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Regional divergence regarding transport flows especially within the Danube region

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Vienna, 10th July 2014

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Elena Campdelacreu Ortega

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Abstract

The Danube is the second largest river in Europe, going through fourteen countries, and it is consider to be “the Gate” of Europe. The Rhine- Main- Danube canal enables the navigation from Rotterdam to the Black Sea. It is therefore very important to have a competent fleet able to meet schedules, to adapt to draught and to be resource efficient, to decrease the harmful exhaust emissions, as well as the fuel consumption. These advantages are compiled in the novel container ship NEWS, as well as logistical innovation to grant costumers satisfaction.

As the topic of the thesis is the regional divergence regarding transport flows, the expected results of the thesis will be the analysis of the good flows between the regions of study. Although the Danube passes through fourteen counties, this thesis will focus on the region from Austria to Hungary, passing through Slovakia. The main result is a complete and competent analysis showing the amount carried by cargoes through the region of study, comparing the goods transported between countries and the way these goods are being transported. Therefore it will be taken into account the modal split of the transportation in the area of study, considering the importance of the road, rail and inland waterway transportation. A more specific study will be developed about the last mode of transport, considering if the transportation is done with or without containers, the capacity of the vessels and their type, etc.

This thesis aims to prove the expected results being as accurate as possible. The results are expected to be useful and enable a conclusion that can be used for forthcoming studies and projects. Moreover this thesis aims to reach the expected results to know the regional divergence within Austria and Hungary.

Concerning to the methodology a deskwork is expected. As the aim is to realize a competent and serious analysis it would be necessary to study real data to understand, and therefore we able to prove, the modes of transport in the three countries of study, focusing in the inland shipping. Thus, the database will be taken by the Eurostat data provided of the last years, enabling the knowledge of the goods transported in the different countries, the capacity of their cargoes and similar data required in the project.

As said above, the development of NEWS can mean the development of the region of the Danube and also a growth oh the GDP of its countries. Furthermore, it should also be considered that a modernization and improvement of the Danube fleet could be one of the basis for the development of East-Europe / Balkan countries, a region with a potential development. Thus, it is indispensable to know how the transportation of goods is working nowadays and its regional divergence, to have a basis to develop the logistical aspects that the main project will have to face.

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1 Introduction

The Danube River is the second largest river in Europe, going through fourteen countries, and is consider to be “the Gate” of Europe. As a part of the Rhine- Main-Danube canal enables the navigation from Rotterdam to the Black Sea.

Even if inland shipping is presently in competition with road and railways as a mode of transport, the carriers are working below their theoretical carrying capacity. The inland shipping has a critical reputation and that may dispel customers. In order to solve the problems that cause a bad reputation and the carrying of a demand below capacity, the use of a novel container ship, NEWS (New generation European Inland Waterway Ship), is intended. This ship would increase the efficiency of the transport, enabling the meeting of schedules and as a consequence the satisfaction of the costumers. It is also adaptable to draught and would increase the resource efficiency. Nevertheless, logistical innovations would also be provided with the use of NEWS.

The background of this thesis is to analyse the regional divergence regarding the transport flows in the Danube region to provide the necessary information to prove the necessity of acquiring the new ship and analyse why should it be appropriate, as inland waterways is the most cost-efficient and environment-friendly mode of the inland modes of transport.

In order to develop the thesis the following research questions have been set: Is the divergence between the countries of study significant? Is there a main type of good transported by inland waterways? Why should inland waterway be chosen before the other modes of transport? Are the existing bottlenecks restricting the transportation?

The methodology followed to realize the study has been based in three main phases: literature review of the main topic to increase the general knowledge, research, analysis and interpretation of the data and literature review of the developed aspects in the thesis to provide more scientific and accurate information.

Furthermore, this thesis is staring by a literature review, to provide state-of-the-art information about the topic. It is followed by a section in charge to develop the analysis that will provide the information necessary to reach the expected results. This analysis includes a study about the modal split, the fleet and the infrastructure of the countries of study. It analyses the transportation between this countries from different points of view, as well. Finally, a discussion of the results and conclusions are provided.

2 Literature review

European intermodal transport network has become a high priority since the last decades. It has been the main objective of the European Community and the European Commission has promoted and developed studies, specific legislation and considerable funds.[1] More specifically, a number of infrastructure projects for improving the transport network are programmed in many European Countries. The most important ones are included in the list of TEN-T European priority projects, and several of these projects may concern the Rhine-Danube corridor.[2]

In order to provide more information about the TEN-T European priority projects involving waterways the website of the European Commission has been checked. Inland waterways are made up of rivers, canals and the various branches and links that connect them. The TEN-T inland waterway projects aim to help connect industrial regions and urban areas and link them to ports, as inland ports are considered part of the network, as points of interconnection between the waterways and the other modes of transport. The main projects related to inland waterways related to the topic of study are the River Information Services (RIS) and the related projects that involve traffic management infrastructure on the inland waterway network. The RIS project aims to optimise the existing capacity and safety and improve interoperation with the other transport modes establishing an interoperable, intelligent traffic and transport system.[3]

Inland waterway transport is a cost-efficient and environment-friendly mode of transport. It is associated with a high degree of reliability and safety, as well as the lowest noise emissions being reflected in the lowest external costs related to one ton of cargo transported over one kilometre, compared to other modes of transport.[4]

More general, freight transportation is a key supply chain component to ensure the efficient movement and timely availability of goods. As a consequence of the world economic crisis in 2008 many industries of freight transport were forced to reduce their costs and increase performance. As a result, shippers, carriers, and Logistic Service Providers were urged to work at lower cost, while maintaining the quality. This fact was followed by a higher cooperation and integration from many companies of the sector to survive the recession. [5]

[1] c.f. Ballis; Golias, 2004, p.420
[2] Beuthe; Jourquin; Urbain; Bruinsma; Lingemann; Ubbels; Van Heumen (2012), p.387
[3] c.f. http://inea.ec.europa.eu/en/ten-t/ten-t_projects/ten-t_projects_by_transport_mode/water.htm (read 16. 06. 2014)
[4] Schweighofer (2014), p 23
[5] c.f. SteadieSeifi; Dellaert, Nuijten, Woensel; Raoufi (2014), p.1

Environmental concerns should also be taken into consideration, as new regulations and taxes have encouraged companies to shift more sustainable solutions.[5] Transportation policy, planning and research communities are moving towards the paradigm of sustainable logistics, also known as “green logistics”, to address problems and find solutions in the freight sector. The objectives of sustainable logistics pertain to private aspects, such as cost minimization and profit maximization, and also to social well being, in terms of negative externalities associated with climate change, pollution, congestion, accidents and other biological and ecosystem damages deriving from transport. [6]

Similarly to other modes of transport, inland waterways transport has to deal with weather evens, affecting navigation conditions and the infrastructure of inland waterways. [7] Even if a specific analysis about the climatic change and its importance within inland waterway transport is out of scope, a general review about the most significant extreme weather events is provided.

Heavy rainfall, in particular in association with snow melt, may lead to floods resulting in the suspension of navigation and causing damage to the inland waterway infrastructure as well as the property and health of human beings living in areas exposed to flood. Long periods of drought may lead to reduced discharge and low water levels, limiting the cargo-carrying capacity of vessels and increasing the specific costs of transportation. Temperatures below zero degrees Celsius over a longer period may cause the appearance of ice on waterways, leading to suspension of navigation and possible damage of infrastructure.[7]

In the following chapters some aspects of the literature reviewed will be developed and related to the topic explained, in order to provide more information.

