

Fruit and Vegetables Transport Flows in South-West Europe Borders

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Received: December 14, 2018; Published: December 24, 2018

Abstract

The combined production of fruit and vegetables from Spain, France, Portugal and Morocco in 2017 is close to that of the United States, which places this group of neighboring countries, Spain included, as the fourth largest producer of fruit and vegetables in the world, being Spain the leading exporter of fruit and vegetables in the European Union. It is for these reasons that the present work analyses the international transport of fruit and vegetables across the Iberian Peninsula, from the Strait of Gibraltar, the Spanish border with Morocco, to the passes of the Pyrenees Mountains, the Spanish border with France. Since the entry into force of the Schengen agreement in 1995, there is no control along intra-European borders. Although in this context Transit type surveys may have been the best method to determine the percentage of trucks traveling from one place to another, its data processing has led to an excessive proportion of the road trade between Spain and France to the detriment of trade between Spain and the rest of Europe. The present paper seeks an alternative approach strictly based on the analysis of freight tonnage transported by heavy vehicles along international routes. The results of this research have been adapted and applied to the analysis of transport flows of fruits and vegetables in all modes of transport across all Spanish borders.

Keywords: Freight Transport Flows; Fruit and Vegetables; Production; Export and Import; Freight Transport Modes; Dynamic Weighting Road Stations; Logistics Distribution Markets

Abbreviations

EU: European Union; UN: United Nations; FAO: Food and Agriculture Organization; EFTA: European Free Trade Association; Tn: Metric Tonnes.

Introduction

Separated from Africa by the Strait of Gibraltar and located in the south-western part of Europe between the Atlantic Ocean and the Mediterranean Sea, in 2017 Spain was the leading exporter of fruit and vegetables in the European Union (EU), following FEPEX [1], exporting a total volume of 12,617,132 tonnes to the world, which is 7.3% of total Spanish exports and 32% of total domestic trade in fruit and vegetables into the European Union, followed by the Netherlands with 8.3 million Tn and 19% of intra-Community trade in fruit and vegetables, although a large part of Dutch fruit and vegetable exports are re-exports. According to UN [2], Spain is also the second largest exporter of fruits and vegetables in the

world with a monetary export of US\$ 15,441 million, after the United States with US\$ 18,422 million and followed by China with US\$ 15,420, the Netherlands with US\$ 13,003 million and Mexico with US\$ 11,837 million. Spain is also the second largest producer of fruit and vegetables in the European Union, after Italy, with 25% of EU production, being the eighth largest producer of fresh fruit and vegetables worldwide. Estimates from the latest FAO data [3] indicate that world production of fresh fruits and vegetables is around 2,355 million Tn, with world production of fruit at 965 million Tn and vegetable production at 1,390 million Tn. The world's largest producer of fruit and vegetables is China with 708 million Tn, followed by India with 180 million Tn, the United States with 72, Russia with 49, Turkey with 48, and Brazil with 46 million Tn. Italy occupies the seventh position with 34.5 and Spain appears in eighth place with 32.1 million Tn, followed by Ukraine with 32, Egypt with 31.6, Iran with 31, Mexico with 26.7, Indonesia with 22.4, Philippines with 22.2, Vietnam 22.1 and Nigeria with 21.8 million Tn

produced from vegetables and fruit. The seventeenth position is occupied by France with 20 million tonnes. Morocco ranks twenty-second with 12 million Tn (2,231 thousand Tn of citrus fruit, the rest of fruit by 4,302 and 5,516 thousand Tn of vegetables), and Portugal ranks forty-fifth with a production of 4.1 million Tn of fruit and vegetables in 2017. Spain dedicates 39.3% of its fruit and vegetable production to export, mostly to the European Union, where 93% of Spanish exports go, dedicating 60.7% of production to domestic consumption, while Portugal exports 38% of its production.

The combined production of fruit and vegetables from Spain, France, Portugal and Morocco in 2017, according to UN [2], is close to that of the United States, exceeding 68 million tonnes, which places this group of neighboring countries, Spain included, as the fourth largest producer of fruit and vegetables in the world. It is for this reason that this work analyses the international transport of fruit and vegetables across the Iberian Peninsula, from the Strait of Gibraltar, the Spanish border with Morocco, to the passes of the Pyrenees Mountains, the Spanish border with France.

Since the entry into force of the Schengen agreement in 1995 and considering that Spain and Portugal have been an effective part of the European Union since 1991, the border control between both countries and France has disappeared in order to make possible the free movement of people and goods between the signatory countries of the agreement, which are the majority of European Union countries. This fact makes it difficult to control the freight volume that passes from one country to another within the Union, which does not happen at the border between Spain and Morocco, where the respective customs offices do carry out this control. Most of the volume of freight traffic between Spain and the rest of the European Union is done by road transport. In order to estimate the freight volume crossing the border between France and Spain, France has carried out a series of surveys known as "Transit" [4,5], whose results were successively made public in 1993, 1999, 2004 and 2010, also supported by various French truck registration surveys. On the other hand, the Spanish Ministry of Public Works carries out every year the Permanent Survey of Road Freight Transport [6], which also evaluates cross-border transport. In the same sense, the French-Spanish Observatory of traffic across the Pyrenees [7,8], was created jointly between France and Spain and, from 1999 to 2018, has been responsible for regularly updating the corresponding "Transit" surveys. The Spain-Portugal Cross-Border Observatory [9] was also set up for this purpose between Portugal and Spain. On the other hand, the European Union itself has the Eurostat database [10], which collects the volume of trade among the member countries. Potentially reliable sources of infor-

mation in this field are statistics provided by certain carriers and entities: mainly railway companies, airlines, companies engaged in maritime transportation, oil pipelines, harbours and airports. Even more challenging is the estimation of the number of road operations engaged in intra-community trade. The available data for the volume of freight transported by road are provided by general directorates of customs and foreign trade reporting to the central government in the different member states; generally, these data do not exactly match reciprocal data (mirror data) for several reasons, i.e. the volume of goods received does not match the goods shipped. However, in this context, the number of operations or journeys remains the most evasive piece of information concerning freight road transport among EU countries. The purpose of the present article is to provide an estimate of freight volume in 2017 and of heavy vehicle traffic operations that specifically transport fruits and vegetables, which cross all Spanish borders by means of all modes of transport.

