Modeling the Logistics Sector in Catalonia

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Introduction

Maz Nadjm

MIT Influencer
Forbes Top 50 Social Media Influencers
UK Head of Global Media Ogilvy Group

Maz Nadjm
Dear Mr. Nadjm,

Britain's vote to leave the European Union will severely affect your operations in the United Kingdom. Probably you will already check the feasibility to move your company to a location right in the heart of the European Union.

Therefore, I would like to direct your attention to the dynamic economic location Berlin.

Berlin is not only the capital of Europe's strongest national economy but also the fastest growing state in Germany. During the last four years global companies moved their EMEA headquarters to Berlin. Other multinationals opened up Shared Service Centers, Global Labs and Digital Units.

Berlin is an international open-minded city attracting highly qualified talents from all over the world. The Start-up community number one in Europe is based here. Berlin was again ahead of London and other EU startup hubs in terms of financing rounds and investment sum in 2015.

The city is tech-driven. The strong expertise in the sector of digitization is an asset a lot of global players already taking advantage of. Prestigious research institutions of applied sciences, renowned universities, provide excellent opportunities for co-operations that create added value.

The political institutions of the German capital are next door.

I am sure that we can not only offer publicly funded programs as an incentive to relocate in Berlin. We will also be able to offer the tailor made solution which serves exactly the needs of your company.

The staff of the Senate Department for Economics, Technology and Research will be available for your team at any time to offer the support needed. For an initial contact the head of my industry department, Mr. Hans-Georg Kauert, will be happy to meet your team. His contact details are attached as well as further contact information of public institutions that will provide help in the onboarding process.

Please feel free to contact me in person. It will be a pleasure to get to know you personally.

Yours sincerely,

Senator for Economics, Technology and Research
Introduction
Introduction

The world got flat… [obsolescing] geography, distance or, in the near future, even language.
The reality is that DISTANCE MATTERS… A LOT
Introduction
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Catalonia is the main logistics center not only in Spain, but throughout southern Europe and the Mediterranean due to its strategic location, its complete infrastructure network and the high level of service provision of logistics companies.
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The economic weight of the logistics sector in the Catalan economy as a whole is quite significant. According to Pimec Logística (2018), in 2018, the logistics sector represented 12.3% of Catalan GDP.
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The economic weight of the logistics sector in the Catalan economy as a whole is quite significant. According to Pimec Logística (2018), in 2018, the logistics sector represented 12.3% of Catalan GDP.

The activities of transport and storage land, sea and air amounted to more than 27,000 million euros.
HOWEVER…

YOU CANNOT MANAGE WHAT YOU CANNOT MEASURE
This project, based on the actual (observed) data, allows us to obtain an overview of the movement of goods in Catalonia by adding detailed information available at the road segment level for a better understanding of Catalan logistics.

The ultimate goal is to allow an improvement in decision making.
CONTEXTUAL DATA
The volume of imports, in tons, was higher than that of exports during the period analyzed in that report.

Imports were 1.5 times higher than exports during those four years, thus presenting a deficit balance.
Balance of Trade by Transport Type

Contextual Data

By road and by air, the volume of imports and exports is very similar. That is, the trade balance of products transported by road and by air has a balanced balance.

Fuente: Idescat. (2019). Datos del COMEST (Comercio con el extranjero).
In the case of rail and mainly maritime transport, there is a greater volume of imports than exports.
While Barcelona and Tarragona (both with important ports) present the same pattern of the Catalan aggregate scenario, that is, imports exceed exports in tons…
...Girona and Lleida (without access to the sea) show an opposite evolution. In these two provinces, the trade balance measured in tons is inverted and presents a deficit balance.
It is observed that the number of trucks that move between Catalonia and Aragon varies (in working days) from around 800 vehicles per day at the beginning of 2016 to 1,400 at the end of 2018.
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If a shorter period is analyzed in detail, we can see the traffic fall on the AP-2 motorway on Saturday and, especially, on Sunday.
Although they show a similar pattern, the traffic volume is four times more intense in the France direction than towards Valencia.
C-16, C-17, C-25 and C-35

Contextual Data

Número de camiones en C-17 (2015-2018)

Número de camiones en C-25 (2015-2018)

Número de camiones en C-35 (2015-2018)

In the figures based on the data provided by Cedinsa we see the same pattern of truck movement that was observed in the AP-7 and AP-2, that is, a constant level with a slight upward trend (more intense in the case of C-25) during the last years and seasonal falls in January and August.