[6] c.f. Iannone (2012), p1424
[7] Schweighofer (2014), p 23

3 The Danube River

The Danube River is an international waterway flowing 2,845 km across Europe, with an elevation of 1,079 m. It is the European Union's longest river and the second in Europe, after the Volga. It originates in the Black Forest of Germany, and passes through ten countries before emptying into the Black Sea via the Danube Delta in Romania and Ukraine, being the only major river which flows west to east, from Central to Eastern Europe. The ten crossed countries are: Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Rumania, Bulgaria, Moldavia and Ukraine. [8]

It is considered to be the most international river in the world, being the only one that flows through four national capital cities (Vienna in Austria, Bratislava in Slovakia, Budapest in Hungary and Belgrade in Serbia). [8]

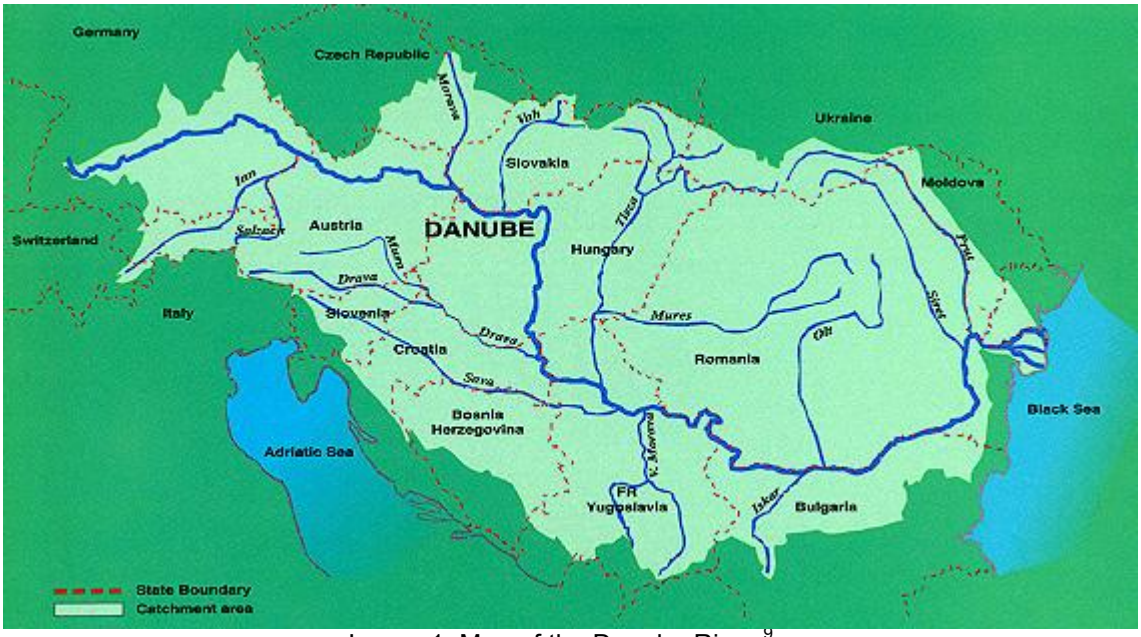


Image 1: Map of the Danube River [9]

The European Commission recognizes the Danube as the "single most important non-oceanic body of water in Europe" and as the "future central axis for the European Union".

The Danube River basin can be divided into three sub-regions. Upper Danube flows from Germany to Bratislava, in Slovakia. Its navigable section length is 621 km and the height of fall is about 250 m. Nevertheless, the vessel speed going upstream is between 9 and 13 km per hour and going downstream between 16 and 18 kilometres per hour. The Middle Danube comprises the section from Bratislava to the Iron Gate Dams, located in the boundary between Romania and Serbia. This section has a

[8] c.f. http://www.donauschifffahrt.info/en/facts_figures/ (Read 16.06.2014)

[9] source: http://www.ramsar.org/cda/fr/ramsar-news-archives-2002-new-ecological-expert/main/ramsar/ 1-26-45-87%5E19849_4000_1__ (Read 16.06.2014)

navigable length of 860 km and a height of fall of about 70 m. The vessel speed of this section is the same one than in the Upper Danube going upstream and higher flowing downstream, between 18 and 20 kilometres per hour. The Lower Danube, includes the Danube Delta, has a navigable length of 930 km and a height of fall of 35 metres. In addition, the vessel speed in this section of the river is higher than the one of the others going upstream, between 11 and 15 km per hour, and between 18 and 20 km per hour going on the downstream direction. [10] [11]

Moreover, the Danube has several dozen tributaries but not all of them are relevant for inland navigation. According to via donau the most important tributaries are the following. On the right bank: Isar, Inn, Traum, Enns, Ybbs, Traisen, Leitha, Raab, Sió, Drava, Sava, Morava, Timok, Isker and Jantra. On the left side: Altmühl, Naab, Regen, Kamp, March, Váh, Nitra, Hron, Ipoly, Tisza, Tamis, Jiul, Olt, Vedea, Arges, Jalomiţza, Seret and Prut. [11]

Furthermore, The Danube Delta is the second largest river delta in Europe, after the Volga Delta, and is the best preserved on the continent. Its greater part lies in Romania and its northern part in Ukraine. In the Danube delta area on the Black Sea, the Cernavoda Canal connects Romania's Black Sea port of Constanta with the Danube.[12]

Nowadays is the Danube the "Corridor VII" of the European Union. The Pan-European Transport Corridor VII refers to the Danube inland waterway, the Black Sea-Danube Canal, the Danube branches Kilia and Sulina, the inland waterway links between the Black Sea and the Danube, the Danube - Sava canal, the Danube - Thissa canal and the relevant port infrastructures situated on these inland waterways. As will be more extensively explained in the following chapters, the inland waterway transportation is almost always complimented with other modes transport, railways and roads. Therefore, transhipment facilities, necessary for developing combined transport, inland waterways with other modes of transport, are also considered as part of the Corridor. [13]

The Danube River is a waterway designed for large-scale inland vessels and can also carry much larger vessels on most of its course. In Austria and Germany has been partly canalized, with 10 and 5 locks respectively, but other proposals to build a number of new locks to improve the navigation have not been developed, especially due to environmental concerns. Downstream from the Austrian locks, the canalization of the river is limited to the Gabčíkovo dam and locks near Bratislava and two double Iron Gate locks, with larger dimensions, in the border stretch of the Danube between

[10] c.f. http://www.icpdr.org/main/danube-basin/river-basin (Read 17.06.2014)
[11] c.f. Manual on Danube Navigation, 2007
[12] c.f. http://whc.unesco.org/en/list/588 (Read 16.06.2014)
[13] c.f. http://www.corridor7.org/about-corridor-vii/ (Read 16.06.2014)

Serbia and Romania. From that part, the river is free flowing all the way down to the Black Sea.[14]

The Danube is navigable by ocean ships from the Black Sea to Brăila, Romania, and to Kelheim in Germany by river ships. Upstream can only be navigated by smaller craft, until Ulm, also in Germany. It should also be considered that about 60 of its tributaries are navigable.[15]

