Travel Times and Basic GTCs between Spanish Provinces circa 1867 and Geolocation of Railway Stations and Stops (1848-1930)

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Related publications: Sáiz, Patricio and Zofío, José Luis (2020): The Making and Consolidation of the First National Trademark System: Diffusion of Trademarks across Spanish Regions (1850–1920), *Papers in Evolutionary Economic Geography*, 20.60, Utrecht University. http://econ.geo.uu.nl/peeg/peeg2060.pdf.

ABSTRACT:

We provide a first estimation of ground travel times between Spanish provinces circa 1867 (with a basic indicator of generalized transportations costs [GTCs]) and the geolocation of railway stations and stops between 1848 and 1930. This is work in progress that will be periodically updated with new times and GTCs estimations (for other years), new stop geolocations, and/or data correction when necessary.

1. Introduction

This study provides a first approach to the estimation of ground travel times between Spanish provinces and generalized transport costs (GTCs) circa 1867 as well as to the geolocation of railway stations and stops between 1848 and 1930. Concerning travel times and GTCs, we are aware of the difficulties of constructing these kinds of estimations due to the scarcity of reliable historical data on, for instance, travel frequencies between main railway stations, actual fares for each company/good, or cabotage shipping times and costs. Thus, our estimations are just a first proxy that notwithstanding its partial character, may be very useful to other researchers. Likewise, the geolocation of railway stations and stops was developed following a straightforward method based on open sources/publications and geolocation tools that may be prone to errors. In fact, there are small geolocation conflicts depending on the tool used, the changing names of the stops, etc. In these cases, we have checked and selected the more plausible option. We will acknowledge comments, suggestions and corrections to improve next versions of these series. Therefore, this paper and accompanying dataset will be periodically updated on-line with new or corrected figures. The next sections explain the methods followed to calculate the travel-time matrix, to construct a basic indicator of GTCs, to geolocate the stations and stops, and, finally, to share the results.

2. Travel-Time Matrix between Provinces and GTCs in Spain circa 1867

GTCs define as the minimum cost of transporting goods or individuals from an origin to a destination, considering the network of transport infrastructure (from a historical perspective railways, ancillary roads, and cabotage shipping) and the time and distance economic costs associated to the optimal itinerary between the two locations. GTCs represent the most sophisticated definition and measure of transport costs, surpassing its rough proxies associated to alternative measures of distance and time, particularly in times series analysis where transport cost can vary over time due to investment in infrastructure and changes in economic costs (e.g., labor and energy inputs). For the definition and calculation of GTCs indices, see Zofío et al. (2014). GTCs represent a key variable in economic geography when explaining market accessibility (Persyn et al., 2020), trade flows through gravity equations (Zofío et al., 2020), or the location of economic activity based on the postulates of new economic geography (Teixeira, 2006).

Indeed, it is the unavailability of the statistical information required for their calculation what forces researchers to adopt inferior definitions of transport costs in regional and urban studies where this explanatory variable is required. While GTCs are currently available for EU regions, including Spain, covering recent years (Persyn et al., 2020), there is a gap from a historical perspective covering longer periods of time. The reason is, again, the enormous difficulties to gather and organize the data and information required to build the index, due to the scarce of sources and statistics. In fact, we have not been able to surpass this problem and what we offer here is a first basic proxy of ground GTCs in mid-nineteenth century (as there are not enough data to incorporate the alternative of cabotage shipping between coastal provinces).[1] The aim is not only to offer historic GTCs calculations between Spanish provincial capitals to scholars interested in economic geography, but also to encourage for its improvement and to provide methodological guidelines that can be adopted for studies in other countries and time periods.

