airport. A similar

hypothesis was made using survey variables that identify airports where individuals made stopovers.[18][19]

By following these steps, we were able to identify and collate a representative set of data of journeys involving the three suspended routes, thus allowing a meaningful comparison to be made between the different modes of transport used for these specific journeys.

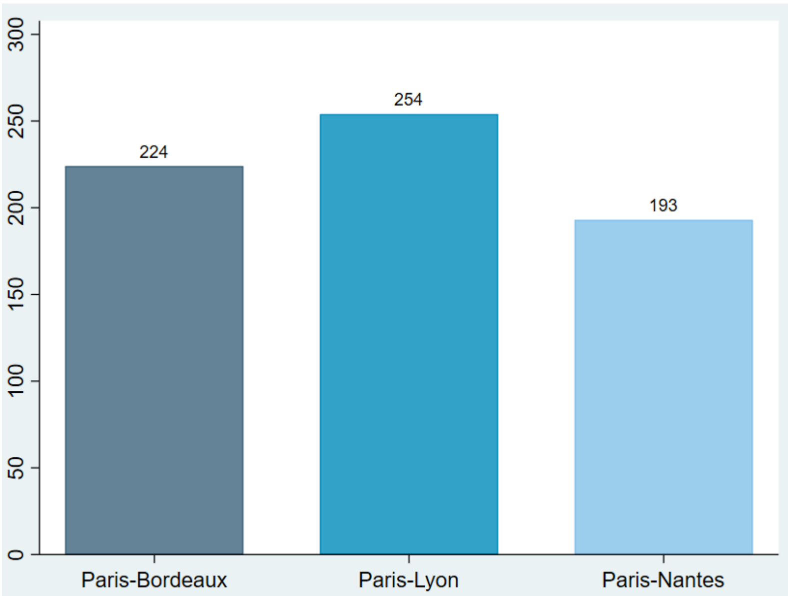
To overcome the problem of the region being the most accurate geographic area we have in the data, we have put in place several measures. First, we applied the opposite method to that described above for places of change of means of transport.

Where we identified routes that indicate a change of means of transport in another city in the same region (e.g. Pau or Biarritz in the case of Bordeaux), but which do not mention that the journey went through Bordeaux itself, we eliminated these observations from our analysis. This step aims to eliminate data that could be falsely attributed to one of the suspended links.

On the other hand, when we found no variable indicating a change in means of transport, which is frequently the case for car trips, we considered that the journey corresponded to a Paris-Bordeaux, Paris-Lyon or Paris-Nantes depending on the region of origin and destination mentioned in the data since this is the most probable trip.

As a result of this process, we finally obtained 671 observations, broken down as follows in Figure 5:

Figure 5 Distribution of trips consistent with the government measure



[18] Finally, there are only 23 trips for which this information (stopovers) was useful in identifying routes.
[19] This shows that in our analysis we are conservative and take into account even more air trips than those considered by the government because it considers that connecting flights should not be taken into account for the flight ban.

Each observation corresponds to a movement, and we therefore observe that the distribution is rather homogeneous. But, as expected, the Paris-Lyon link is the most used, which would seem logical since they're the first and third most populated city in France followed by the Paris-Bordeaux link and finally Paris-Nantes. It is important to note that this graph considers trips between these cities regardless of the mode of transportation used.

Statistics on the mode of transport used.

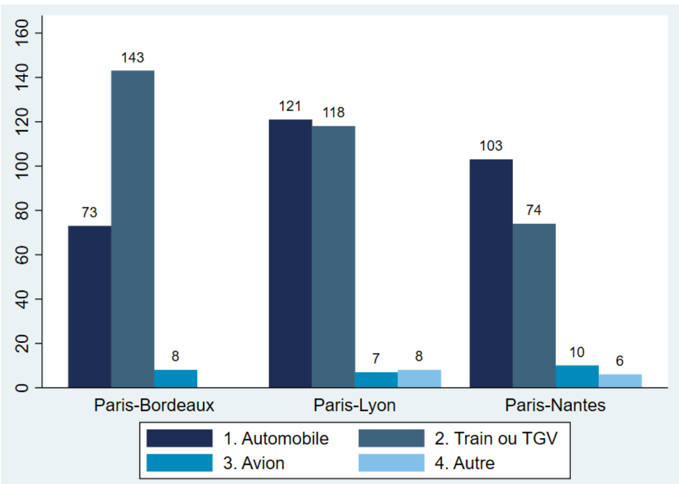
Initially, trips are categorized into 9 main modes of transport: pedestrian; two wheels; cars; specialized transport, school, taxi; urban or regional public transport, coaches; mainline train or "*TGV*"; airplane; boat and others. To simplify the interpretation of the results and models, and without major loss of information, we decided to group our trips into only 4 categories:[20] Airplane, Train, Car and Other.