Materials to analyze heavy road traffic at French-Spanish borders in 2001

Approximately 22 roads cross the Pyrenean border between Spain and France. The most significant ones are (Figure 1): i) Coastal motorways A8-A63 along the Cantabrian-Atlantic coast and A7-A9 along the Mediterranean coastline. ii) Central pass roads: N1-RD912, N1-RN10, N206-RN114, N2-RN9, N135-RD933 via Roncesvalles, N330-RN134 via Comport, N230-RN125 via the Valley of Aran and N260-RN20 via Puigcerdá. On the other hand, and referred to measurements in the year 2001, the following data types were available to specifically measure traffic in tonnes of freight and operations across the Pyrenees: i) Those obtained from EUROSTAT's database [10], containing the contributions of the different European governments. ii) Data provided by national customs authorities in every country, more specifically the Spanish General Customs Directorate of the Ministry of Finance, and those found in the Foreign Trade database, integrated in the INTRASAT database. iii) Data generated by French traffic surveys Transit 1993 and 1999 [4]; the Spanish Permanent Survey of Road Freight Transport of the Ministry of Public Works [6]; and other permanent surveys carried out by EU member states among their lorries. iv) Data resulting from the French vehicle registration survey. v) Data supplied by infrastructure operators, particularly roadway operators, collected at the so-called traffic counting points and route counters.

The Spanish Ministry of Public Works and the French Ministère de l'Équipement are the official institutions responsible for handling heavy road traffic between Spain and France. However, sup-

pression of border customs as a consequence of the European Union's development process has posed increasing difficulties to exert this type of control. In consequence, the French Ministère de l'Équipement set in motion and piloted in 1993 the so-called Transit survey, a new kind of survey, more thorough than permanent measurement stations, which attempted to put an end to the existing contradictions in EUROSTAT's database concerning cross-mirror data; the survey was carried out again in 1999. Transit-type surveys are possibly the best method to ascertain the percentage of lorries going from one place to another and the use of this type of survey was adopted by agencies reporting to the French Ministère de l'Équipement, more specifically the Observatoire des trafics au travers des Pyrénées, which projected outcomes for the year 2001 in the publication entitled Bilan 2001, [11]. Another French-Spanish agency, Observatorio franco-español de los Pirineos, was founded in 1998 and published projections for the years 2000, 2002, 2003, 2006 and 2018.

The above agencies state that, in addition to Transit surveys, the most reliable indirect counters are based on measurements at Hestia-type dynamic weighting stations and data originating from toll stations located on both sides of transnational motorways. There are three types of Hestia stations: type-T stations meet the needs of counting, speed measurement and vehicle length; Hestia C stations also classify vehicles into 18 different categories according to their silhouette; and Hestias P allow for dynamic weighting of axles and vehicles. Hestias T and C may be portable. Hestias are not reliable for humidity rates above 95%, but feature $\pm 1.5\%$ accuracy rates in vehicle counting and 10%-20% in weighting. As for random sampling techniques, the most frequently used surveys are the Permanent Surveys of Road Freight Transport carried out by every European country on domestic heavy vehicles traveling along international routes. There are two Hestia P stations on French soil along the French-Spanish border: one located on coastal Basque-French motorway A-63, 19 km from the border (Biriadou-La Négresse), and another on the coastal Catalan-French motorway A-9, 8 km away from the border (Perthus-Le Boulou). The remaining traffic counting stations are based on the toll stations of French motorways, which distinguish five vehicle categories and are located 1 and 10 km away from the Basque and Catalan border, respectively. Data on both motorways are also supplied by Spanish toll stations and two French secondary data collection stations, one located 3 km from the Basque border and the other 6 km from the Catalan border. However, the data obtained from these stations are not consistent with those supplied by toll stations. Hestia traffic analysis stations have had to be updated after 2006. Additionally, the French vehicle registration survey is also taken into ac-

count. For data processing purposes, the Observatoire des trafics au travers des Pyrénées and the Observatorio Hispano Francés de Tráfico en los Pirineos discards data originating from EUROSTAT's database, as they do not match mirror data and sometimes even contradict data submitted by member states. In addition to this, only the net weight of goods is accounted for, i.e. EUROSTAT does not compute the weight of packaging or containers, its data being to a certain extent inconsistent with gross weight figures supplied by Hestias. Data obtained from the Spanish Permanent Survey of Road Freight Transport published by the Spanish Ministry of Public Works are also deemed unfit, as only Spanish lorry drivers are surveyed.

As for data processing outcomes and based on the different countings of transnational operations carried out in 2001, the Observatoire des trafics au travers des Pyrénées in its Bilan 2001, [11], refers 17,965 daily heavy vehicles on average crossing the Pyrenean border in both directions, largely based on the information provided by Hestia stations: i.e. 6,577,225 heavy vehicles during 2001. The method used by these entities to estimate the number of tons of products exchanged in transnational commerce involves multiplying the number of heavy vehicles, which in theory is obtained from the reliable count made by the Hestia stations, multiplied by the estimated average load by truck. The average load per truck at the French-Spanish borders estimated by the aforementioned institutions would amount in this case to 14.09 Tonnes/heavy vehicle in 2001, so that the number of tons that would cross the Franco-Spanish borders in 2001 would amount to $6,577,225 \times 14.09 = 92,720,950$ gross tonnes per year, classified into 46,991,925 Tn North \rightarrow South and 45,729,025 South \rightarrow North. Even though according to Bilan 2001 the data provided by the Transit 99 survey concerning the origin and final destination of goods are not particularly reliable, data processing facilitated by the Observatoire des trafics au travers des Pyrénées reveals the following: Of all goods crossing the Pyrenees by road during 2001, France is the country of origin and destination of approximately 50.6%, while the remaining European countries north of the Pyrenees are the origin or destination countries of 49.4%, except France, particularly when considering traffic along coastal motorways.

However, it is difficult to believe that gravitational laws of attraction and generation of commercial traffic are so powerful in France, even though this is a highly populated economic power of neighbouring Spain. Especially if we look at the databases on Foreign Trade and the Spanish General Customs Directorate and their export/import data, the overall volume of trade between Spain and France is approximately only 31% with respect to total trade

between Spain and the remaining European countries with a certain trade level on the other side of the Pyrenees; very far from the 50.6% estimated for road transport. These are the reasons why we have sought a new approach for the calculation of the gross tonnes that annually cross the French-Spanish borders.

An alternative methodology to typical data processing

Our first proposal would therefore be to perform: A thorough analysis of load per heavy vehicle. Once these data are known together with a reliable number of operations, the aim of this proposal is also to ascertain the number of tonnes transported. Conversely, if we know the total number of tonnes transported, we may estimate the number of operations. In our view, counting vehicles creates lesser confusion than weighting them. Only Hestia stations can weight vehicles in a reliable manner; however, only two stations of this kind are available, each located along the motorway, and there remain twenty additional border crossing points. Apart from Hestia stations, motorway toll stations and other counting points assist in the counting of vehicles. The Observatoire des trafics au travers des Pyrénées itself starts by measuring the number of operations using the above techniques and then infers the number of tonnes transported by multiplying the number of operations times the average load per vehicle. The present paper assumes as true the data coming from the Hestia stations: 6,577,225 transnational freight operations crossed the borders between Spain and France in the year 2001 but discusses the use of a single average global load per vehicle (14.09 Tn/heavy vehicle).