To calculate the basic GTCs in Spain in 1867, we computed the least expensive itinerary, normally corresponding to the shortest travel time by ground transportation, between the capital cities of the 47 Spanish provinces located in the Iberian Peninsula.[2] We used detailed maps of the railway and ordinary road networks, as they existed in 1867 and

[1] Although the calculation of GTCs includes the choice of the least cost mode of transportation, and it is likely that a significant share of overall freight between coastal locations was shipped by sea, we do not have information of cabotage travel times and costs. This rules out the possibility of identifying this mode of transportation as the best alternative for freight flows between provincial capitals having ports or seaworthy waterways (i.e., Seville).

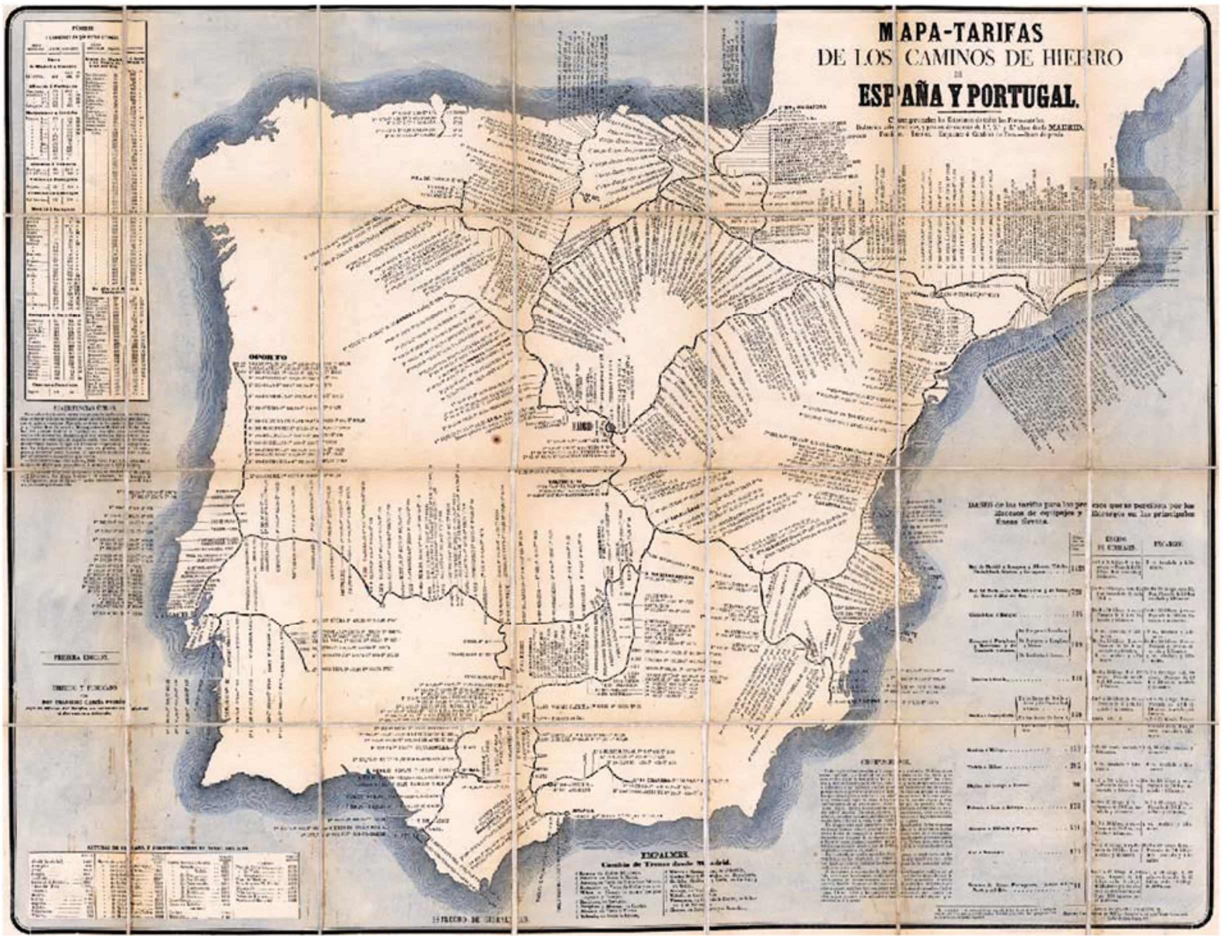
[2] Consequently, the Canary Islands and Balearic Islands, as well as the cities of Ceuta and Melilla, are excluded from our analysis because they were reachable only by sea.