Once this categorization is done, we obtain the first simple but important statistic of our analysis: the French did not mainly use the plane to travel through the routes where the plane was removed.

We can observe in Figure 66 that the car remains the most used mode of transport for journeys between Paris and Lyon and between Paris and Nantes. Similarly, the journey between Paris and Bordeaux is mainly by train, mainly for reasons of time (Bordeaux and Paris are connected by "*TGV*" or "*Intercités*" trains that take between 2h and 3h30 while the journey by car is estimated at 6h for 585km of road).

Finally, the aircraft would be used only on 25/671 of the routes which would correspond to a utilization rate of 3%.

Figure 6 Distribution of trips by mode of transportation



[20] Indeed, an individual can use several modes of transport for the same trip (for example, train + plane). The main mode of transport is the "heaviest" mode of transport that follows this classification: plane > train > bus > car > urban public transport > motorized two-wheelers.

In addition, we identified a total of 464 intra-France air trips out of the initial 22,291 trips. This means that the ratio of banned flights to the total number of flights is 5%. To put this proportion into perspective, we can compare it with the data provided by Le Monde[21], which indicate that these banned flights concern about 500,000 passengers per year out of a total of 16 million, a ratio of 3.1% (<5%). The difference between this one ratio and ours is mainly explained by the fact that we took a conservative approach in our analysis by including international flights that made stopovers at one of the airports concerned. By removing these flights (9 flights out of 25), we obtain a new ratio of 3.5%, which is very close to the estimate reported elsewhere.

These results give an idea of the scope of the measure to abolish the three specific aeronautical routes. About 3.5% of initial trips were impacted by this removal, which represents a relatively small proportion of total intra-France flights. Therefore, we observe that the removal will affect airlines that were already very little used by French travelers. Actually, it was reported that the Paris Orly-Bordeaux and the Paris Orly-Nantes routes were not even available anymore in 2020, during Covid-19, so before the introduction of the ban.

Greenhouse gas (GHG) emissions related to these trips.

In July 2023, the Ministry of energy transition and territorial cohesion published a methodological note explaining how to use the data from the mobility survey to estimate the GHG emissions of French people.

Indeed, for each mode of transport we can find the unit emissions in grams of CO2 per kilometer travelled. The data provided are presented in Table 1.

From the data from the Mobility of Persons Survey, we can approximate the emissions related to travel on routes prohibited by the government measure. By using the distance as the crow files we are able to simply compute the total emissions emitted by the passengers we identify previously (671 in total). Results are presented in Table 2:

It is important to note that although airplanes are the most polluting choice when considering emissions per person, they are not necessarily the mode of transportation that generates the most emissions in nominal terms. By analyzing the data, we see that passengers on prohibited routes were already favoring other transport alternatives, such as the train (especially for the Bordeaux-Paris route) and the car.

[21] See the link to the full article in the footnote 17

Table 1 Average emissions of each mode of transport

Mode of transport	Unit consumption	Source	Note
Airplane	258gCO2/km.voy	Ademe	Unit emissions with upstream fuel and contrails
Train (TGV)	3gCO2/km.voy	SNCF	New method of calculation of the SNCF. Unit emissions with upstream fuel
Car	156gCO2/km.voy and an[22] average occupancy rate of 2.25.	Statistical Register of Road Vehicles (RSVERO)	

Table 2 Total CO2 emissions by mode of transport

		Airplane	Train (TGV)	Car
Paris-Nantes	Distance (km) – as the crow flies	341	341	341
	Unit emissions	258gCO2/km.voy	3gCO2/km.voy	69.3gCO2/km.voy
	Total emissions per person (kgCO2)	87.98	1.02	23.63
	Total emissions (kgCO2)	**879.78**	**75.70**	**2 434.02**
Paris-Bordeaux	Distance (km) – as the crow flies	498	498	498
	Unit emissions	258gCO2/km.voy	3gCO2/km.voy	258gCO2/km.voy
	Total emissions per person (kgCO2)	128.48	1.49	34.51
	Total emissions (kgCO2)	**1 027.87**	**213.64**	**2 519.33**
Paris-Lyon	Distance (km) – as the crow flies	393	393	393
	Unit emissions	258gCO2/km.voy	3gCO2/km.voy	258gCO2/km.voy
	Total emissions per person (kgC02)	101.39	1.18	27.23
	Total emissions (kgCO2)	**709.76**	**139.12**	**3 295.42**

[22] This rate corresponds to the average value computed by economists working in the Ministry's methodological note for long distance journeys (>80km)

Indeed, in terms of total emissions, the car remains the most polluting means of transport, generating between 2.5 and 4.5 times more emissions than the plane, depending on the routes considered.

These results highlight the importance of considering both per capita and total emissions when assessing the environmental impact of different modes of transport. While the aircraft may be more emitting per person, its ability to carry many passengers combined with the fact that most passengers were not travelling by plane make its nominal emissions less important than those of the car for any of the three routes considered.