Since the Rhine-Main-Danube Canal was completed, the river has been part of a trans-European waterway from Rotterdam to the Black Sea. Since 1994 the Danube River has been declared one of ten Pan-European transport corridors, routes in Central and Eastern Europe that require major investment over the following ten or fifteen years.[16]

Moreover, there are three artificial waterways built on the Danube, the Danube-Tisa-Danube Canal, in Serbia, the Danube-Black Sea Canal, in Romania and the already described Rhine-Main-Danube Canal, as is more extensively explained in the Danube's infrastructure chapter.[17]

The Danube River's navigation has also international cooperation. The Danube Commission, according to the commission itself, is concerned with the maintenance and improvement of the river's navigation conditions. This commission is integrated by the ten countries of the Danube plus Russia, meets twice a year and convenes groups of experts to consider items provided for in the commission's working plans. The priority areas of the Commission's activity are focused on unifying and providing mutual recognition of the basic regulatory documents, required for the navigation on the Danube and on the other sections of the unified navigation system, contributing to the improvement of navigation conditions and safety of navigation, creating requirements for the Danube integration into the European system as the significant transport corridor. As this commission is formed by a large number of countries, in order to ensure integration the Commission actively cooperates with the relevant international bodies, involved in different aspects of inland waterway transport, such as United Nations Economic Commission for Europe, Central Commission for the Navigation of Rhine and European Commission.[18]

The Ecology and environment of the Danube should also be taken in consideration. The International Commission for the Protection of the Danube River, consisted by Germany, Austria, the Czech Republic, Slovakia, Slovenia, Hungary, Croatia, Bosnia

[14] c.f. Manual on Danube Navigation, 2007
[15] c.f. http://www.iweee.ugal.ro (17.06.2014)
[16] c.f. http://www.corridor7.org (Read 16.06.2014)
[17] c.f. http://www.donauschifffahrt.info/en/facts_figures/the_danube_as_a_major_route_of_transport/navigability/ (Read 16.06.2014)
[18] c.f. http://www.danubecommission.org/index.php/en_US/welcome (Read 16.06.2014)

and Herzegovina, Serbia, Bulgaria, Romania, Moldova, Montenegro and Ukraine, and the European Union, deals with the whole Danube River Basis, including its tributaries and the groundwater resources. It aims to implement the Danube River Protection Convention by promoting and coordinating sustainable and equitable water management, including conservation, improvement and rational use of waters and the implantation of the EU Water Framework Directive. [19]

Due to the industrial areas nearby and the cities, the water of the Danube has been harmed. However, not all the course of the Danube is equally polluted and, as a result, some categories have been given. Danube's upper waterway, Germany and Austria, belongs to the II category, which implies a moderate pollution in the river and good oxygen supply. After going through Vienna the Danube loses on quality and changes to the III category, with higher organic pollution and low oxygen content. At some points, the change is even bigger and the Danube's water becomes of the IV category, what means restricted living condition for higher life forms and extremely high organic pollution.[20]

Going through Hungary and reaching Serbia, the water quality is even worse and becomes of the category V. Going downstream all the way to the Black Sea, the Danube is extremely polluted and at a certain point it is even considered to be of VI or VII category. This dramatic situation is not only caused by the industries but also to the insufficient and inadequate laws regarding environment. [20]

[19] c.f. http://www.icpdr.org/main/ (Read 17.06.2014)
[20] c.f. Mihic, S.; Golusin, M.; Mihajlovic, M. (2011), p.1806

4 Modal split of the countries of study

According to Eurostat, modal split[21] is the varying proportion of different transport modes, which may be used at a time. Is the share of different modes of transport, including non-motorized modes and pedestrian trips, within overall transports demand.

It is also interesting to distinguish, and therefore define, the different terminologies that circulate in the literature related to the modal split topic.

Multimodal freight transportation is defined as the transport of goods by a sequence of at least two different modes of transport. The unit of transportation can be a box, a container, a swap body, a road/rail vehicle, or a vessel. On the other hand, intermodal transportation is defined as a particular type of multimodal transportation where the load is transported from an origin to a destination in the one and same intermodal transportation unit without handling of the goods themselves when changing modes. Nevertheless, co-modal transportation focuses on the efficient use of different modes on their own and in combination. Co-modality is defined by the Commission of the European Communities as the use of two or more modes of transportation, but with two particular differences from multimodality: it is used by a group of consortium of shippers in the chain and transportation modes are used in a smarter way to maximize the benefits of all modes, in terms of overall sustainability.[22]

The modal split of the countries of study is analysed and a following comparison will be done. In these countries the modal split is done between road, rail and inland waterway transport.

The study of the modal split of the selected countries has been separated into two parts. The inland freight transport volume relative to Gross Domestic Product (GDP) and the modal split of freight transport. The first indicator expresses the ratio between tonne-kilometres and GDP, indexing on 2000 as the reference year. The second is defined as the percentage share of each mode of transport in total and expressed in tonne-kilometres (tkm). This unit of measure for freight transport takes into account the weight carried and the distance travelled.

Inland freight transport includes road, rail and inland waterways. The data given should be reported according to the “territoriality principle”. This implies that the only data that should appear on the database should be the transport performance that takes place on the territory of the country, regardless of the nationality of the vehicle

[21] This indicator is defined as the percentage share of each mode of transport in total inland transport expressed in tonne-kilometres (tkm). It includes transport by road, rail and inland waterways. (EUROSTAT 16.06.2014)

[22] SteadieSeifi; Dellaert, Nuijten, Woensel; Raoufi (2014), p.2

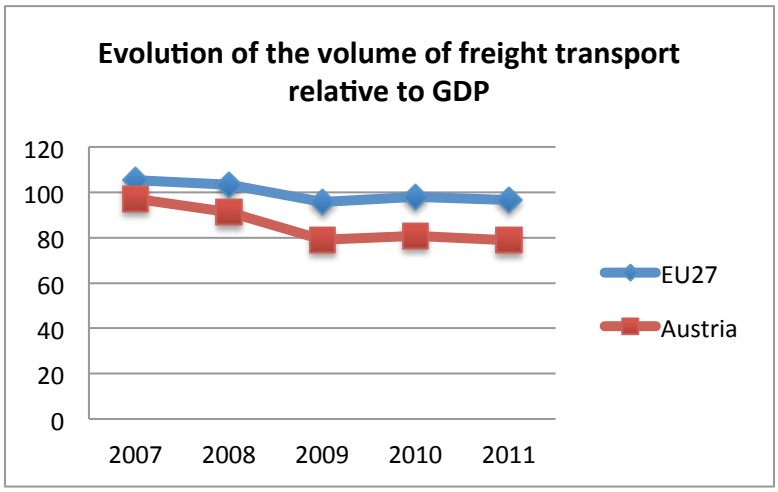
or vessel. On the other hand, road is not treated as the other two modes of transport. Road transport is currently based on all movements of vehicles registered in the reporting country and for this reason further methodological developments are needed for estimating road transport according to the "territoriality principle". Summarizing, rail and inland waterways transport are based on movements on national territory and road transport is based on all movements of vehicles registered in the country.[23]

Nevertheless, as said, the data is taken from the database Eurostat and, although the database was updated on May 2014, the last information found for the first part is from 2011, and as a result this year will be studied. An exchange rate has been done, being 2000 =100. On the other hand, the data of the modal split is more current, from 2012. The study is done with the most recent data.