To infer load per vehicle, unfortunately Transit-type surveys do not provide the percentage of Spanish vehicles for each itinerary or load per vehicle, nor the international route travelled by vehicles, as French measuring stations weight lorries and record vehicle registration numbers separately, preventing us from establishing a bi-univocal correspondence between both magnitudes. To do so, it is necessary to use different data. In this particular case, the following data have been very useful: i) Statistics and Statistical Yearbook 2003 published by the Spanish Ministry of Public Works [12]. ii) Spanish Permanent Survey of Road Freight Transport by the Ministry of Public Works, years 2001 and 2002. iii) EUROSTAT's statistical database. As far as weight goes, EUROSTAT's data do not match those supplied by the other two sources, as data provided by the Ministry of Public Works are expressed in gross figures while EUROSTAT's are net figures. However, statistics published by the Ministry of Public Works are uniform and considered to be reliable.

Based on the 2003 Statistical Yearbook [12] published by the Spanish Ministry of Public Works, we may obtain gross tonnage transported individually by Spanish lorries traveling from Spain to France, Portugal, Italy and Germany, by dividing, to the 2001 year, the number of transported tonnes by the number of operations. Similarly, we may obtain gross tonnage transported on an individual basis by Spanish lorries going from Spain to France, Portugal, Italy, Germany, Belgium, Denmark, Greece, Ireland, Luxembourg, Netherlands and the United Kingdom, by dividing, to the 2001 year, the number of transported tonnes by the number of operations. Load per heavy vehicle in road transport across the Pyrenees to countries outside the European Union is yet to be determined until the exact number of operations and thousand tonnes exchanged is known. To determine freight transport between countries exchanging more than 1000 Tn south (Spain, Portugal, Andorra, Gibraltar, Morocco, Algeria and Tunisia) and north of the Pyrenees, including non-member countries, EUROSTAT's statistical database was used, despite the fact that data are provided in net tonnes. Since both the statistics supplied by the Ministry of Public Works and EUROSTAT refer to exchanges of freight (tonnes) by road across the European Union and knowing that some are expressed in gross figures (packaging included) while others are expressed in net tonnes (without packaging), we may convert gross tonnes into net tonnes and vice versa.

Determining the number of international operations is more difficult than estimating tonnage. The Spanish Ministries of Public Works [12] and Finance only provide data on operations carried out by Spanish lorries, not foreign lorries. Apparently, no other data are available. The only significant flows that remain unknown are those between Spain and France and Spain and Portugal, as flows into non-member countries may be estimated based on bilateral travel permits to non-member countries under the assumption that there must be a certain proportionality between the number of journeys and the number of permits, and based on the data contained in the statistical yearbooks published by EFTA countries: "Comerce extérieur de la Suisse avec l'Europe 2003", published by the Direction Générale des Douanes Suisses [13], and "Statistics Norway, Statistical Yearbook 2004" [14]. Since the Statistical Yearbook published by the Ministry of Public Works [12] reports 3,200,000 operations by Spanish heavy vehicles, whether crossing the Pyrenees or not, and overall transit by third countries across Spain in 2001 was 801,657 operations by heavy vehicles, there are two other significant areas that may help determining the number of international operations across the Pyrenees: the

number of trips between Spain and Portugal and between Spain and Europe with Morocco. These may be inferred from the following statistical yearbooks: "Statistics Portugal" [15], published by the Portuguese National Statistics Institute, and "Le Maroc en Chiffres" [16] supplied by the Direction Statistique del Ministère de la Prévision Economique et du Plan de Maroc. In addition, from the Hestia stations, we also know that in 2001 there were 6,577,225 international operations across the Pyrenees.

However, the main problem revolves around the estimation of operations carried out by Spanish vehicles involved in road freight transportation between Spain and France; this figure remains unknown. Several cross-section regressions and panel data techniques have been used to try and ascertain these data. These have been applied to a small sample of countries for whom data are available. Considering the ratio of foreign/Spanish operations as an endogenous variable, after testing several explanatory variables, we found a relation between the endogenous variable and i) the ratio of foreign/Spanish heavy vehicles and ii) the ratio between the share of trade (adding in US\$ exports plus imports) of foreign countries and Spain. Cross-section regression with limited information maximum likelihood (LIML) estimates and panel techniques based on ordinary least squares estimations with error auto-correlation by means of a first order auto-regressive process have yielded a percentage of Spanish operations in road freight transport with France of 58.9%, and barely 38.6% between Spain and Portugal.

Once the total tonnage of each itinerary and the corresponding number of operations are known, to estimate the load per heavy vehicle involved in international freight transportation in 2001 across the Pyrenean borders, we divide total tonnage for each itinerary by the number of operations. The results are shown in Table 1 and the itinerary aggregation of these results coincides with the global data provided by EUROSTAT. According to EUROSTAT's statistics, for the sample of countries trading by road more than 1000Tn across at least one of the French-Spanish borders, total tonnage traded in both directions by heavy vehicles crossing the French-Spanish borders in 2001 rose to approximately 69,000,000 net tonnes. Since according to the most reliable data available, those related to the countries of the EU, we can infer that the proportion of gross to net tons transported is 1.334; that is, 25% of the weight for the total load corresponds to the weight of the packaging and other materials. Thus, if total tonnage crossing the Pyrenean borders in 2001 amounted according to EUROSTAT to 69 million net tonnes, the total number of gross tonnes transported will amount to 92,064,000.

According to these results, we consider that the total gross tonnes of freight crossing the Pyrenees by road in international transport operations is 92,064,000 Tn, of which 79,874,000 (86.7%) originated from or were shipped to Spain; 11,424,000 (12.4%) originating from or shipped to Portugal; and 727,000 (0.8%) originated from or were shipped to Morocco. Of those 92,064,000 Tn of goods crossing the French Pyrenean border, 39.3% originated from or were shipped to France. Total tonnes of goods transported abroad by road with origin or destination in Spain amount to 95,879,000 Tn, approximately one third of those originating from or being shipped to France (34.3%). Therefore, the percentage of tonnes with origin or destination in France crossing the Pyrenees is barely 39.3% of the total, and not 50.6% established by the Observatoire des trafics au travers des Pyrénées, since the average load of vehicles transporting goods between Spain and France is barely 12.85 Tn/vehicle, no 14.09, which is the average of all heavy vehicles crossing the Franco-Spanish borders. The Transit methodology overestimates the volume of trade between Spain and France to the detriment of trade between Spain and the European Union.