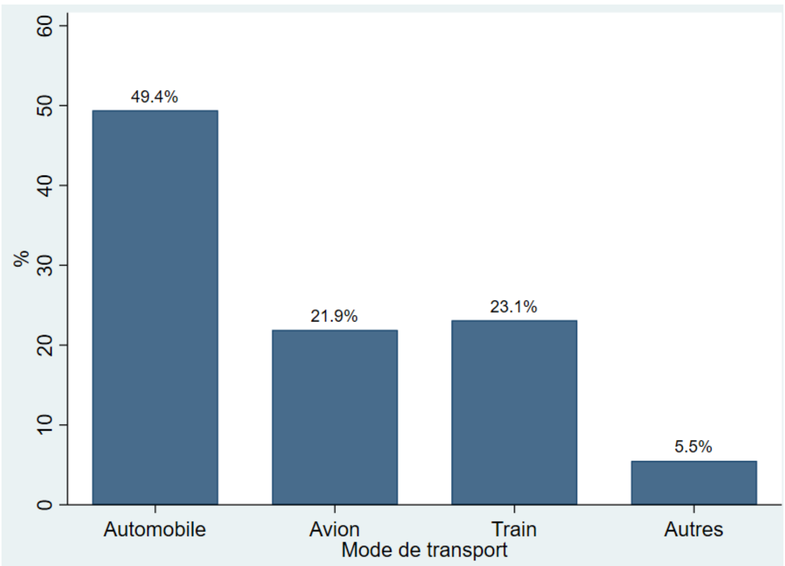
V- Descriptive statistics on all recorded trips of more than 300km.

After analyzing the potential impact of the ban proposed by the government, we seek to understand, in general, what are the factors that determine the choice of mode of transport in France for long trips.

a. The mode of transport used.

The distribution of trips over 300 km is shown in Figure 7 below.

Figure 7 Distribution of modes of transport



Indeed, by analyzing the data of trips of more than 300 km reported by the respondents, we can observe that the car remains the most widely used mode of transport, representing 49.4% of all trips. Train and plane come in second and third, with similar shares of 23.1% and 21.9% respectively.

Moreover, this distribution of modes of transportation appears to be more balanced than the one we observed previously when examining the trips cancelled by the government measure. This finding reinforces the idea that the French already preferred the train and the car specifically for these links before some air routes were suspended. The plane was therefore relatively less used compared to the train and car, indicating that travelers already tended to opt for less polluting alternatives for these specific routes.

These results highlight the importance of awareness and public policies to encourage the use of more sustainable and less greenhouse gas-emitting modes of transport. Promoting alternative transport solutions such as rail and initiatives to encourage carpooling could help reduce the overall environmental impact of travel, while a ban on flying would have less ecological impact.

b. Travel distances and destinations.

The distances travelled are generally variables poorly understood by individuals. For this reason, the INSEE has carried out important methodological work in order to obtain a consolidated variable for the "true" distance. In our analysis we keep this variable rather than the distance initially declared to avoid bias.

We observe in Figure 8 that one in two trips takes place over less than 500 km[23]. Similarly, Figure 9 shows that 85.7% of trips are made in metropolitan France.

Figure 8 Distribution of distances as the crow flies (km – all means of transport combined)

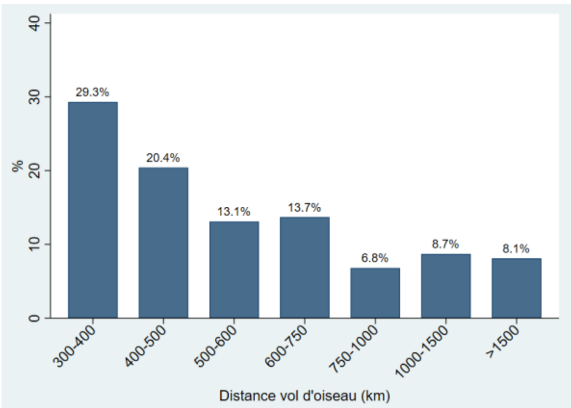
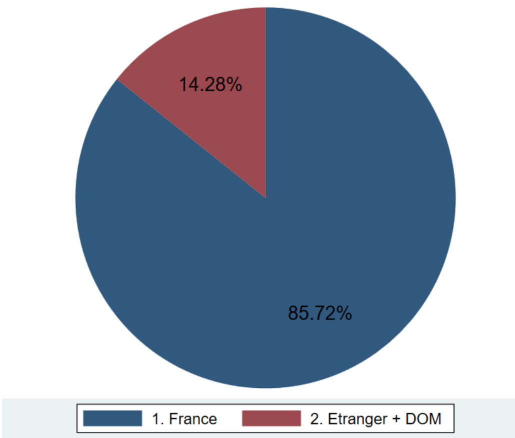