Contextual Data

Número de camiones en C-16 (2015-2018)

C-16, C-17, C-25 and C-35

Contextual Data

Número de camiones en C-16 (2015-2018)

The graph presents the weekly pattern already observed of truck movement on the roads. Both on the roads managed by Abertis and those managed by Cedinsa, during weekends, truck traffic is reduced by more than 70%.

METHODOLOGY
In some selected points of the road network of Catalonia there are stations that count the number of trucks that pass daily through that section. Cedinsa and the Generalitat of Catalonia were the main providers of this data. The ports of Barcelona and Tarragona also have counters at their main exterior doors.
Abertis manages the AP-7 and AP-2 toll roads, and both have toll stations. We have used the data obtained by adding the count of trucks that pass through each pair of stations combining these flows of origin-destination with the total number of trucks that pass through a given point.
Geolocated Data

Methodology

To connect all the information and represent it later on a real map, a road frame was needed. The road network was downloaded from the open-source OpenStreetMap (OSM) project, in ESRI-Shapefile format.

The data not only contains the geolocation of the roads, but also has other relevant information, such as maximum speeds, type and road reference, etc.
Geolocated Data

Methodology

We use this data to build a graph with nodes and arcs that connect all A-B origins and destinations (municipalities and entrances and exits), with innovative methods and our own functions, to preserve directional information and connectivity.
Shortest Paths

Contextual Data

\[ \vec{I} (A \rightarrow B || P_1) = [1De, 1Iz, 3De, 2Iz, 1De, 1Iz, 1De] \]
Shortest Paths

Contextual Data

\[
\vec{I} (A \rightarrow B \parallel P_1) = [1\text{De}, 1\text{Iz}, 3\text{De}, 2\text{Iz}, 1\text{De}, 1\text{Iz}, 1\text{De}]
\]

\[
\vec{I} (A \rightarrow B \parallel P_2) = [6\text{De}, 3\text{Iz}]
\]
Shortest Paths

Contextual Data

To represent and geolocate each route of A B (whatever the two points in the network), all possible routes had to be evaluated. Each route chosen was the result of minimizing the amount of time it takes for a truck to cross it when there is no traffic (so that the speed limit for heavy vehicles given by road data can be applied).

The result of calculating the algorithm for each route of A-B is the matrix of shorter routes $M$. For example, if the shortest route (SP) of the route from La Junquera to Barcelona passes through the AP-7 road, the arcs that represent the part of the AP-7 used will be equal to 1, and 0 for which represent all the roads that were not used. Formally represented as follows:

$$M_{j,i} = \begin{cases} 0, & \text{if } j \notin SP_i \\ 1, & \text{if } j \in SP_i. \end{cases} \forall j \in A, \forall i \in R.$$
Shortest Paths

Contextual Data
Shortest Paths

Contextual Data
Shortest Paths

Contextual Data
**Estimations**

Methodology

Given these data, we had to make an inference about the actual traffic that goes from A B every day.

For each day, we perform a different estimation process, using a linear programming model.
Estimations

Methodology

Given these data, we had to make an inference about the actual traffic that goes from A to B every day. For each day, we perform a different estimation process, using a linear programming model.

THESE OPERATIONS RESULT IN MORE THAN

5.000.000 DATA POINTS
**Estimations**

**Methodology**

IMPORTANT NOTE: Since the model tries to distribute all the trucks that pass through the borders and the origin and destination data refers only to foreign trade, 

**internal traffic is invisible**

The Observatori de la Logística de Cimalsa estimated, in 2018, that internal truck traffic in Catalonia is around 45% of total traffic, so the results we will present should be interpreted as corresponding to the 55% of total truck traffic.
RESULTS
One of the most important results of the model is that **traffic is very clearly concentrated** in the first four positions in a quasi-exponential distribution.
Overall Results

Results

This means that much of the internal traffic has a special presence on roads such as the B-10 (Ronda Litoral de Barcelona), the AP-7, the C33 and the N-2.
Overall Results