Freight flow analysis through Spain in 2017

Based on estimates from the Observatory of Transport and Logistics in Spain [17], discounting air and sea transits through Spain from third countries and pipelines traffic, in 2017 the total volume of goods transported through Spain was 1839 million tonnes, of which, the Spanish internal flow of goods was 1405 million Tn while the flow of transport for the Spanish export was 173 million Tn and that of imports was 248 million Tn. In other words, the total volume of goods transported internationally to or from Spain was 421 million Tn in 2017, of which 121 million Tn were transported by road, 4.5 million Tn were transported by rail, 294.7 million Tn were transported by ship and 0.8 million Tn by air. The flow of transit between third countries through Spain by road and rail amounted to approximately 13 million Tn, with 12,981,793 Tn of goods transported by road in transit through Spain, while 73,107 Tn of goods were transported by rail in transit through Spain. The Spanish internal road freight transport in 2017 amounted to 1,266,685,560 Tn, while rail transported internally 22,853,470 Tn of goods. The Spanish internal air freight transport in 2017 was 64,218,970 Tn and the volume of Spanish domestic maritime cabotage freight transport in 2017 was 51,588,000 Tn.

The results of our analysis based on the aforementioned methodology show that in terms of the modes of transport by which all Spanish exports of goods are carried out, 39.8% are transported by

To / From	Spain Origin Spanish Vehicle	Spain Destination Spanish Vehicle	Spain total Spanish Vehicle	Spain total Foreign Vehicle	Spain	Portugal	Morocco
Germany	15.50	15.50	15.50	14.41	14.78	15.31	15.00
Italy	16.99	14.65	15.72	13.52	14.15	15.27	15.41
France	10.51	13.03	11.80	14.36	12.85	15.27	15.10
United Kingdom	16.87	13.00	15.66	14.40	14.86	15.51	14.60
Netherlands	17.52	16.19	16.80	14.33	15.29	15.50	14.50
Belgium	14.26	17.53	16.11	14.29	15.01	15.24	17.00
Luxembourg	18.00	13.33	16.25	14.15	14.77	15.00	—
Ireland	—	—	13.00	14.50	14.38	7.00	7.00
Austria	—	—	16.30	13.95	14.48	16.06	—
Greece	—	—	15.00	16.00	15.66	17.00	—
Czech Republic	—	—	17.00	13.96	14.92	16.33	—
Hungary	—	—	16.28	13.90	14.83	14.50	—
Poland	—	—	15.57	13.38	14.68	14.00	—
Slovenia	—	—	17.00	15.00	15.66	—	—
Slovakia	—	—	13.00	16.00	14.50	—	—
Sweden	—	—	15.66	14.22	14.45	15.60	—
Denmark	—	—	16.70	14.32	14.71	15.83	—
Finland	—	—	16.62	14.28	14.72	12.50	—
Norway	—	—	17.00	13.00	14.33	9.00	—
Switzerland	—	—	15.85	14.66	15.40	16.20	12.00
Bosnia	—	—	14.00	—	14.00	16.00	—
Croatia	—	—	14.00	16.00	15.00	—	—
Romania	—	—	13.00	16.00	14.50	—	—
Bulgaria	—	—	12.00	11.00	11.50	—	—
Morocco	—	—	6.75	7.33	7.10	7.66	—
Portugal	13.13	6.45	9.85	9.84	9.84	—	7.66

Table 1: Freight road transport. Average load per truck in 2001: Tn/heavy vehicle.

Source: Own elaboration.

road, including roll-roll transport between Algeciras (Spain) and Tanger-Med (Morocco), since in 2017 Spain exports 68,861,900 Tn of goods by road; by rail Spain exports 2,709,242 Tn of goods, i.e. 1.6% of all tonnage of goods exported; by sea, excluding roll-roll traffic, Spain exports 100,752,000 Tn of goods (58.4%) and by air Spain exports 409,371 Tn (0.2%). With regard to imports of goods, in 2017 Spain imported 21% of total imports by road, i.e. 52,117,000 Tn of goods, including roll-roll transport; 1,749,658 Tn (0.7%) were imported by rail; 193,828,000 Tn (78.1%) were imported by sea, excluding roll-roll traffic, and 380,497 Tn (0.2%) were imported by air.

The international transport of goods on Spanish roads, consisting of Spanish export and import plus transits between third countries is carried out on average by 27,542 trucks per day, including empty trucks, with an average load of 13.33 Tn each. Based on [6,8,17,18] the tonnes of goods that crossed the borders between Spain and France by road in 2017 were a total of 106,687,686 (see Table 2) of which 60,913,993 Tn were transported South → North and 45,773,893 Tn were transported North → South. The main border crossings between Spain and France are located on the western (Biriattou) and eastern (Perthus) sides of the Pyrenees Mountains, near respectively the Atlantic Ocean (Biriattou) and the Mediterra-

nean Sea (Perthus). The two coastal motorways that connect Spain and France pass through both border points: the A9-A7 via Perthus and the A63-A8 via Biriattou. 49.8% of the freight volume transported by road in the South → North direction passes through the Perthus border post to France and 47% through Biriattou.

The border crossings between Spain and France are on average crossed daily in both directions by 20,482 lorries, with an average load of 14,25 Tn each, of which 1,602 lorries per day cross the central French-Spanish crossings of the Pyrenees: 498 in the South → North direction and 1104 in the North→South direction. On average, 9,102 lorries circulate daily along the western border of Biriattou, while 9,778 lorries circulate daily along the Fraenche-Spanish eastern border of Perthus, of which 5,068 go in the direction to France and to the other countries of the European Union, except Portugal, with an average load of 16.4 tonnes each. From Spain to Portugal 12,742,300 Tn of goods were transported by road in 2017, while from Portugal to Spain 9,851,900 Tn of goods were transported by road annually. The border points between Spain and Portugal are crossed daily on average by 9,184 trucks in both directions with an average load of 10 Tn each, of which 349 trucks daily transport fruit and vegetables. The Spanish-Portuguese border crossings that supported the most freight traffic was Fuentes de Oñoro, with 2,058 trucks per day, Badajoz with 1,845 and Tuy, with 1,746 trucks per day loaded with freight.

Year	All Freight		Fruit and Vegetables
	2001	2017	2017
Tn transported in both directions	92,064,000	106,687,686	13,620,912
Average daily trucks in both directions	17,965	20,482	2,412

Table 2: Freight road traffic in all French-Spanish borders 2001-2017.

Source: Own elaboration.