Figure 9 Country of destination



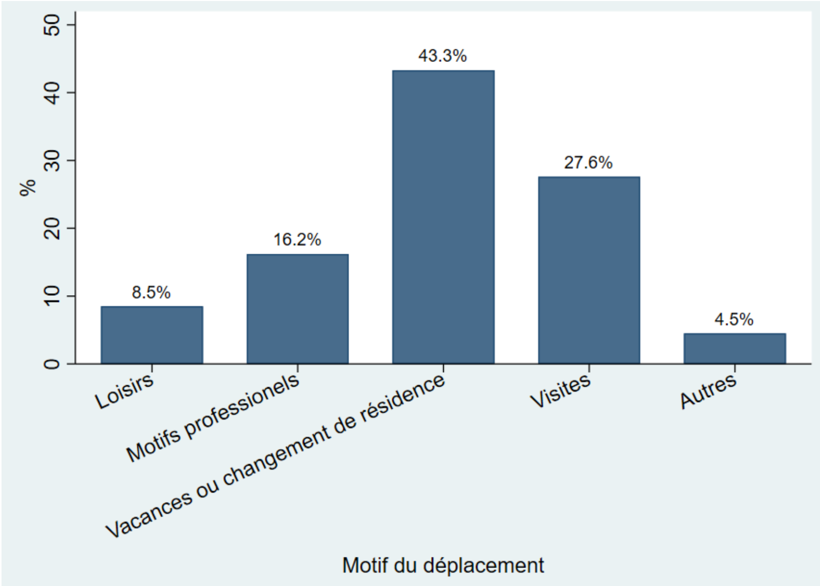
c. The purpose for the trip.

The reasons for which an individual travels may also play a role in his or her choice of mode of transport. Indeed, a business trip and a holiday trip will not determine the choice in the same way.

[23] Distance as the crow flies and in kilometers.

In our database, the reasons are distributed as follows in Figure 10:

Figure 10 Purpose of travel



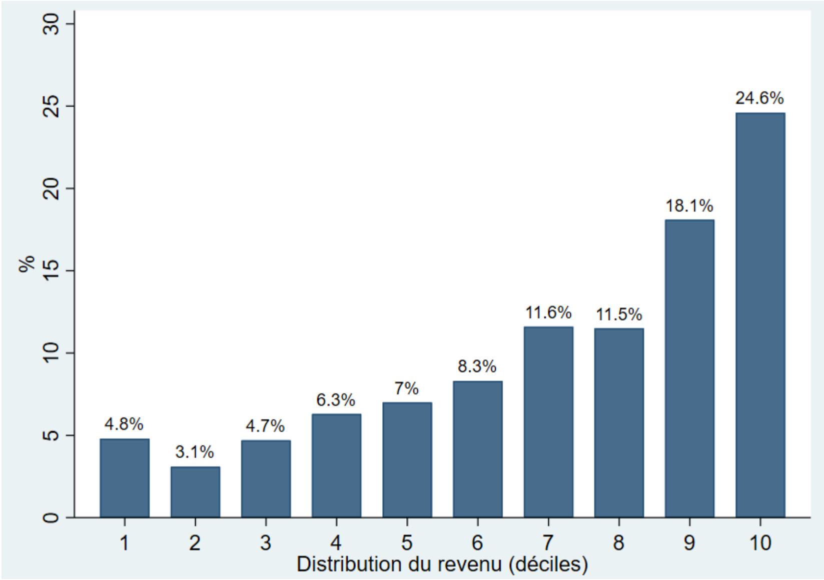
Holidays and visits remain largely the most common reasons for trips over 300km. However, there is a significant share of business trips (16.2% or 1 in 6 trips) that are also made.

d. Income of individuals/households.

The survey does not provide accurate data on individual or household income in order to respect anonymity and confidentiality. However, we have the household income deciles for each individual in the dataset. That is, we can order to distinguish the richest 10%, the richest 10% after them and so on up to the poorest 10%.

Figure 11 shows the distribution of the total amount of trips, depending on the income deciles:

Figure 11 Distribution of the number of trips by income deciles



As expected, the wealthiest individuals travel much more than the poorest individuals. An individual belonging to the richest decile makes on average 5 times more trips of more than 300 kilometers than an individual belonging to the poorest decile.

VI- Econometric model for estimating the determinants of transport mode choice.

To try to understand the reasons and characteristics that lead an individual to choose one mode of transport over another, without limiting ourselves to simple correlation analyses, we will use an econometric discrete choice model. Specifically, we will use a multinomial logistic model. These models, while not excessively complicated, are largely used in economic literature when modeling discrete choices made by individuals.