1876 respectively (Figures 1 and 2).[3] Our methodology calculates the optimal itinerary that minimizes the transportation costs between two locations (see Zofío et al., 2014); in general, this implies the use of the railway network when possible as the road network was undeveloped (Gómez & San Román, 2005). However, several provinces lacked this infrastructure in 1867, so both passenger and freight shipping required road transportation to complete trips.

For rail travel, we analyze railway distances and travel times between Madrid and the capitals of each connected province in 1867, following Cabanes and González (2009). Then, we construct the 47x47 travel-time matrix for all the provinces from contemporaneous sources, specifically from a map that gives distances for railway lines in kilometers (Figure 1). We estimate the best routes for each pair of province capitals: several itineraries were calculated through Madrid (north to south, east to west) as the center of the radial railway system, but most routes were estimated using shorter sections through key network hubs crossed by extant lines or railway companies. By knowing the distances and travel times between Madrid and the capitals of each railway-connected province, we can calculate the hours per kilometer of major rail sections (between Madrid and each province capital) and then determine the travel time corresponding to shorter sections in each route. Linking two or more of these shorter rail sections through cross hubs made it possible to reach neighboring provinces to the north, the south, and so on (without passing through Madrid). Of course, these produce theoretical travel times as actual figures will also depend on travel frequencies, stand-by times in stations/towns, and connection availability between companies, etc. which seems not easy to find and incorporate. However, we think that this first estimation is reliable enough to be used in economic research.

[3] We use a detailed 1876 map of ordinary roads as a valid representation of the network to complete the sections without railway.