Following [16,19], in 2017 the Strait of Gibraltar, between Morocco and Spain, was crossed daily in both directions, between the Moroccan port of Tanger-Med and the Spanish port of Algeciras, by 916 trucks in roll-roll regime, loaded on average with 21 Tn each, which implies an annual traffic of 7,054,000 Tn of goods that crossed the Strait between Morocco and Spain, of which 3,636,000 Tn are in the South → North direction and 3,418,000 Tn are in the North → South direction. A small part of this roll-roll traffic, 76,000 Tn, crosses the strait in both directions from the port of Tanger-

Med to the Spanish port of Motril by means of 10 daily trucks loaded with 20.8 Tn of goods each. The international freight transport from or to Spain by sea reaches a volume of 301,634,000 Tn (78% of the volume of Spanish international trade in goods), including roll-roll transport. Spain provides international roll-roll cargo transport between the ports of Algeciras and Tanger - Med (Morocco), Motril and Tanger-Med, Santander-Plymouth and Portsmouth (United Kingdom), Santander-Cork (Ireland) Bilbao-Portsmouth (United Kingdom) and Barcelona-Genova (Italy). From Spain, the international freight trade by sea is basically carried out from the Spanish port of Algeciras, in the Strait of Gibraltar, 4th European port and 25th worldwide in commercial traffic which, in this order, is mainly used by Morocco, Spain, China, the United States and Nigeria. The next Spanish ports preferably used for international freight traffic are the Mediterranean ports of Valencia, 5th European port and 26th worldwide, and Barcelona, 11th European port in freight traffic. With regard to international rail freight transport on the Iberian peninsula in it should be noted that in 2017, according to [9,20] the volume of goods transported by this means was much lower than by road mode: 4,532,007 Tn, including transits between France and Portugal, compared to 133,960,493 Tn for road mode, which includes Spanish exports and imports by road and road transits between Portugal and France, Portugal and Morocco, plus road transits between France and Morocco. Therefore, international rail freight transport over Spain accounts for only 3.3% of international land freight transport and 16.5% of total rail freight transport. The volume of rail freight traffic crossing the border between France and Spain is only about 400 freight wagons per day. This is partly due to the different track gauge of the railways of Spain and Portugal (1,668 mts) compared to the track gauge of most European countries (1,435 mts), which forces the trans-shipment of goods in the only two rail crossings between Spain and France: Hendaye, on the side of the Atlantic Ocean and Port-Bou on the side of the Mediterranean Sea. Spain exports 2,709,242 Tn of goods by rail to the rest of the European Union countries, and imports 1,749,658 Tn by rail. Rail transit between Portugal and France, which passes through Spain, amounts to 73.107 Tn. The volume of international freight traffic on the French-Spanish western rail frontier at Hendaye is lower (43.4%) than on the eastern Port-Bou crossing (56.6%). From [21], we can deduce that the volume of goods transported by rail only between Spain and Portugal is 38% of the international freight transport by rail in the Iberian Peninsula, probably due to the fact that both countries have the same track gauge. In the Spain → Portugal direction, 1,253,242 Tn of goods were transported in 2017, while in the Portugal → Spain direction 455,658 Tn were transported. Rail freight transport to and from Morocco

via the port of Algeciras is negligible due not only to the crossing of the Strait of Gibraltar but also to the different track gauge. International air freight transport in 2017 reached 789,868 tonnes in Spain, approximately 0,2% of Spanish international freight transport, with 409,371 Tn exported and 380,497 Tn imported. The main Spanish air cargo terminals are located in airports of Madrid, Barcelona and Zaragoza. See more freight transport data in Figures 1, 2 and 4.

Figure 1: International freight transport by road and sea: Tn transported in 2017.

Source: Own elaboration. Notes: i) PT: Portugal; SP: Spain; B: Biriattou; P: Perthuis; A: Algeciras. ii) Without the traffic between Spain and Portugal.

Figure 2: International freight transport by rail and air: Tn transported in 2017.

Source: Own elaboration. Notes: i) PT: Portugal; SP: Spain; H: Hendaye; P: Port-Bou; A: Algeciras. ii) Without the traffic between Spain and Portugal.

Commercial flows of fruit and vegetables through Spain in 2017

In 2017, fruit and vegetables accounted for 11% of international goods that passed through Spain by road and rail. Almost 4% of the volume of all Spanish international trade in goods is due to Spanish exports and imports of fruit and vegetables.

Total Spanish exports of vegetables in 2017 amounted to 5,143,715 tonnes. Taking into account [1], the main Spanish vegetables exported in 2017 were: tomato (809,527 Tn), lettuce (761,905 Tn), pepper (686,558 Tn), cucumber (626,689 Tn), cabbages (446,895 Tn), onion (336,832 Tn), courgette (319,844 Tn), potato (294,676 Tn), garlic (165,874 Tn), zucchini (143,884 Tn) and carrot (111,032 Tn). As for fruit, the total Spanish export was 7,356,383 tonnes, mainly orange (1,603,684 Tn), mandarin (1,356,106 Tn), watermelon (738,627 Tn), lemon (688,842 Tn), as well as nectarine (468,445 Tn), peach (453,550 Tn), melon (441,292 Tn), strawberry (303,950 Tn), persimmon (214,904 Tn), table grapes (143,552 Tn), apple (123,086 Tn), pear (119,582 Tn), avocado (107,006 Tn), banana (98,943 Tn), blueberries (46,510 Tn) and raspberries (45,809 Tn). Of the 12,617,132 tonnes of fruit and vegetables exported by Spain, exports to the countries of the European Union represent 93,4% of all Spanish exports of fruit and vegetables, i.e. 11,786,468 Tn, of which 6,880,451 Tn are fruit and 4,906,017 Tn are vegetables exported. The main destinations being Germany, France, the United Kingdom and the Netherlands. Spanish fruit and vegetable exports to Germany represented 26% of Spain's total exports, i.e. 3,274,759 tonnes. Spanish exports of fruit and vegetables to France accounted for 17% of the total, with 2,193,073 tonnes. Shipments to the United Kingdom accounted for 12% of the total with 1,487,252 tonnes and to the Netherlands for 8% of the total with 988,177 tonnes. Exports to non-EU countries were mainly to Switzerland (109,340 Tn), Morocco (95,369 Tn), Brazil (69,061 Tn), Norway (47,342 Tn), as well as to the United Arab Emirates (38,653 Tn), Saudi Arabia (32,632 Tn), Canada (26,624 Tn), China (18,310 Tn), México, South Korea, Australia and Malaysia.