The seven road segments corresponding to the B-10 accumulate more than 5,000,000 trucks during the 2016-2018 period.
Overall Results

Results
Overall Results

Results

The B-10 stands out from the rest of the roads, especially between 2017 and mid-2018.
In contrast, as of mid-2018, the C-33 takes on special importance, although always below the B-10 values.
The N-2 and C-25 also follow an upward trend, although at a lower speed. Finally, the AP-7 remains relatively stable over the years, with values ranging between 7,000 and 10,000 trucks per month.
Entries and Departures through Catalan borders

Results - Trucks heading to France

Número estimado de camiones que se dirigen a Francia por las 5 principales carreteras

Snow Storm (AP-7 was closed)
Entries and Departures through Catalan borders

Results – Trucks coming from France

Número estimado de camiones que vienen de Francia por las 5 principales carreteras
Entries and Departures through Catalan borders

Results – Trucks heading to Aragón

Número estimado de camiones que se dirigen a Aragón por las 5 principales carreteras
Entries and Departures through Catalan borders

Results – Trucks coming from Aragón

Número estimado de camiones que vienen de Aragón por las 5 principales carreteras
Entries and Departures through Catalan borders

Results – Trucks heading to Valencia

Número estimado de camiones que se dirigen a Valencia por las 5 principales carreteras

Carreteras
- AP-7
- C-14
- C-1415c
- C-352
- LV-2021

Fechas
- 01/2019
- 06/2019
- 01/2018
- 12/2019

N. de Camiones
Entries and Departures through Catalan borders

Results – Trucks coming from Valencia
Entries and Departures through Catalan borders

Results – Trucks heading to Tarragona’s port

Número estimado de camiones que llegan al puerto de Tarragona por las 5 principales carreteras

Carreteras
- A-27
- AP-7
- B-30
- C-1410c
- C-352
Entries and Departures through Catalan borders

Results – Trucks coming from Tarragona’s port

Número estimado de camiones que salen del puerto de Tarragona por las 5 principales carreteras

Fecha

N de Camiones

Carreteras
- A-7
- AP-7
- BV-5105
- N-340a
- TV-3148
Entries and Departures through Catalan borders

Results – Trucks heading to Barcelona’s port

Número estimado de camiones que llegan al puerto de Barcelona por las 5 principales carreteras
Entries and Departures through Catalan borders

Results – Trucks coming from Barcelona’s port

Número estimado de camiones que salen del puerto de Barcelona por las 5 principales carreteras
Interactive Map

General Results
Interactive Map
Filter by Origin

Truck Flows
Date:
17-11-23

Origin
France

Type
All

Submit
Interactive Map

Road Segment Information

Catalonia Logistic Map  Truck Flows

Trucks: 3259
Estadons: Aforament: NA
Ref: 6P-7

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CONCLUDING REMARKS
Concluding Remarks

The contribution of the project is twofold:

• **Determining the number of trucks that circulate on each segment on a daily basis.** Although it might seem obvious that some roads were the main ones for the transport of goods, thanks to the model, the number of trucks that circulate on them can be established and thus compare the magnitude of the differences between the different roads.

• **Granularity:** as we have stated previously, the Catalan road structure is made up of more than 5,000 sections of road, so that, for one person, it is impossible to know each and every one of the sections. Thanks to modeling, we have created a database that can be explored in detail, municipality by municipality, section by section, to identify potentialities, possible problems and contextualize existing data through comparatives. This is of great importance for decision making.
Future Steps

This project is a demonstration that we achieve a greater knowledge about our infrastructure based on new methodologies like Big Data or Machine Learning.

Nowadays we have greater computing capacity, greater data availability and improvements in the calculation processes and algorithms.
Future Steps

This opens the doors to analysis that were previously impossible to perform due to lack of resources in one of the three aspects indicated. Therefore, we propose the following steps:

- Geographic expansion of the model
- Better data: Internet of Things
- More data: GPS traces

The benefits obtained with this type of analysis far outweigh the costs of abandoning old information systems and adopting new methodologies based on big data, artificial intelligence or machine learning.
Future Steps

The time has come for organizations to go one step further and focus on data-driven management.