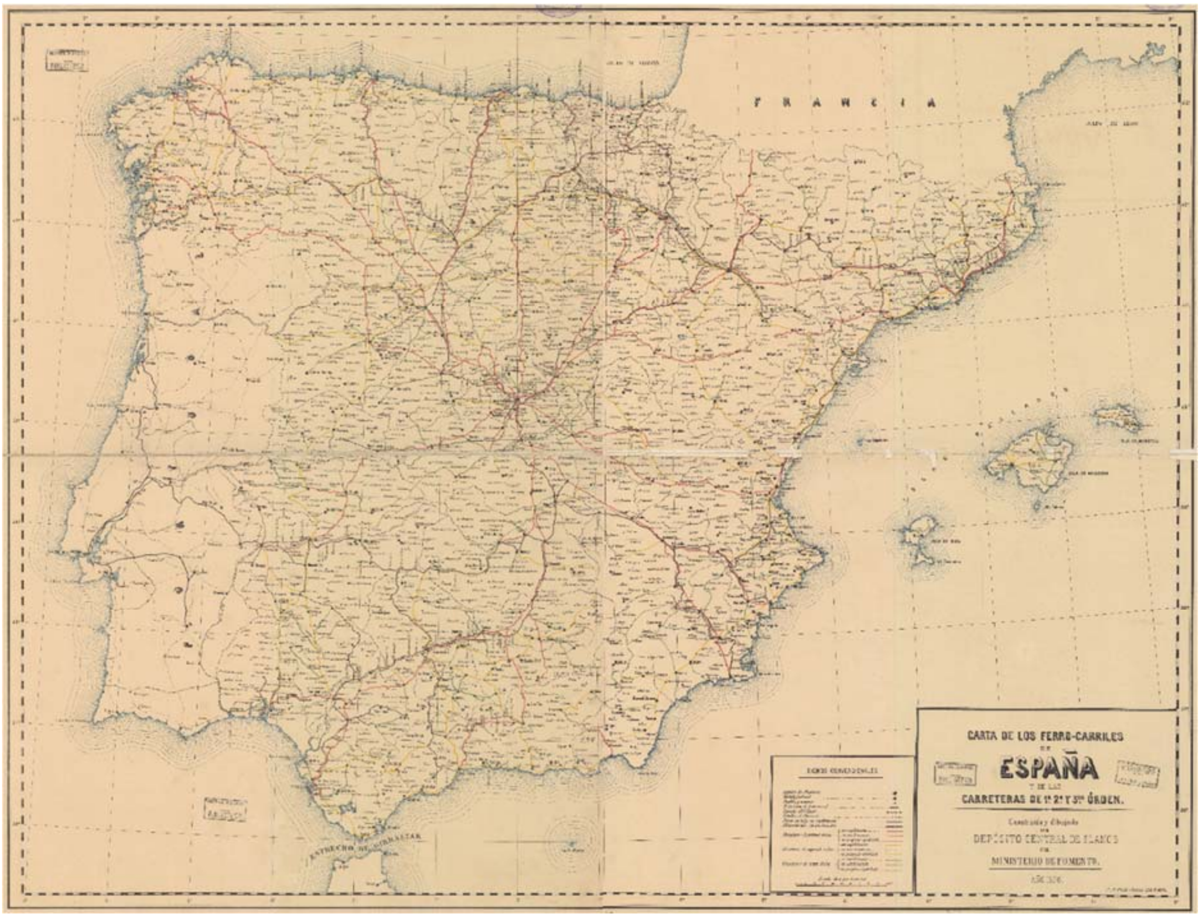
Figure 1. Railway network, Spain, 1867



Source: García Padrós (1867). See a high-quality map at:
https://artsandculture.google.com/asset/_/oQGtebN54fVeZA

When a province capital was not linked to the railway network, we calculate distances by ordinary roads from the most accessible railway stations of neighboring lines (Figure 2) and the help of GIS tools (Google Maps, QGIS, etc.). We estimate travel time for such road legs by applying a "penalty"; that is, we multiply the average hours per kilometer of the neighboring railway line by 2.5. This specific multiplier is based on existing estimates of the overall reduction in travel time via railways over ordinary roads, which has been calculated at 60% (2.5=1/[1-0.6]); Cabanes & González, (2009, p. 12). In several cases, we compare our travel time results with contemporaneous sources (*Guía oficial*, 1866) that provided road time tables for certain locations, such as Villalba to Segovia and Vimbodi to Tarragona. Our times are robust. Finally, to obtain a basic GTC in economic values, we calculate the average railway freight cost in *pesetas* per ton/kilometer at the time (Gómez & San Román, 2005, Table 7.3) to determine *pesetas* per ton/hour for each itinerary, thereby completing the bilateral matrix of GTCs. We know that railway fares were not homogeneous and that they may change depending on the company, the distance, the kinds of goods transported, or even the client, but again there is not clear data available on these price revenue management strategies and we have no better way to compute the GTCs that taking the average fare as offered in Gómez & San Román.

Figure 2. Ordinary road network, 1st, 2nd, and 3rd class, Spain, 1876



***Source*:** Ministerio de Fomento (1876). See a high-quality map at:
http://www.ign.es/web/catalogo-cartoteca/resources/html/003800.html

Finally, Tables 1 and 2 show an example of the travel-time and basic GTC matrixes between the capital cities of the Spanish provinces. The entire dataset (times, distances, and GTCs) is available in XLSX format at: https://ibcnetwork.org/e_research_resource.php?id=26. These data will be periodically upgraded (and corrected if necessary). We welcome any comments and suggestions leading to their improvement.