In 2017 the total Spanish import of fruit and vegetables registered a volume of 3,068,472 Tn, which represents a trade surplus in the Spanish agricultural balance of 9.6 million Tn equivalent to US\$ 11,500 million. Fruit imports amounted to 1,706,392 Tn. It should be noted the imports of bananas (306,998 Tn), kiwi (217,499 Tn), apples (191,829 Tn), as well as pineapple (168,740 Tn). The total Spanish import of vegetables amounted to 1,362,080 Tn, with potatoes (780,905 Tn), tomatoes (188,912 Tn) and green beans (112,131 Tn), as the main vegetables imported by Spain. The ba-

nana is the main fruit imported by sea (196,000 Tn of 306,998 Tn). As for the countries supplying fruit and vegetables to Spain, it is worth highlighting the imports from France (824,003 Tn) and from Morocco (392,017 Tn). Morocco is Spain's second largest supplier of fresh fruit and vegetables, accounting in volume for almost 13% of total Spanish fruit and vegetable imports. Then there is Portugal (298,262 Tn), Belgium (172,902 Tn), Costa Rica (168,507 Tn), the Netherlands (167,725 Tn), Italy (149,655 Tn), the United Kingdom (79,492 Tn) and Peru (73,881 Tn). Spain imports fruit by air from Costa Rica, Guatemala, Venezuela, Mexico, Panama, Brazil, the Dominican Republic and Argentina. Most of the vegetables imported by air coming from Perú. Spanish imports of fruit and vegetables from the EU total 1,758,538 Tn, i.e. 57% of all Spanish imports of fruit and vegetables, corresponding to 665,254 Tn of fruit imports and 1,093,284 Tn of vegetable imports.

As for Spanish consumption of fruit and vegetables in 2017, the main fruit consumed in Spain was apple (422,000 Tn), followed by watermelon (400,000 Tn) and strawberry (130,000 Tn). The main vegetable consumed in Spain was potato (1,000,000 Tn), followed by tomato (700,000 Tn) and onion (400,000 Tn).

The agri-food sector has become the second most important sector of the Spanish economy after tourism, and the first industrial manufacturing sector in the country. In this way, from the primary production, through the transformation and ending in the commercial distribution, the sector generates 9% of Spanish GDP, giving employment to 2.5 million people. The Spanish fruit and vegetable sector accounts for 65% of the total agricultural production of Spain and generates 400,000 direct jobs, representing 40% of the employment generated in the countryside.

Results: Fruit and vegetables transport flows in Spanish borders in 2017

In 2017 Spanish exports of fruit and vegetables by road amounted to 11,742,186 Tn, including 95,369 Tn exported by roll-roll to Morocco and exports by road to European Union countries and European non-EU countries, all of which means 17% of the total tonnes of goods exported by road from Spain, which is much higher than the proportion of fruit and vegetables exported by rail (5%), by cargo aircraft (3.6%), or by maritime transport (0.7%) excluding the roll-roll regime. The road transport of perishable goods is done respecting the cold chain using refrigerated lorries. It is the form of transport generally used for the export and import of fruit and vegetables to and from the countries of the European Union. In absolute terms, Spain in 2017 exported 139,651 Tn of

fruits and vegetables by rail and imported 40,636; by ship exported 720,436 Tn and imported 900,260; and by air, Spain exported 14,859 Tn of fruits and vegetables, and imported 17,657.

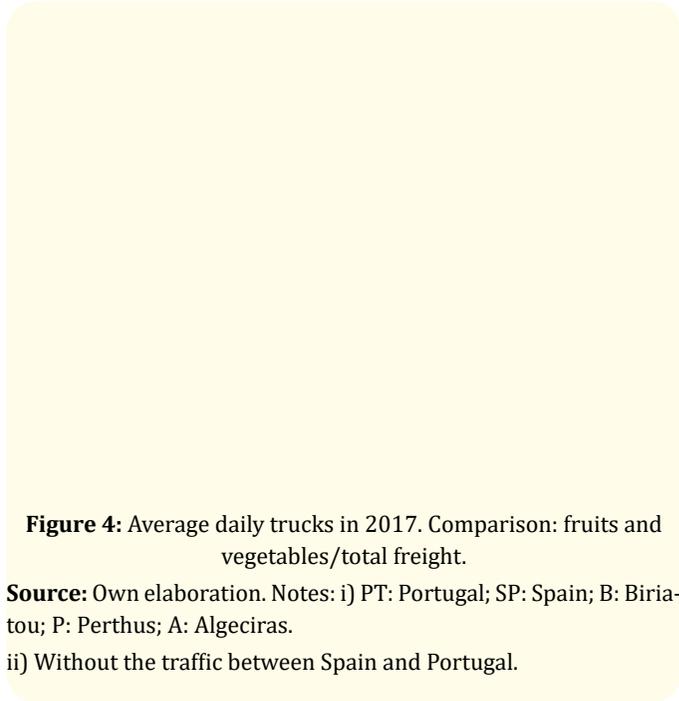
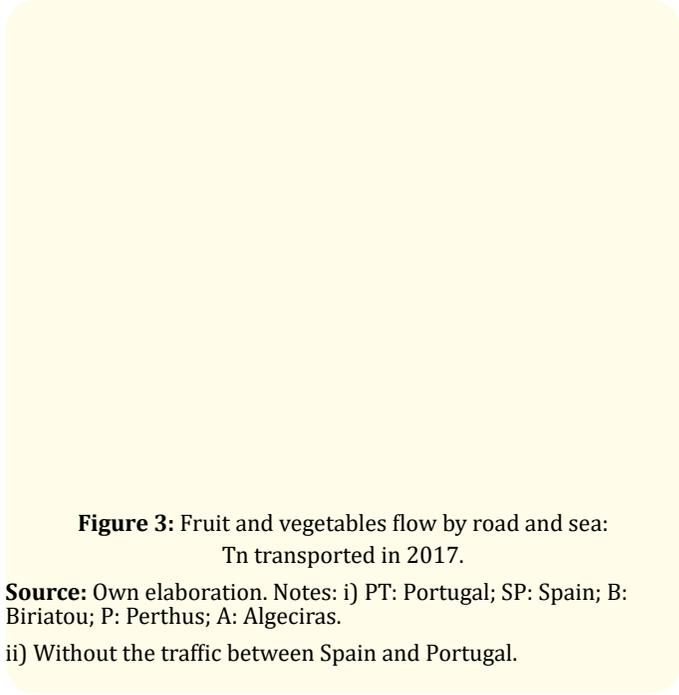
During the year 2017, the Spanish imports of fruit and vegetables by road, including imports from the EU and roll-roll transport, were 2,109,919 Tn, ie 68.7% of all Spanish import of fruit and vegetables. Considering all modes of transport, the ratio between Spanish exports of fruit and vegetables and total freight exports is 7% overall, while the same proportion in the case of Spanish imports of fruit and vegetables is only 1.2%. In the case of Spanish imports of fruit and vegetables, the highest proportion between imports of fruit and vegetables and imports of goods is accounted for by air transport (5%), followed by road transport (4%), rail transport (2.3%) and finally sea transport (0.5%) excluding roll-roll transport. Following (19), the most important Spanish ports for importing fruit and vegetables are: Algeciras, which including the roll-roll transport imports 1,190,000 Tn of fruit and vegetables, Valencia imports 292,000 Tn, Tarragona 185,800 Tn, Marin (Atlantic) 99,600 Tn, Barcelona 97,800 Tn and Gijon (Atlantic) 51,400 Tn of imported fruit and vegetables. The largest maritime import quota corresponds to vegetables, with 475,000 Tn imported, among which 282,000 Tn of tomatoes stand out.