4.1 Austria

Austria reported on 2011 a volume of freight transport relative to GDP of 78.8. This value is lower than the European Union one, which is of 96.5. [24]

To see how this values have been changing over the last years an evolution graphic has been done to show it.



Graphic 1: Evolution of the volume of freight transport relative to GDP in Austria and the European Union [25]

As it can be seen, the volume of freight transport relative to the Gross Domestic Product of Austria has decreased since 2007. A high reduction was done between 2008 and 2009, followed by a light recuperation in 2010 and another reduction in

[23] http://epp.eurostat.ec.europa.eu/tgm/web/table/description.jsp (Read 17.07.2014)
[24] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)
[25] source: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)

2011. Compering to the European Union's values, a biggest reduction is seen in 2009, probably due to the world economic crisis.

Following the world economic crisis in 2008 many industries have tried to reduce their costs and increase performance. Shippers, carriers and Logistic Service Providers had to work at lower cost while maintaining the quality.[26] However, even if the performance was tried no to be reduced, the amount of goods transported was smaller than the previous years and as a consequence the indicator suffered a reduction.

Focusing more specifically on the distribution of the above mentioned modes of transport, a representative graphic has been done. In this case, data from the 2012 has been found and used.

Graphic 2: Modal split of Austria in 2012 [27]

The main mode of transport is by road, followed by the railways and the inland waterways. Even if the road transport is more dominant than the others, it is under the European Union's average, which is 75.1%. The freight transport by road is mainly Austrian domestic transport, with source and destination in the country. The most important group is "Minerals and building materials"[28].

On the other hand, Austria has a percentage of use of railways higher than most of the countries of the European Union. The most important group of this mode of transport is "Machinery and other manufactured articles" [29]. It must be taken into consideration that the use of railways is used in a high proportion for importations, exportations and transit. This type of transportations implies usually a long distance

[26] SteadieSeifi; Dellaert, Nuijten, Woensel; Raoufi (2014), p.1
[27] source: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frmod&lang=en (Read 16.06.2014)
[28] http://statcube.at/superwebguest/login.do?guest=guest&db=degvk_ware (Read 16.06.2014)
[29] http://statcube.at/superwebguest/login.do?guest=guest&db=desgv_daten (Read 16.06.2014)

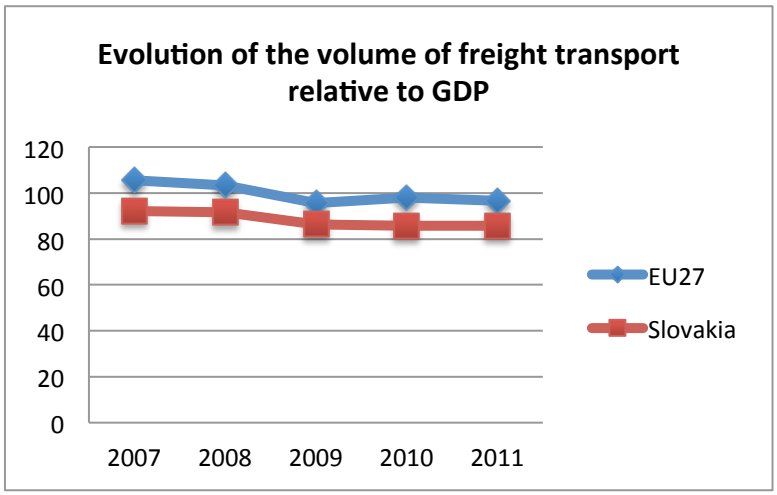
travelled and, considering that the unit used to measure this indicator is tkm, a big proportion is resulted.

Inland waterways represent the other 4.6%. This mode of transport is done through the Danube River and is under the European Union's average, which is of 6.7%.

4.2 Slovakia

The volume of freight transport relative to the GDP of this country was reported to be 85.7 on 2011. This value is also lower than the one of the European Union.[30]

An evolution graphic has also been developed to show the variation of this indicator during the years.

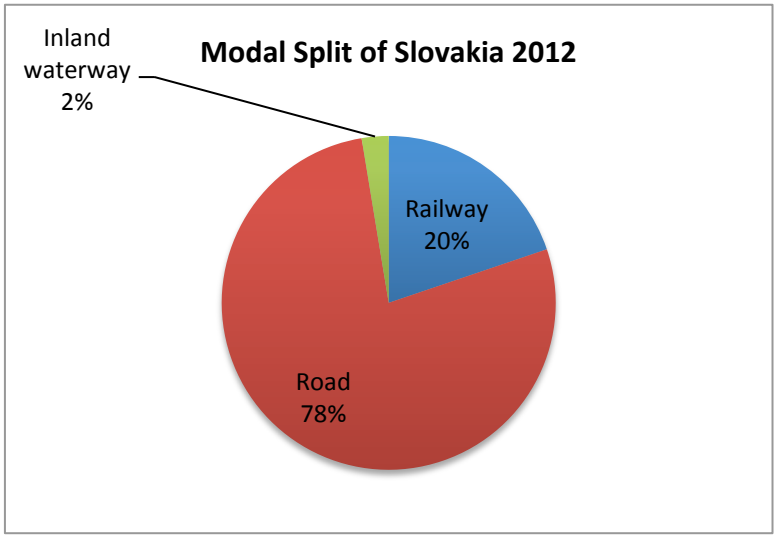


Graphic 3: Evolution of the volume of freight transport relative to GDP in Slovakia and the European Union [31]

In this case a reduction is also observed. Slovakia's volume of freight transport in relation to its GDP suffered a bigger decrease between the years 2008 and 2009, but in this case the following years remained almost constant.

The way this freight is transported is showed in the following graphic. As said above, the modal split is done between Railways, Road and Inland Waterways. As shown in the graphic below, the most used mode of transport is road, with a 77% of use. Railway has a 19.8% and inland waterway a 2.6%. All these values are more similar to the ones of the European Union than the ones of Austria.

[30] http://epp.eurostat.ec.europa.eu/tgm/web/table/description.jsp (Read 17.07.2014)
[31] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)



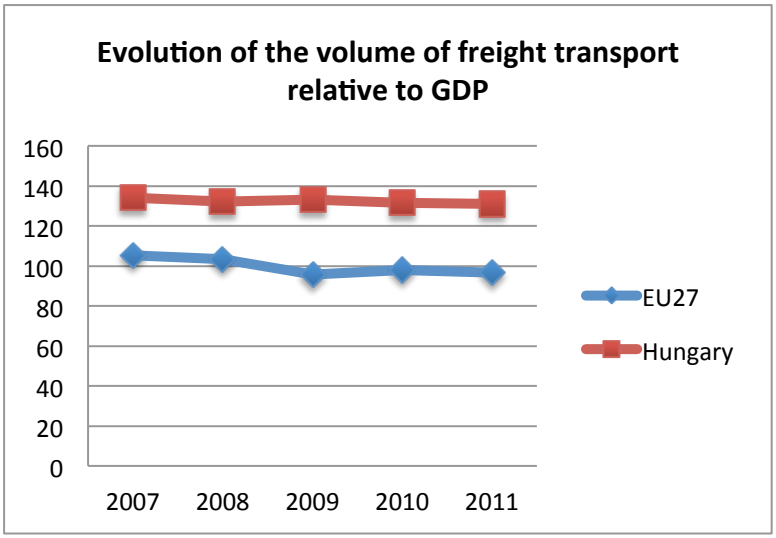
Graphic 4: Modal split of Slovakia in 2012 [32]

Regarding to the weight transported, the national transport is the most important in roads, however, taking also into account the distance travelled, is transit the one with a biggest percentage. Railways are mainly used for transit and the most important group of goods transported is the one named "Metal ores and other mining and quarrying products; peat; uranium & thorium".[33]

4.3 Hungary

In contrast to Austria and Slovakia, the volume of freight transport relative to GDP of Hungary was higher than the European Union one, with a value of 131.[34]

In this case an evolution graphic was also done.