Table 1. Partial View of the Time-Travel Matrix between Capitals of Spanish Provinces in 1867 (hours)

	ACoruña	Alava	Albacete	Alicante	Almeria	...
ACoruña	0,00	46,80	60,65	66,85	84,89	...
Alava	46,80	0,00	28,99	28,99	47,00	...
Albacete	60,65	28,99	0,00	6,23	23,65	...
Alicante	66,85	28,99	6,23	0,00	23,72	...
Almeria	84,89	47,00	23,65	23,72	0,00	...
Asturias	32,33	32,45	46,71	52,95	70,96	...
Avila	46,96	10,46	12,30	18,53	36,54	...
Badajoz	70,30	32,41	17,79	23,77	44,99	...
Barcelona	66,46	21,50	24,97	23,28	48,62	...
Burgos	41,67	3,64	19,43	25,66	43,67	...
Caceres	74,21	36,32	21,70	27,68	48,90	...
Cadiz	79,05	41,16	23,89	29,87	35,05	...
Cantabria	49,46	17,14	29,88	36,11	54,12	...
Castellon	75,83	34,24	15,18	10,53	34,43	...
CiudadReal	60,46	22,57	7,71	13,69	34,91	...
Cordoba	68,05	30,16	15,21	21,18	25,27	...
Cuenca	64,49	26,60	10,93	16,67	34,58	...
Gerona	69,96	25,00	29,51	27,81	51,71	...
Granada	79,97	42,08	26,59	32,57	15,20	...
Guadalajara	53,71	15,82	10,26	16,49	34,50	...
Guipuzcoa	50,64	3,84	26,91	33,14	51,15	...
Huelva	82,64	44,75	29,02	35,00	39,86	...
Huesca	56,22	11,26	23,18	29,41	47,42	...
Jaen	67,62	29,73	14,59	20,57	20,27	...
LaRioja	46,90	3,65	27,26	33,49	51,50	...
Leon	32,85	12,46	27,80	34,03	52,04	...
Lerida	59,79	14,83	26,43	29,95	50,67	...
Lugo	10,86	34,45	49,80	55,99	73,99	
Madrid	52,05	14,16	8,60	14,83	32,84	...
...	...	...	...	...	...	...

Notes: Provinces with port or seaworthy waterway (Seville) are highlighted in blue. Madrid is highlighted in red as transport hub for many bilateral connections.

The entire table is available at: https://ibcnetwork.org/e_research_resource.php?id=26

Table 2. Partial View of the GTC Matrix
between Capitals of Spanish Provinces in 1867 (pts./ton.)

	ACoruña	Alava	Albacete	Alicante	Almeria	...
ACoruña	0,00	106,24	137,69	151,76	192,72	...
Alava	106,24	0,00	65,81	65,81	106,70	...
Albacete	137,69	65,81	0,00	14,14	53,69	...
Alicante	151,76	65,81	14,14	0,00	53,85	...
Almeria	192,72	106,70	53,69	53,85	0,00	...
Asturias	73,39	73,67	106,04	120,21	161,09	...
Avila	106,61	23,75	27,92	42,07	82,95	...
Badajoz	159,59	73,58	40,39	53,96	102,14	...
Barcelona	150,88	48,81	56,69	52,85	110,38	...
Burgos	94,60	8,26	44,11	58,25	99,14	...
Caceres	168,47	82,45	49,26	62,84	111,01	...
Cadiz	179,46	93,44	54,23	67,81	79,57	...
Cantabria	112,28	38,91	67,83	81,98	122,86	...
Castellon	172,15	77,73	34,46	23,90	78,16	...
CiudadReal	137,25	51,24	17,50	31,08	79,25	...
Cordoba	154,49	68,47	34,53	48,08	57,37	...
Cuenca	146,40	60,39	24,81	37,84	78,50	...
Gerona	158,82	56,75	66,99	63,13	117,39	...
Granada	181,55	95,53	60,36	73,94	34,51	...
Guadalajara	121,93	35,91	23,29	37,44	78,32	...
Guipuzcoa	114,96	8,72	61,09	75,23	116,12	...
Huelva	187,61	101,59	65,88	79,46	90,49	...
Huesca	127,63	25,56	52,62	66,77	107,65	...
Jaen	153,51	67,49	33,12	46,70	46,02	...
LaRioja	106,47	8,29	61,89	76,03	116,91	...
Leon	74,58	28,29	63,11	77,25	118,14	...
Lerida	135,73	33,67	60,00	67,99	115,03	...
Lugo	24,65	78,21	113,05	127,11	167,97	
Madrid	118,16	32,15	19,52	33,67	74,55	...
...	...	...	...	...	...	...