Suppose that for an individual n, the utility from a movement d when using a mode of transport i is given by:

$$U_{n,d,i} = \delta_i + \alpha_i X_n + \beta_i X_d + \gamma_i D_d + \epsilon_{n,d,i}$$

where the utility function depends on:

- The mode of transport used i, where $i \in \{Plane, Automobile, Train, Other\}$
- The characteristics of the individual n: X_n. Within this vector we include the following variables: *age of the individual, sex, socio-professional category*[24]*, type of job, status,*

[24] A grouping was carried out according to the aggregated categories proposed by INSEE to reduce the number of *dummies*.

maximum level of education, number of people in the household, number of vehicles available[25]*, income*[26].

- The characteristics of the movement d: X_d . We have included here: *the region of origin and destination, the door-to-door distance of the trip*[27]*, the purpose for the trip, the number of nights spent during the trip, the number of means of transport used, controls on the rates paid by the individual*[28]*, fixed temporal effects (day of the week and month of the year of travel)*.
- The distance associated to each movement D_d.
- An unobserved random term $\epsilon_{n,d,i}$.

The probability of choosing the mode of transport i over the mode of transport j can be written as follows:

$$P[U_{n,d,i} \geq U_{n,dnj,}, \forall\, j \neq i] = \frac{e^{(\delta_i + \alpha_i X_n + \beta_i X_d + \gamma_i D_d)}}{1 + \sum_{j=1, j\neq i}^{3} e^{(\delta_i + \alpha_i X_n + \beta_i X_d + \gamma_i D_d)}}$$

Model 1 estimates probability using **distance as the crow flies** as an explanatory variable, and **we do not include temporal fixed effects**. In model 2 we include **time fixed effects.** Finally, in the 3rd model we use the "**true" distance traveled during the trip**, it is important to note again that this variable is generally poorly known by individuals and that corrections have been made by INSEE to consolidate the information. We also include **time fixed effects** in Model 3.

VII- Econometric model results.

Our main coefficients of interest are those associated with variables concerning individuals' income, distance of travel and purpose for travel. As this is not a model estimated by ordinary least squares (OLS), we must be cautious when interpreting the coefficients of the model.

The tables in the Appendix contain the average marginal effects (AME) of these variables for each mode of transport used. Average marginal effects are a good way to interpret the changes in the probability for each outcome. A marginal effect of a variable X for an individual i, corresponds to the change in probability of choosing a particular method of transportation, when X varies by a *"very small amount"* (when continuous), keeping all the other variables as observed in the data. Therefore, the average marginal effect would be the sum of all the marginal effects for each individual i divided by the total number of individuals N.

[25] Cars, two-wheelers and bicycles.
[26] Deciles.
[27] As the crow flies distance or actual distance depending on the model used.
[28] Although we do not have the exact price paid by individuals, we do have variables indicating if the individual used a discount rate or not.

Table 3 contains the results using distance as the crow flies and without fixed effects (Model 1).

Various observations can be drawn from our results. First, we find that income plays an important role in choosing to take the car for travel. From the 4th income decile, each decile would have a higher probability, with a 95% confidence level, of making a trip by car compared to the 1st decile (our reference category for this variable). However, the variations do not increase with each decile. There is a similar increase for the 4th decile (+5.91 p.p) than for the 10th decile (5.92 p.p) compared to the reference category. Therefore, it would seem that revenue plays a significant role when travelling by car but only up to a certain level of income.

For travel by train, we do not observe a significant impact of income, except for people belonging to the 3rd and 5th decile, who would be more likely to take this mode of transport than those in the 1st decile (+3.5 p.p and +3.8 p.p respectively). Similarly, the probability of flying would be similar between individuals in the 1st decile and those in other deciles, apart from individuals in the 2nd decile and 10th decile. This suggests that income would not play a decisive role, and that people who fly would not be limited to the wealthiest.[29]

In addition, work purposes and holidays significantly increase the probability of flying (+4.5 p.p and +5.5 p.p respectively in relation to movements without specified purpose – the category of reference-). On the other hand, these purposes do not have a significant impact on the probability of taking other mean of transport. Thus, even taking into account distance and travel time controls, travel for business reasons would continue to increase the likelihood of flying. Similarly, the car is preferred for visits to relatives, while other reasons do not have a significant impact on this mode of transport.

Finally, distance as the crow flies has heterogeneous effects on each mode of transport. When it comes to driving, this variable would not have a significant impact on probability, which may seem surprising since one would expect long trips to discourage individuals from using their cars more. In contrast, for train and plane, we see the opposite logic: as distance increases, the probability of taking the train decreases by 0.1 p.p for every 10 km increase in the crow flies, while the probability of flying increases by 0.1 p.p for each similar increase in distance. Although the variations cancel each other, we cannot conclude with our analysis that people that stop taking the train due to the increase of distance are instead taking the airplane.