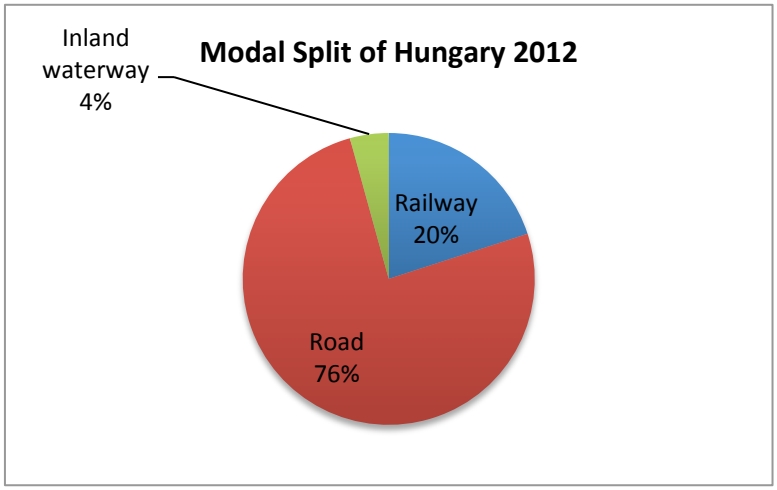


[32] source: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)
[33] Yearbook of transport, posts and telecommunications in 2013 (2013)
[34] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 17.07.2014)

Graphic 5: Evolution of the volume of freight transport relative to GDP in Hungary and the European Union [35]

The evolution shows that even if the volume of freight transport in relation to the GDP of Hungary has decreased, its reduction is less significant that the ones of the other studied countries, being the value of 2011 just a 2.3% lower than the one of 2007.

The modal split of Hungarian's freight transport was also studied. In this case, a graphic showing the proportions of each more was done.



Graphic 6: Modal split of Hungary in 2012 [36]

The distribution is very similar to the one of Slovakia and the European Union. The most used mode of transport was road, with a 77,6%, followed by railway with 20,5% and inland waterways with 4,4%.

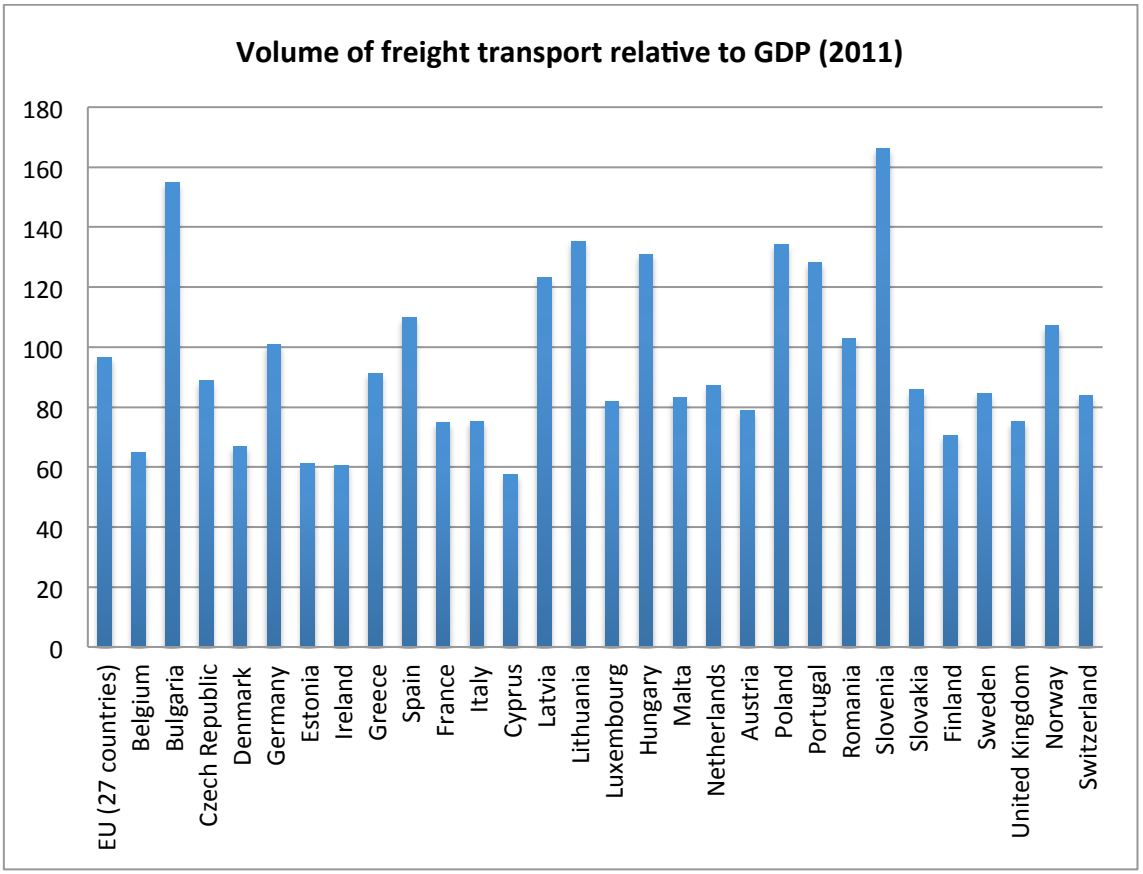
4.4 Comparison

Despite the fact that the three countries of study are in a row, regarding to the Danube course, their modal split values are significantly different.

Concerning to the volume of freight transport relative to GDP two comparative graphics have been developed.

The first one shows the values of all the European Union countries. It must be said that Croatia, Iceland, the Former Yugoslav Republic of Macedonia and Turkey are not included, due to non-availability of their data.