With respect to the flow of international transport of fruit and vegetables through the Iberian Peninsula, 14,954,709 Tn of fruit and vegetables passed by road through the Iberian Peninsula during 2017, transported by means of 2,717 trucks per day, loaded on average with 15.1 tonnes of fruit and vegetables each. According to [1] and [16], during the year 2017, 1,078,600 Tn of fruit and vegetables crossed the Strait of Gibraltar on a roll-roll basis from Morocco to Spain as Moroccan exports to countries of the European Union by means of 137 daily trucks, each with an average load of 21.6 Tn of fruit and vegetables, as we can see in Figures 3 and 4. This traffic represents 30% of the roll-roll transport from Morocco to the European Union. The flow of fruit and vegetables from the countries of the European Union to Morocco is much smaller. Following [21], the transport of fruit and vegetables by road from Spain to Portugal and vice versa amounted to 861,821 Tn in 2017, of which 577,314 Tn in the Spain → Portugal direction.

In relation to the analysis of the flow of transport of fruit and vegetables that crossed the borders between Spain and France by road in 2017, we have applied the aforementioned methodology to the data coming from [6,8,17,18,22], to be able to deduce that during 2017 a total of 13,620,912 Tn of fruit and vegetables passed

in both directions, transported by means of 2,412 daily trucks including empty ones, loaded on average with 15,5 Tn of fruit and vegetables each. In the South → North direction, 11,876,297 Tn of fruit and vegetables from Portugal, Morocco and Spain crossed the French-Spanish frontiers by road to European Community and non-EU countries. The percentage of fruit and vegetables crossing French-Spanish border points by road in relation to the total goods crossing these border points is 12.8%. The flow of fruit and vegetables by road through the French-Spanish border crossing points in the South → North direction is much larger than the North → South flow, and the percentage of fruit and vegetables that cross the French-Spanish border points in the South → North direction in relation to all the products that cross the same French-Spanish border points in the South → North direction is 19.5% and at the Perthus eastern border crossing this same ratio reaches 32.2%, while at the Biriattou western border crossing it is only 7.3%. Overall, in the North → South direction, this percentage is significantly lower (around 4%). In absolute terms, 9,752,767 Tn of fruit and vegetables passed through the Perthus border crossing in the South → North direction in 2017, handled by 1,684 trucks per day loaded on average with almost 16 Tn, while 2,109,620 Tn passed through the Biriattou border crossing in the South → North direction by means of 324 trucks per day loaded on average with 17.8 Tn each. This implies that the volume of fruit and vegetables passing South → North across the Perthus border was 82% of the total volume of fruit and vegetables that crossed the French-Spanish borders South → North, while only 17.8% of the total passed through Biriattou. In 2017, an average of 1870 trucks of fruit and vegetables passed through the eastern French-Spanish border of Perthus in both directions, while only 531 trucks of fruit and vegetables passed through the western French-Spanish border of Biriattou each day. The passage of fruit and vegetable lorries through the central passages of the Pyrenees Mountains is not significant.

The fact that at the eastern border crossing of Perthus fruit and vegetable traffic by road is greater than at the western border crossing of Biriattou, and that rail traffic at the Port-Bou border is greater than at Hendaye, is to some extent linked to the existence near the Perthus border in Perpignan (France) of the Saint Charles International fruit and vegetable distribution market and the Toulouse distribution market, also in France. The market of Saint Charles International throughout 2017 managed about 2,500 trucks per day and distributed annually 1,766,000 Tn of fruit and vegetables, 40% of them marketed outside France throughout the various countries of the European Union, of which 1,140,000 Tn were from Spain and 430,000 from Morocco and the rest from France and Portugal. The Saint Charles International market has



access to the A9 motorway and also to the Perpignan railway station, the French port of Port-Vendres and the Perpignan-Rivesaltes airport. It is currently the leading fruit and vegetable marketing and logistics centre in Europe. Following [22], another important European distribution point for perishables, which usually has access from the border points of Perthus and Port-Bou, is the Barendrecht market in the Netherlands, which concentrates and distributes the

import of fruit and vegetables to several European countries. Another important logistics market for fruit and vegetables in Europe is Rungis in Paris. In 2017 Rungis marketed 1,207,401 Tn of fruits and vegetables: 752,014 Tn of fruits and 455,387 Tn of vegetables. Rungis has access to part of the fruit and vegetable traffic which, by road, passes through the French-Spanish border crossing at Biriattou, as well as the railway traffic which crosses the border crossing at Hendaye, border points from which the New Spitafields market in London can also be accessed.

From [20,21], the volume of international transport of fruits and vegetables transported by rail in 2017 through the Iberian Peninsula is much lower than by road: 181,354 Tn, compared to 14,954,709 Tn transported by road, which includes Spanish exports and imports by road and road transits between Portugal and France, Portugal and Morocco, plus road transits between France and Morocco. i.e. only 1.2% of the total international land transport of fruit and vegetables, partly because of the different track gauge with respect to the European, also because in this mode of transport it is more difficult to maintain the cold chain and because the railway reaches fewer places than the road. The volume of international fruit and vegetable rail traffic via the French-Spanish western rail border of Hendaye is lower (38.7%) than in the eastern pass of Port-Bou (61.3%), as we can see in Figure 5. The largest international flow of fruit and vegetable by rail traffic occurs at the borders between Spain and Portugal in the Spain → Portugal direction, through which crossed 115,224 Tn of fruit and vegetables in 2017, followed by North→South traffic at the Port-Bou crossing, with 21,642 tonnes of fruit and vegetables. However, rail traffic of fruit and vegetables from Portugal to Spain was only 4.825 Tn in 2017. With regard to South → North traffic at the French-Spanish railway borders, 64.4% pass through the Port-Bou railway border.

16,785,275 tonnes of fruit and vegetables cross Spanish borders in all modes of transport and the largest commercial flows are made by road transport, representing 89% of the international total. The volume of fruit and vegetables transported internationally by ship represents 9.7% of the total transported; by train, 1.1% of the total and by plane 0.2%. The main international transport flow of fruits and vegetables take place by road, from Morocco and Spain to the countries of the European Union beyond the Pyrenees mountains, by the eastern French-Spanish border of Perthus with 58.1% of all the international flow. The second major flow passes the western Spanish-French border of Biriattou by road to France with 12.6% and the third flow is the one that crosses the Strait of Gibraltar from Morocco to Spain and EU in regimen roll-roll, with 6.4% of the total.