Model 2 (represented in Table 4) is more suitable since it controls for the day of the week when the trip is made as well as for the month of the year. The inclusion of these fixed temporal effects is important since it allows control for seasonal effects that impact the choice to make a long-distance trip or not. Similarly, we control for the day of the week since an individual will not have the same probability of choosing a mode of transport, indeed we can think that a trip is more likely to arrive on weekends than in the middle of the week.

[29] We can see that the estimators of the 6th and 9th deciles are also significant but only at a 90% confidence level.

The results of the Model 2 average marginal effects' estimations do not change significantly. Income has an impact only from decile 4 for cars, but the magnitudes of the average effects are somewhat larger. We observe the same dynamic for the train, with deciles 3 and 5 being the only ones with a greater probability of taking this mode of transport. For the plane, only the 1st and the 10th decile maintain their significance.

As for the purposes of travel, there are no major changes other than the purposes that increased the probability of flying (work reasons, vacation) now show a larger average marginal effect (+5p.p and +5.8 p.p respectively).

Finally, the impact of the distance variable on the probability of taking one of the modes of transport has not changed.

Finally, in our average marginal effects displayed on Table 4, we also consider using as an independent variable the actual distance of the movement rather than the distance as the crow flies. We also include time fixed effects in this model 3.

We can see some changes from the previous two estimates. First of all, income becomes much more important regardless of the decile level for the choice of car (with the exception of decile 3 which is statistically positive only at a confidence level of 90%). For the train we do not observe changes while for the plane we can confirm our first intuition which would confirm that not only the rich take the plane since there is no homogeneity between the effects of each decile and actually the effects are only significant for the 2nd and the 10th deciles.

Regarding the purposes for travel, professional reasons would no longer be one of the purposes that would increase the probability of flying (the confidence level has decreased from 99% to 90%) but holidays remain a significant reason. Similarly, we can still observe that visits to close people remain one of the reasons that most push individuals to choose the car (the probability increases by 3.8 p.p.).

Finally, the actual "true" distance would have a smaller impact on the probability of taking the train or plane than the distance as the crow flies (-0.04 p.p. vs. -0.10 p.p. for the train and +0.05 p.p. vs 0.10 p.p. for the plane). However, the probability of taking the car would also decrease by the distance and this at a confidence level of 90% while for the distance as the crow flies this estimator was not statistically different from 0 for this confidence level.

Summary and conclusion

In summary, this study offers two analyses. First, we examine the travel ban proposed by the government and approved in 2023. Secondly, we conduct a comprehensive examination of the determinants influencing travel behavior in France, based on an econometric analysis and empirical evidence drawn from an extensive dataset, the Mobility Survey 2018-2019, from the Ministry of energy transition and territorial cohesion.

The government's decision to permanently suspend three aviation routes in France—Paris Orly to Nantes, Paris Orly to Bordeaux, and Paris Orly to Lyon—based on the availability of high-speed rail alternatives meeting specific criteria has yielded several noteworthy insights. Firstly, it is evident that most travelers on these suspended routes did not primarily rely on airplanes for their journeys. Instead, car travel remained the dominant mode for trips between Paris and Lyon and Paris and Nantes, while the Paris to Bordeaux route saw a significant preference for trains due to time considerations. The relatively low utilization rate of airplanes, accounting for only 3% of trips on these routes, reflects a limited reliance on air travel for these specific connections. The same conclusions have been raised by the media when assessing the measure.

Furthermore, when considering greenhouse gas (GHG) emissions, it becomes apparent that although airplanes exhibit higher emissions per person, the total emissions generated by car travel significantly exceed those of airplanes on these routes. The car, in fact, produces between 2.5 and 4.5 times more emissions than airplanes, emphasizing the importance of evaluating both per capita and total emissions when assessing the environmental impact of different modes of transport. It would seem logical that the government should also focus their environmental policies on reducing the carbon emissions from cars, which are the main transport method used in France, even for some longer distances and even when high-speed trains are available.

In essence, this analysis underscores the relatively small proportion of travelers impacted by the suspension of these specific aviation routes, as well as the role of alternative modes of transportation, particularly trains and cars, in reducing emissions on these routes. It highlights the complexity of assessing environmental impacts and the necessity of comprehensive evaluations to inform transportation policies effectively.

Transitioning to the core of our investigation, we introduced an econometric model, a robust tool for estimating the determinants of transport mode choice, although with some limitations. This model, encompassing individual characteristics, trip-specific factors, and unobserved variables, allowed us to quantify the influence of income, travel distance, travel purpose, and temporal factors on mode choices. Variations of this model, accounting for temporal effects and utilizing both crow-fly and actual travel distances, enriched our understanding of these determinants.

Our findings underscore several critical facets of travel behavior in France. Income's role emerges as a pivotal determinant only for some transport modes, significantly impacting car travel choices, up to a specific income threshold. However, it does not wield the same influence on train and plane travel, indicating that these modes of transportation would not be exclusive to the wealthier segments of the population.