[35] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)
[36] source: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)



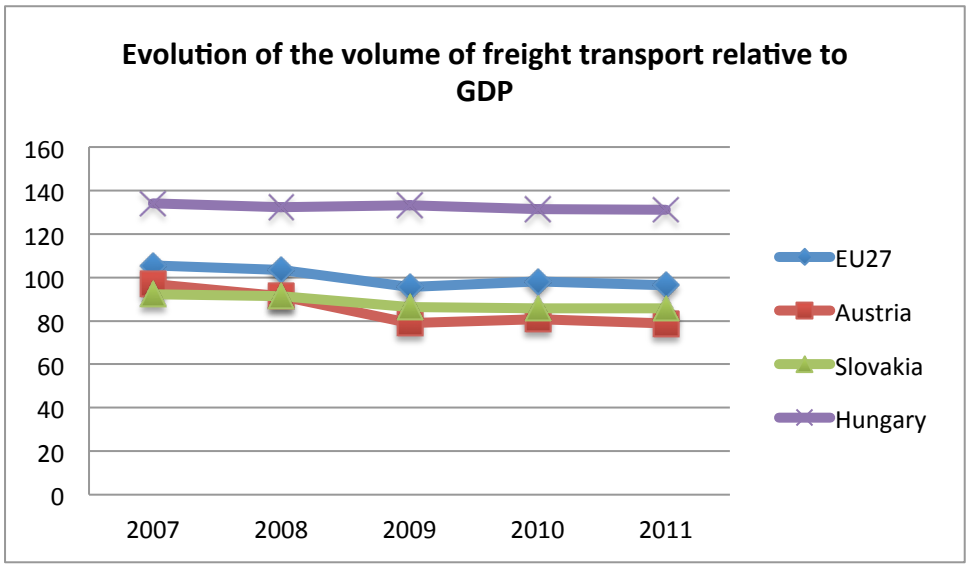
Graphic 7: Comparative of the volume of freight transported relative to GDP in 2011 of the different European Countries [37]

Observing the graphic it can be said that the countries with the highest freight transportation in relation to their GDP are Slovenia and Bulgaria. Hungary has one of the highest rates, too. On the other hand, Cyprus and Ireland are the ones with the lower rates. Even if Austria and Slovakia are not on the extreme, their volume of freight transport relative to GDP is lower that the European Union's one.

In order to extract more information of the graphic, a common characteristic of the countries with the highest volume of freight transportation in relation to their GDP has been searched. However, a connection between Slovenia, Bulgaria, Poland, Portugal, Lithuania, Hungary and Latvia could not been found. A concrete study of the just mentioned countries is out of scope and, therefore, the only conclusion that can be extracted is that these countries transport a high amount of goods comparing to their GDP. This can be caused by the fact that their GDP is low and due to the transportation with the neighbour countries the ratio results to be high, or it can be caused by the importance of the transportation of goods in the country.

The second graphic is focused on the evolution of this indicator in the countries of study. It is an addition of the already commented evolution graphics.

[37] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)



Graphic 8: Evolution of the volume of freight transport relative to GDP of the countries of study in 2011 [38]

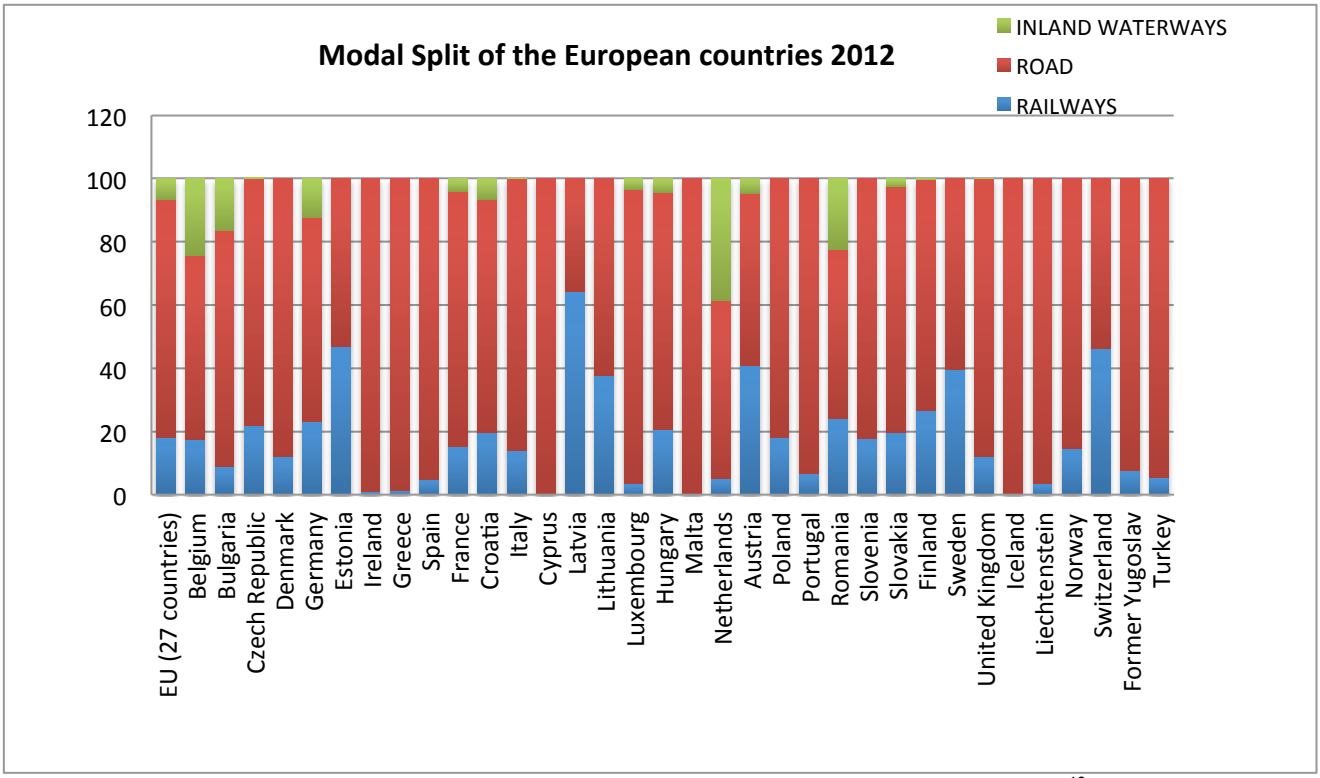
Looking at the evolution of the European Union and the three selected countries, a general decrease in the values can be observed. Comparing them, it can be said that the country with the most constant values is Hungary, with a decrease of 2.3% from 2007 to 2011, as said before. The European Union values have a reduction of almost 8.5%, starting with a value of 105.4 in 2007 to a value of 96.5 in 2011. Austria and Slovakia have reported a more significant decrease. Austria has had the biggest reduction, having a rate of 97 in 2007 and 78.8 in 2011. This represents a reduction of almost 19%. Slovakia's case is different. It experienced a big decrease from 2007 to 2009, but for the last two studied years its values have been almost constant.

In order to explain the differences in the just mentioned indicator within the countries of study, information about the GDP of each country in the year 2011 has been searched. The Gross Domestic Product of Austria in 2011 was 417.70 USD Billion. The one of Slovakia was 96.1 USD Billion and the one of Hungary 139 USD Billion.[39] In can be observed that the relation between the freight transport and the GDP of Austria and Slovakia has the same order of magnitude. Considering that the GDP of the first country is more that four times bigger that the second, it can be said that the amount of tonnes per kilometre transported in Austria is much bigger than the one of Slovakia. In the following chapters a comparison of the haulage between the three countries of study will be provided, but only the weight carried and not the performance will be considered. Nevertheless, Austria's good transportation has played a much more important role that the Slovakian. In Hungary the relation showed by the indicator was higher than in the other two countries, as already mentioned. This shows that even if the GDP of Austria was three times the one of Hungary, the inland haulage in the last country played a bigger role. This can be

[38] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)
[39] http://www.tradingeconomics.com (Read 18.02.2014)

caused because of the geographical situation of the country. Even if the three countries of study are neighbours, Hungary is located in the epicentre of Europe, enabling a connection between East-Europe and Central and West-Europe.