Figure 5: Fruit and vegetables flow by rail and air: Tn transported in 2017.

Source: Own elaboration. Notes: i) PT: Portugal; SP: Spain; H: Hendaye; P: Port-Bou; A: Algeciras.

ii) Without the traffic between Spain and Portugal.

Conclusion

The combined production of fruit and vegetables from Spain, France, Portugal and Morocco in 2017 places this group of neighboring countries as the fourth largest producer of fruit and vegetables in the world and Spain was the leading exporter of fruit and vegetables in the European Union. It is for these reasons that in this paper we have tried to analyze the transport flows of fruits and vegetables that pass through all Spanish borders. But since the entry into force of the Schengen agreement, border control along intra-European borders has disappeared in order to make possible the free movement of people and goods among the European countries that signed the agreement. This fact makes it difficult to control the freight volume that passes from one country to another within the Union. In order to estimate the freight volume crossing the intra-European borders by road and taking into account the existence of contradictions in the EUROSTAT data, France carried out a series of surveys known as "Transit" assisted with dynamic weighting stations and data from toll road stations and vehicle registration surveys. But some European organizations detected that the processing of data from these surveys has led to an excessive proportion of road trade between Spain and France to the detriment of trade between Spain and the rest of Europe. In this paper we have analyzed the results of Transit 1999, detecting that the average load of vehicles transporting goods from Spain and France and vice versa in 2001 is only 12.85 gross tonnes/vehicle, not 14.09 as indicated by the official exploitation of the results of the survey.

The successive updates of the Transit surveys continue to drag that bias, which obliges us to propose a new measurement methodology strictly based on the analysis of freight tonnage transported by heavy vehicles along the itineraries traveled by international routes. The results of this methodology applied to 2001 data are close to those of calculations made by other international organizations, so in this paper we have applied this same methodology, firstly for the calculation of freight flows in general at Spanish borders in 2017, particularizing later the results to the calculation of the flows of traffic of fruits and vegetables in the Spanish borders during 2017.

The results of the analysis of fruit and vegetable flows indicate that 4% of the volume of all Spanish international trade in goods is due to Spanish exports and imports of fruit and vegetables. Spain exports more fruit and vegetables than it imports. Of the 12,617,132 tons of fruit and vegetables exported by Spain, exports to the countries of the European Union, which are made mostly by road, represent 93.4% of all Spanish fruit and vegetable exports. The main Spanish fruit and vegetables exported in 2017 were orange and tomato. Spanish fruit and vegetable exports to Germany represented 26% of Spain's total exports and France accounted for 17% of the total. In 2017 the total Spanish import of fruit and vegetables registered a volume of 3,068,472 Tn, during 2017 Spanish imports of fruit and vegetables by road, including roll-roll transport, accounted for 68.7% of all Spanish fruit and vegetable imports, including Spanish imports of fruit and vegetables from the countries of the EU, which account for 57% of all Spanish fruit and vegetable imports. The main fruit and vegetables imported by Spain in 2017 were bananas and potatoes. As for the countries supplying fruit and vegetables to Spain, it is worth highlighting the imports from France and from Morocco, which is Spain's second largest supplier of fresh fruit and vegetables, accounting in volume for almost 13% of total Spanish fruit and vegetable imports.

In 2017 Spanish exports of fruit and vegetables by road were 17% of the total tonnes of goods exported by road from Spain, which is much higher than in the other transport modes. Fruit and vegetables account for 11% of international goods passing through Spain by land, road and rail, of which 14,954,709 Tn of fruit and vegetables passed by road through the Iberian Peninsula during 2017, transported by means of 2,717 trucks per day, loaded on average with 15.1 tonnes of fruit and vegetables each; 1,078,600 Tn of fruit and vegetables crossed the Strait of Gibraltar in 2017 on a roll-roll basis from Morocco to Spain as Moroccan exports to countries of the European Union by means of 137 daily trucks, each

with an average load of 21.6 Tn of fruit and vegetables. Between Spain and France, a total of 13,620,912 Tn of fruit and vegetables passed by road in both directions, transported by means of 2,412 daily trucks loaded on average with 15.5 Tn of fruit and vegetables each. The percentage of fruit and vegetables crossing French-Spanish border points by road in relation to the total goods crossing these border points is 12.8%. At the eastern border crossing of Perthus fruit and vegetable traffic by road is greater than at the western border crossing of Biriadou: the volume of fruit and vegetables passing from Spain to France across the east border pass of Perthus was 82% of the total volume of fruit and vegetables that crossed the borders from Spain to France, while only 17.8% of the total passed through the west pass of Biriadou. In 2017 an average of 1870 daily trucks of fruit and vegetables passed through the eastern French-Spanish border of Perthus in both directions, while only 531 trucks of fruit and vegetables passed through the western French-Spanish border of Biriadou each day; 9,752,767 Tn of fruit and vegetables passed through the Perthus border crossing from Spain to France, handled by 1,684 trucks per day loaded on average with almost 16 Tn, while 2,109,620 Tn passed through the Biriadou border crossing from Spain to France by means of 324 trucks per day loaded on average with 17.8 Tn each. The volume of international transport of fruits and vegetables transported by rail in 2017 through the Iberian Peninsula is much lower than by road: 181,354 Tn, compared to 14,954,709 Tn transported by road (1.2% of the total). The largest international flow of fruit and vegetable by rail traffic occurs at the borders between Spain and Portugal, in the direction from Spain to Portugal, followed by the traffic at the Port-Bou crossing from France to Spain.

The results of this research indicate that in 2017 the largest commercial flows of fruit and vegetables that cross the Spanish borders in all modes of transport are carried out by road transport using refrigerated trucks to ensure the cold chain and are directed basically to the countries of the European Union beyond the Pyrenees, being 89% of the international total. The volume of fruit and vegetables transported internationally by ship represents 9.7% of the total transported; by train, 1.1% of the total and by plane 0.2%. The most important international transport flows of fruits and vegetables take place by road, from Morocco and Spain to the countries of the European Union beyond the Pyrenees mountains, by the eastern French-Spanish border of Perthus with 58.1% of all the international flow and by the western Spanish-French border of Biriadou with 12.6%. The third flow in volume of international transport of fruits and vegetables is the one that crosses the Strait of Gibraltar from Morocco to Spain and EU in regimen roll-roll, with

6.4% of the total. The rest of the international fruit and vegetable flows that cross the Spanish borders by any mode of transport account for 22.9% of the total.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Volume 3 Issue 1 January 2019

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