The influence of travel purposes on mode choice is pronounced, with work and vacation trips notably enhancing the likelihood of air travel. Conversely, car travel remains the preferred option for visits to relatives. Distinct relationships between travel distance and mode choice further enhance our comprehension, revealing that for car travel, distance holds minimal sway over decision-making, while for train and plane travel, it impacts choices in contrasting ways, as expected.

While our econometric modeling offers valuable insights into the determinants of travel mode choice, it's important to acknowledge certain limitations that could be addressed for further refinement.

Firstly, our analysis assumes that unobservable factors, captured by the error term, follow a generalized extreme value distribution of type I (GEV I). This distributional assumption may not fully capture the complexity of individual preferences and constraints, potentially leading to model misspecification. Future research could explore alternative error structures or incorporate latent variables to better account for the unobservable determinants of travel mode choice.

Moreover, our analysis predominantly focuses on individual-level factors, such as income and trip characteristics, while overlooking broader contextual factors like regional infrastructure development and pricing policies. Incorporating these external factors could offer a more comprehensive understanding of travel mode choices and help policymakers design more effective interventions. Indeed, the absence of a price variable in our econometric model is notable. Price is a fundamental factor influencing travel mode choice, and its omission represents a limitation in our analysis. While we have included a group of dummies determining the use of discounted rates by individuals, the explicit inclusion of price as a variable would provide a more comprehensive understanding of how economic considerations shape transportation decisions.

Price considerations can be critical in mode choice, particularly in the context of public transportation, where fares may vary based on time of day, ticket class, and discounts. Furthermore, the availability of special offers, season tickets, or loyalty programs can significantly impact an individual's decision to opt for a particular mode of transport. By incorporating price-related variables, such as ticket fares, subsidies, or discounts, into our model, we could better assess the trade-offs individuals make between cost and convenience when choosing their mode of travel.

While there have been some papers, which we presented in the literature section, that have also used distance as a good proxy for price, when data was not available, it might not be sufficient. In future research, the inclusion of price-related variables could enhance the accuracy and policy relevance of our econometric modeling, enabling a more comprehensive analysis of the factors driving travel mode choices and offering valuable insights for policymakers seeking to promote sustainable and cost-effective transportation options.

Finally, there are some more advanced econometric models such as a random coefficient logit model or a BLP model that can be used to estimate more precise parameters and therefore better identify the effects of certain variables when the price data is available.

VIII- Appendix

Table 3 Average marginal effects for each mode of transport

	Car		Train or TGV		Airplane		Other	
Revenue decile								
2	0.0281		-0.0118		0.0550	***	-0.0713	***
	(0.0207)		(0.0198)		(0.0192)		(0.0257)	
3	0.0228		0.0354	**	0.0250		-0.0832	***
	(0.0201)		(0.0171)		(0.0188)		(0.0247)	
4	0.0593	***	0.0040		0.0103		-0.0736	***
	(0.0187)		(0.0173)		(0.0152)		(0.0253)	
5	0.0413	**	0.0381	**	0.0180		-0.0974	***
	(0.0189)		(0.0162)		(0.0160)		(0.0241)	
6	0.0581	***	0.0139		0.0273	*	-0.0992	***
	(0.0188)		(0.0157)		(0.0156)		(0.0235)	
7	0.0757	***	0.0169		0.0068		-0.0994	***
	(0.0183)		(0.0144)		(0.0147)		(0.0236)	
8	0.0509	***	0.0214		0.0140		-0.0863	***
	(0.0185)		(0.0147)		(0.0157)		(0.0241)	
9	0.0443	**	0.0179		0.0260	*	-0.0882	***
	(0.0191)		(0.0144)		(0.0150)		(0.0246)	
10	0.0592	***	-0.0207		0.0627	***	-0.1012	***
	(0.0196)		(0.0149)		(0.0159)		(0.0253)	
Distance as the crow flies (10km) origin - destination	-0.0001		-0.0011	***	0.0011	***	0.0002	*
	(0.0001)		(0.0004)		(0.0003)		(0.0001)	
Purpose: Leisure	-0.0065		0.0042		-0.0018		0.0041	
	(0.0140)		(0.0154)		(0.0200)		(0.0218)	
Purpose: Professional reasons	0.0059		0.0196		0.0454	**	-0.0708	***
	(0.0154)		(0.0142)		(0.0184)		(0.0207)	
Purpose: Vacation and other private reasons	0.0114		-0.0189		0.0545	***	-0.0470	**
	(0.0110)		(0.0129)		(0.0178)		(0.0186)	
Purpose: Visits	0.0447	***	-0.0004		0.0338	*	-0.0781	***
	(0.0109)		(0.0127)		(0.0174)		(0.0181)	

p<.01, ** p<.05, * p<.10

Table 4 Average marginal effects for each mode of transport including time fixed effects.