To compare the modal split of the countries of study a modal split graphic has been done with the 27 countries of the European Union. The following graphic expresses the percentage of use of the different modes of transport studied, railway, road and inland waterways.



Graphic 9: Comparison of the modal split of the European Countries in 2012 [40]

It can be observed that the most used mode of transport is the road, followed by the railways. The countries with a biggest percentage of use of inland waterways are Netherlands, Belgium and Romania. Railways have a bigger percentage of use in Latvia, Estonia and Switzerland.

In this case a relation between the countries with the higher percentage of a specific mode of transport has also been searched. The case of inland waterways is not surprising. The Netherlands and Belgium are the countries containing some of the most important port of Europe. These two countries are the leaders in inland transportation through inland waterways. Germany should also be taken into account in this group. However, this country is characterized by the good infrastructures, also including road and railways. Romania's case is different from the other two but is also

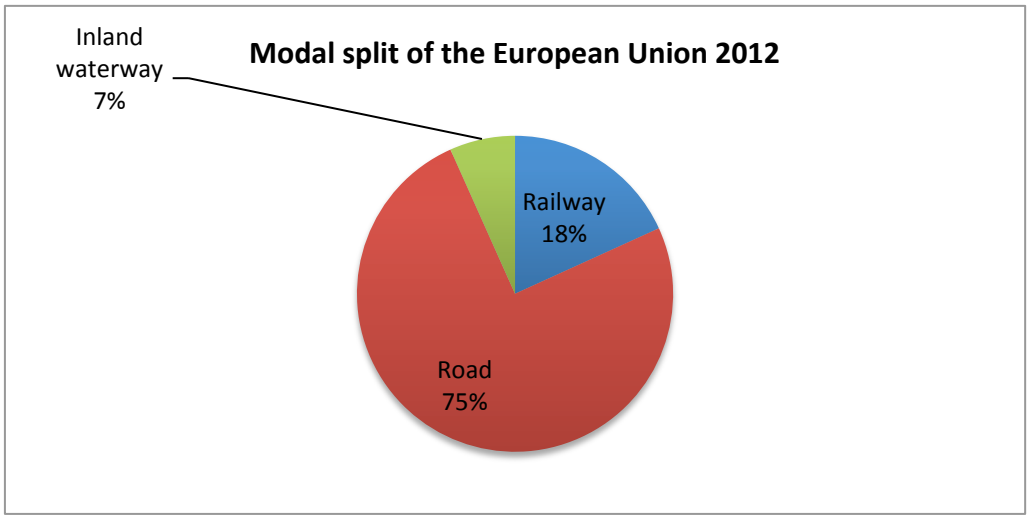
[40] source: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)

not surprising, as the Danube delta is located in this country and in Ukraine. Romania plays a very important role in Danube navigation, as will also be shown in the following chapters.

Regarding railways two trends have been found. The countries where this mode of transport plays the most important role are Latvia and Estonia. It should be mentioned that, also considering Lithuania, these countries are neighbours and this shows a trend of use of haulage by railways in this part of Europe. The other countries where railway transportation is also an important mode of transport are characterized by high mountains and therefore higher strength is needed, making this mode of transport appropriate. According to Notteboom (2010) Czech Repulic, Poland, Slovenia and Hungary have strong rail networks while road networks in Eastern Europe are less well developed.[41]

As said above, it must be considered that the unit of measure is tonne per kilometre. This indicator expresses not only the amount carried but also the distance travelled. The fact that some countries don't have a railway infrastructure, like Malta, or inland waterways should also be noticed.

Focusing on the European Union a graphic has also been done. As said above, the values are not far from the ones from Hungary and Slovakia. In this case, the road is again the most shared mode of transport. Comparing to the three studied countries, the use of inland waterways is bigger. This difference can be caused because in some countries this mode of transport is very used, such as Netherlands and Belgium. It can also be caused by the fact that the navigable rivers have a considerable length. Considering that the distance is also taken into account, the percentage of this mode of transport is increased.



[41] Notteboom, T. E. (2010), p 576

Graphic 10: Modal split of the European Union in 2012 [42]

On the other hand, it should also be considered that modal split does not mean that the transportation of a good has been done exclusively by road, rail or inland waterway. As above defined, multimodal freight transportation refers to the transport of goods by a sequence of at least two different modes of transportation and it is commonly used in Europe. In Europe, modal shift and co-modality (above defined) policies have been implanted to stimulate the use of the different modes of transport by supraregional, national and regional governments.[43]

Reviewing related literature a contradiction has been faced. On the one hand external costs[44] have been considered. Road transport is by far responsible for the largest share on transport external costs; meanwhile modal shift from just road to intermodal transport solution is currently being aimed by institutions and governments. In other words, a change to a more multimodal freight transportation is aimed and it would imply a higher use of railways and inland waterways.[45]

On the other hand, according to climate change a reduction in the use of inland waterway transportation can be expected. Low water levels force inland waterway vessel to use only a part of their carrying capacity, and as a result the cost per tonne transported increases causing an increase in the price. Increased transportation costs for inland waterways imply that the other modes of transport become more competitive and can take a part of the load originally transported by barge. Therefore, a change in the modal split can occur.[46]

Considering both points of view a conclusion has been reached. The use of more environmental-friendly modes of transport is expected to reduce the emission of CO_2 and other pollutants. In order to follow a direction to safe the environment, the point of view of the increasing use of inland waterways is accepted. This mode of transport is considered to be the most safe and environmental-friendly mode of transport of the inland freight transportation[47]. However, the weather events should also be taken into account. According to the arguments of this point of view, a reduction of the use of inland waterways as freight transport is expected because of the possible increase of the price per tonne transported. In order to avoid this restrictions that vessels face on the summers, an elimination of the bottlenecks of the Danube River related to draught is needed. Summarizing, if the low water aspect is solved, the use of inland

[42] source: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)
[43] c.f. Notteboom, T. E. (2010), p. 569
[44] External costs: costs associated with climate change, pollution, congestion, accidents and other biological and ecosystem damages deriving from transport (Iannone, F. (2012), p.1425)
[45] c.f. Iannone, F. (2012), p.1425
[46] c.f. Jonkeren, O; Jourquin, B; Rietveld, P. (2011), p.1008.
[47] c.f. Schweighofer (2014), p 23

waterways will not decreased because of an increase in the price but increased, and the modal split can suffer a shift to a more sustainable way of transport.

5 Current fleet and characteristics

This project is focused on the regional divergence regarding transport flows, especially within the Danube region. As mentioned in other parts, the regions chosen are Austria, Slovakia and Hungary, and the mode of transport chosen is inland waterway through the Danube River. A study of the vessels owned/used by these countries is required and therefore the types of vessel that navigate the Danube are described.