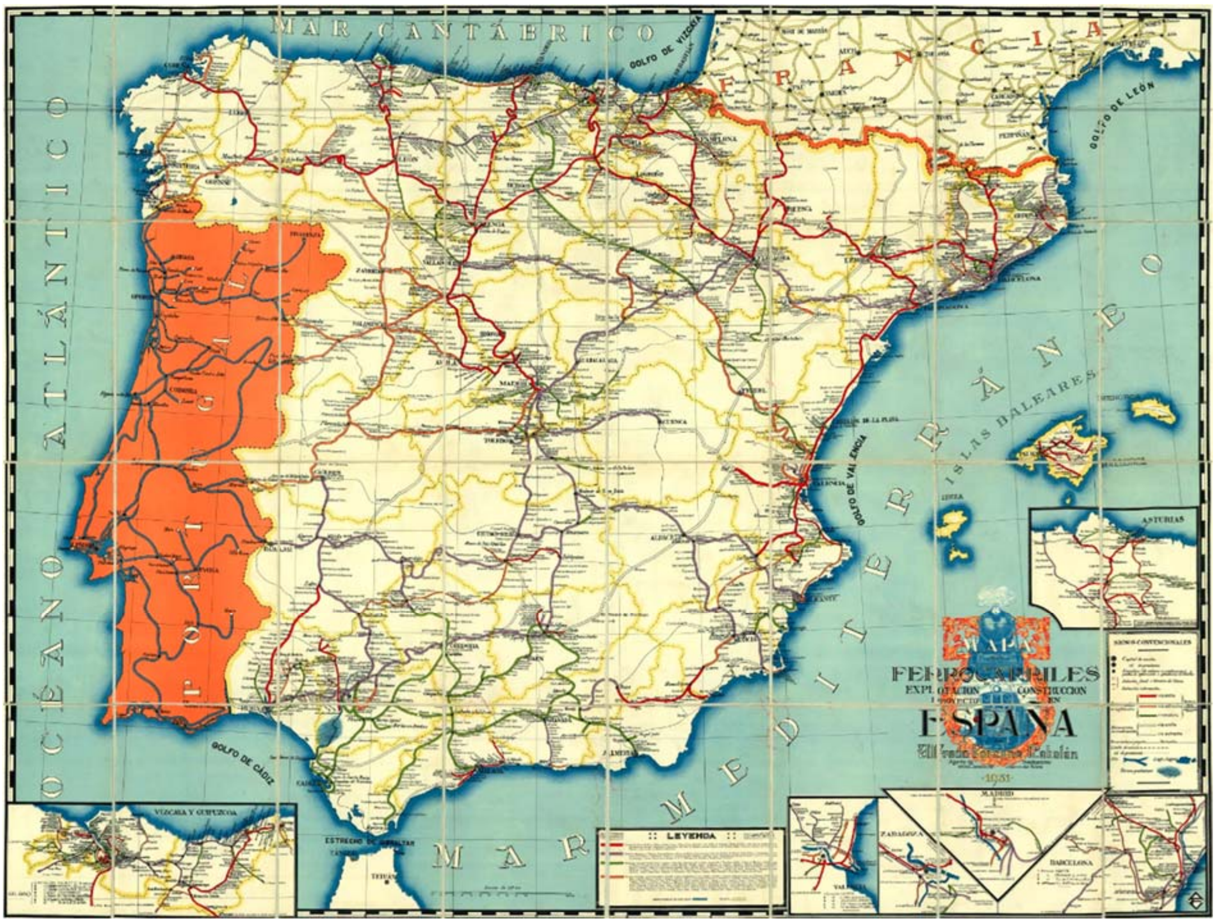
Notes: Provinces with port or seaworthy waterway (Seville) are highlighted in blue. Madrid is highlighted in red as transport hub for many bilateral connections.