	Car		Train or TGV		Airplane		Other	
Revenue decile								
2	0.0227		-0.0140		0.0608	***	-0.0694	***
	(0.0207)		(0.0201)		(0.0196)		(0.0265)	
3	0.0246		0.0379	**	0.0219		-0.0844	***
	(0.0198)		(0.0172)		(0.0191)		(0.0250)	
4	0.0638	***	0.0042		0.0077		-0.0757	***
	(0.0185)		(0.0175)		(0.0155)		(0.0260)	
5	0.0458	**	0.0420	***	0.0160		-0.1039	***
	(0.0189)		(0.0163)		(0.0163)		(0.0247)	
6	0.0620	***	0.0150		0.0272	*	-0.1042	***
	(0.0192)		(0.0162)		(0.0162)		(0.0242)	
7	0.0795	***	0.0174		0.0061		-0.1030	***
	(0.0184)		(0.0147)		(0.0149)		(0.0242)	
8	0.0561	***	0.0224		0.0114		-0.0899	***
	(0.0187)		(0.0150)		(0.0163)		(0.0248)	
9	0.0478	**	0.0192		0.0244		-0.0914	***
	(0.0195)		(0.0146)		(0.0154)		(0.0254)	
10	0.0652	***	-0.0160		0.0557	***	-0.1049	***
	(0.0198)		(0.0152)		(0.0161)		(0.0260)	
Distance as the crow flies (10km) origin - destination	-0.0001		-0.0012	***	0.0011	***	0.0002	*
	(0.0001)		(0.0004)		(0.0003)		(0.0001)	
Purpose: Leisure	-0.0089		0.0054		-0.0034		0.0070	
	(0.0139)		(0.0152)		(0.0193)		(0.0215)	
Purpose: Professional reasons	0.0033		0.0106		0.0501	***	-0.0639	***
	(0.0156)		(0.0140)		(0.0179)		(0.0207)	
Purpose: Vacation and other private reasons	0.0072		-0.0231	*	0.0586	***	-0.0427	**
	(0.0108)		(0.0126)		(0.0171)		(0.0184)	
Purpose: Visits	0.0414	***	-0.0063		0.0373	**	-0.0724	***
	(0.0110)		(0.0125)		(0.0167)		(0.0181)	

p<.01, ** p<.05, * p<.10

Table 5 Average marginal effects for each mode of transport with actual distance and time fixed effects.

	Car		Train or TGV		Airplane		Other	
Revenue decile								
2	0.0357	**	-0.0011		0.0355	**	-0.0701	***
	(0.0179)		(0.0159)		(0.0158)		(0.0214)	
3	0.0292	*	0.0260	*	0.0161		-0.0712	***
	(0.0172)		(0.0141)		(0.0164)		(0.0214)	
4	0.0493	***	0.0035		0.0025		-0.0553	***
	(0.0166)		(0.0142)		(0.0130)		(0.0212)	
5	0.0457	***	0.0302	**	0.0090		-0.0848	***
	(0.0174)		(0.0137)		(0.0138)		(0.0208)	
6	0.0597	***	0.0051		0.0217		-0.0865	***
	(0.0166)		(0.0139)		(0.0137)		(0.0202)	
7	0.0709	***	0.0067		0.0034		-0.0811	***
	(0.0170)		(0.0121)		(0.0126)		(0.0209)	
8	0.0575	***	0.0117		0.0050		-0.0742	***
	(0.0166)		(0.0130)		(0.0136)		(0.0209)	
9	0.0414	**	0.0198		0.0152		-0.0764	***
	(0.0174)		(0.0124)		(0.0129)		(0.0213)	
10	0.0559	***	-0.0156		0.0458	***	-0.0861	***
	(0.0178)		(0.0131)		(0.0139)		(0.0221)	
Distance as the crow flies (10km) origin - destination	-0.0001	*	-0.0004	***	0.0005	***	0.0001	
	(0.0001)		(0.0002)		(0.0001)		(0.0001)	
Purpose: Leisure	-0.0224	*	0.0023		-0.0112		0.0312	*
	(0.0127)		(0.0136)		(0.0173)		(0.0184)	
Purpose: Professional reasons	-0.0096		0.0067		0.0316	*	-0.0288	
	(0.0134)		(0.0127)		(0.0163)		(0.0182)	
Purpose: Vacation and other private reasons	0.0037		-0.0194		0.0477	***	-0.0319	**
	(0.0100)		(0.0118)		(0.0156)		(0.0155)	
Purpose: Visits	0.0383	***	-0.0055		0.0279	*	-0.0606	***
Revenue decile	(0.0100)		(0.0117)		(0.0153)		(0.0152)	

p<.01, ** p<.05, * p<.10

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