The entire table is available at: https://ibcnetwork.org/e_research_resource.php?id=26

3. Geolocation of Stations and Stops (1848-1930)

The geolocation of stations and stops was mainly carried out by Sergio Barbosa. In doing so, we design a straightforward method based on the extraction of all the stations and stops available in a detailed 1931 map of the Spanish railway network including widen and narrow gauges (Figure 3). Afterwards, the station names were checked in Ferropedia, Wikipedia, and, general bibliography on the railway extension in Spain to extract the location, province, and opening date, when available. The stations and stops were geolocated using, mainly, Google Maps and Geohack.

Figure 3. Railway network, Spain, 1931



Source: Forcano (1931).

See a high-quality map at https://g.co/arts/QpufXXMm3yojfmnH8

Table 3 shows an example of the dataset containing 2449 stations/stops opened between 1848 and 1930 ordered by province, year, and location. For each one, we provide latitude, longitude, type (wide/narrow) and opening date. Although we thoroughly revised the results, they may contain geolocation or other errors that we will fix and upgrade on-line periodically at: https://ibcnetwork.org/e_research_resource.php?id=26.

Table 3. Partial View of the dataset with stations/stops opened in Spain (1848-1930)

ID	Province	Year	Location	Station / Stop	Latitude	Longitude	Wide / Narrow Gauge	Opening Date
1	A Coruña	1873	Boimorto	Casal	42,86177700	-8,58769500	N	15/09/1873
2	A Coruña	1873	Brión	Osebe	42,82525200	-8,61583800	N	15/09/1873
3	A Coruña	1873	Padrón	Esclavitud	42,78330600	-8,65041500	N	15/09/1873
4	A Coruña	1873	Padrón	Padrón	42,73905700	-8,65256000	N	15/09/1873
5	A Coruña	1873	Santiago de Compostela	Santiago	42,87076100	-8,54471800	N	15/09/1873
6	A Coruña	1875	Aranga	Aranga	43,17946900	-7,98353600	W	10/10/1875
7	A Coruña	1875	Bergondo	Guisamo	43,29191500	-8,27019800	W	10/10/1875
8	A Coruña	1875	Betanzos	Betanzos-Infiesta	43,27070000	-8,22615000	W	10/10/1875
9	A Coruña	1875	Cambre	Cambre	43,29050000	-8,35211000	W	10/10/1875
10	A Coruña	1875	Cesuras	Cesuras	43,17300100	-8,20048700	W	10/10/1875
11	A Coruña	1875	Cesuras	Oza de los ríos	43,21875900	-8,18699200	W	10/10/1875
12	A Coruña	1875	Curtis	Curtis	43,12717300	-8,14318400	W	10/10/1875
13	A Coruña	1875	Curtis	Teijeiro	43,14139200	-8,03770200	W	10/10/1875
14	A Coruña	1875	El Burgo	El Burgo - Santiago	43,31790000	-8,36868000	W	10/10/1875
15	A Coruña	1875	La Coruña	Abegondo	43,28880200	-8,32613300	W	10/10/1875
16	A Coruña	1875	La Coruña	Coruña	43,35260000	-8,40977000	W	10/10/1875
17	A Coruña	1875	La Coruña	La Frigosa	43,33515000	-8,41263900	W	10/10/1875
18	A Coruña	1875	La Coruña	Puente del Pasaje	43,33217800	-8,38371370	W	10/10/1875
19	A Coruña	1913	Betanzos	Betanzos-Pueblo	43,28420000	-8,21623000	W	05/05/1913
20	A Coruña	1913	El Ferrol	El Ferrol	43,48810000	-8,23106000	W	05/05/1913
21	A Coruña	1913	Fene	Barallobre	43,46280000	-8,18858000	W	05/05/1913
22	A Coruña	1913	Fene	Cabañas	43,41560000	-8,16884000	W	05/05/1913
23	A Coruña	1913	Fene	Franza	43,43850000	-8,19748000	W	05/05/1913
24	A Coruña	1913	Fene	Perlío	43,47240000	-8,17473000	W	05/05/1913
25	A Coruña	1913	Miño	Miño	43,34940000	-8,20731000	W	05/05/1913
26	A Coruña	1913	Neda	Neda	43,49540000	-8,16100000	W	05/05/1913
27	A Coruña	1913	Paderne	Paderne	42,25640000	-7,75311000	W	05/05/1913
28	A Coruña	1913	Perbes	Perbes	43,37820000	-8,20112000	W	05/05/1913
29	A Coruña	1913	Puentedeume	Puentedeume	43,41170000	-8,18056000	W	05/05/1913
30	...	...	...	...	...	...	...	...

The entire dataset is available at: [*https://ibcnetwork.org/e_research_resource.php?id=26*](https://ibcnetwork.org/e_research_resource.php?id=26)

4. References

Cabanes, A., & González, R. (2009). El tiempo del tren: Las velocidades comerciales en las líneas españolas desde sus orígenes hasta la actualidad. *V Congreso de Historia Ferroviaria*. https://www.docutren.com/HistoriaFerroviaria/PalmaMallorca2009/pdf/050310_Cabanes-Gonz%C3%A1lez.pdf

Forcano, E. (1931). *Mapa de los ferrocarriles en explotación, construcción y proyecto en España* [Map]. FFE. https://g.co/arts/QpufXXMm3yojfmnH8

García Padrós, F. (1867). *Mapa-Tarifas de los caminos de hierro de España y Portugal* [Map]. FFE. https://artsandculture.google.com/asset/_/oQGtebN54fVeZA

Gómez, A., & San Román, E. (2005). Transportes y comunicaciones. In A. Carreras & X. Tafunell (Eds.), *Estadísticas históricas de España: Siglo XIX-XX* (pp. 509–572). FBBVA.

Guía oficial de los caminos de hierro de España y Portugal. Indicador del viajero y del comerciante. (1866). La Iberia.

Ministerio de Fomento. (1876). *Carta de los ferrocarriles de España y de las carreteras de 1º, 2º y 3er orden* [Map]. IGN. http://www.ign.es/web/catalogo-cartoteca/resources/html/003800.html

Persyn, D., Díaz-Lanchas, J., & Barbero, J. (2020). Estimating road transport costs between and within European Union regions. *Transport Policy*. https://doi.org/10.1016/j.tranpol.2020.04.006

Teixeira, A. C. (2006). Transport policies in light of the new economic geography: The Portuguese experience. *Regional Science and Urban Economics*, *36*(4), 450–466. https://doi.org/10.1016/j.regsciurbeco.2006.01.002

Zofío, J. L., Condeço-Melhorado, A., Maroto, A., & Gutiérrez, J. (2014). Generalized transport costs and index numbers: A geographical analysis of economic and infrastructure fundamentals. *Transportation Research Part A: Policy and Practice*, *67*, 141–157. https://doi.org/10.1016/j.tra.2014.06.009

Zofío, J. L., Díaz-Lanchas, J., Persyn, D., & Barbero, J. (2020). *Estimating foreign and national trade elasticities in the EU internal market using generalised transport costs* (No. 05/2020; JRC Working Papers on Territorial Modeling and Analysis). https://ec.europa.eu/jrc/sites/default/files/jrc122414.pdf