Pushed convoys are the predominant type of vessels that navigate the Danube River. A convoy comprises a motor cargo vessel, ship with its own cargo hold, or a pusher and one or more barges rigidly coupled to the pusher or freighter. The maximum allowed number of barges depends on the section of the Danube. In normal water conditions four barges can navigate without problems the Danube in Austria and Slovakia. In Hungary more barges are allowed. Finally, it can be said that the arrangement of the barges within the convoy depends on the direction. When going upstream the barges are arranged one after the other to minimize the fuel consumption. On the other hand, when travelling downstream the barges are coupled side by side to facilitate stopping and improve manoeuvrability.[48]

Image 2: Pushed Convoy on the Danube [49]

Image 3: Coupled side by side formation on the Danube [49]

Another type of vessels is dry cargo carriers. These vessels can freight a big variety of goods and are used mostly in pushed convoys or coupled formations. The variety of goods consists in, among others, round timber, steel coils, cereal and ore.[50]

Tankers are the type of vessel responsible for transporting material classified as dangerous. These vessel are prepared to meet the safety requirements and to

[48] c.f. http://www.donauschifffahrt.info/en/facts_figures/inland_vessels/ (Read 17.06.2014)
[49] source: http://www.donauschifffahrt.info/en/facts_figures/inland_vessels/ (Read 17.06.2014)
[50] c.f. http://www.donauschifffahrt.info/en/facts_figures/inland_vessels/ (Read 17.06.2014)

prevent contact of toxic steam and liquids with the environment. Nevertheless, tankers are not very common on the Danube. They are used almost exclusively in pushed convoys or coupled formations, as the dry cargo carriers. The materials transported are mainly liquid goods, such as mineral oil and derivatives, chemicals and liquid gases.[51]

The forth type is container vessels. These vessels carry their entire load in truck-size intermodal containers. The capacity of the containers is measured in twenty-foot equivalent units (TEU). Convoys with pushed barges and an overall slot capacity of 576 TEU are considered to be the optimum future container transport on the Danube River. [51]

Image 4: Container vessel [52]

Roll-on/roll-off traffic, also known as RoRo vessel, is a shipping cargo that can be efficiently rolled on and off the vessel by built-in or port ramps. Almost all RoRo shipping takes place using catamarans. Currently in the Danube four catamarans are being used, two designed in Germany and considered semi-catamarans, and two more designed in Serbia. The group of goods mostly transported by this type of vessel are cars, articulated lorries and semi-trailers, construction and agricultural equipment and heavy and oversized cargo. [51]

Heavy-cargo freight is the last type of vessel that navigates the Danube River. Even if any dry cargo carrier can transport oversized cargo, only vessel tailored to individual job requirements can transport extremely heavy goods. These vessels can be ships with reinforced bottom or ballast tanks. [51]

[51] c.f. http://www.donauschifffahrt.info/en/facts_figures/inland_vessels/ (Read 17.06.2014)
[52] source: http://www.donauschifffahrt.info/en/facts_figures/inland_vessels/ (Read 17.06.2014)

5.1 Austria

The study of the Austrian fleet has found several difficulties. The main one has been the non-obligation of vessel registration in the country, which has complicated the research of the data available. Also, non-recent data has been uploaded and, in some points, the most current data found was from 2010.

In 2011, 83 inland waterways transport enterprises were registered in Vienna. This year, the investment and maintenance expenditures on vessel in goods inland waterways transport enterprises was of about 9 millions of euro. On the other hand, the investment and maintenance expenditures on the inland waterway transport infrastructure were of about 14 million euro. [53]

In order to obtain more data to analyse the Austrian Danube fleet, some important enterprises have been taken into account. The most important inland waterways freight transport is “Erste-Donau-Dampfschiffarts-GmbH” (DDSG). It is a state-run navigation company with a fleet than consists in 51 motorized vessels. About the 40% are motor cargo vessels and the rest push boats. [54]

The second most important enterprise is “Donautankschiffahrtsgesellschaft” (DTSG), which belongs to a German company named “German Reederei Jaegers Group”. This enterprise is the most important regarding to tanker transport. It owns 5 tankers and 1 push boat. It also operates 14 tank barges and 2 bunkering boats. [54]

The third enterprise in importance in inland waterways transport is “Danu Transport”, which owns 4 push boats. Finally, a smaller company called “ Panta Rhei” operates one cargo vessel. [54]

Furthermore, some other enterprises are responsible for the Passengers transport. The most important one is “DDSG Blue Danube”, followed by “Brandner Schiffart”. [54]

Together, freight and passenger register 176 vessels in Austria, being 77 motorized. Nevertheless, the number provided by the companies of motorized vessels was 100. This is caused by the fact that the enterprises don’t have to register the vessels in Austria, as mentioned above. [54]

Another point is the amount transported by the vessels. The data found in this case is more recent, from 2013, and was found in the statistic database Eurostat. The amount carried by self-propelled barges in 2013 was of 4,608 thousands of tonnes and by non self-propelled barges was of 3,903. The amount carried in 2012 was of 4,230 and 4,425 thousands of tonnes, respectively. In the first case, an increase of 8.9% was recorded and in the second one the amount carried decreased about

[53] c.f. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_ec_ent_n&lang=en (read 17.06.2014)
[54] c.f. Waste Management for Inland Navigation on the Danube, 2012.

11.8%. Regarding to tanker vessels, self-propelled barges carried an amount of 1,087 thousands of tonnes in 2013 and 930 thousands of tonnes in 2012. The increase was of about 16.9%. Non self-propelled barges' amount transported was 1,127 thousands of tonnes in 2012 and 995 in 2013. In this case the reduction was of about 11.7%. [55]

Moreover, according to via donau, the movements of the vessels in Austria have also been recorded. The data found is from 2010. In this year, 99,267 vessels were locked through the nine Danube locks of the country. 45,046 were motor cargo vessels and tankers, 22,068 were cargo and tank lighters or barges and 32,153 were passenger vessels.[56]

5.2 Slovakia

Slovakia's data was easier to obtain than the one from Austria. This is the reason why the state of its fleet can be described with more detail.

In 2011 an investment of 3.6 millions of euro was done for the Slovakian water transport, for the Danube and the Vah. 1.3 million euros were designated to investment and the other 2.3 million to the maintenance of the already existing fleet, according to the database Eurostat. Similarly, data from 2012 was also found. The total investment was of 4 millions of Euro, of which 1.4 were designated to investment and 2.6 to the maintenance of the already existing fleet.[57]

The state of the ships in inland waterway transport was found in the "Yearbook of transports, posts and telecommunications in 2013". In 2012 205 cargo vessels were registered. Of them 20 self-propelled vessels were recorded, with a total carrying capacity of 23,424 tonnes and a power of 11,709 kW. In addition, 39 tugboats were registered, with a power of 37,831 kW. Regarding cargo and push boats 116 units were recorded with a carrying capacity of 182,327 tonnes. 28 Tankers and push boats with a carrying capacity of 41,909 tonnes and 2 Ro-Ro boats with 1,958 tonnes were also registered. Finally, 13 passenger ships were recorded.[58]

Furthermore, 44 companies operate in public water transport in Slovakia, being the most important one "Slovak Shipping and Ports, Joint Stock Company"(SSaP). It is a water transport carrier and operator only in cargo services. Mainly corporate entities operate in the freight transport, while only three personal entities do it in personal

[55] c.f. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_go_atyve&lang=en (Read 17.06.2014)

[56] http://www.donauschifffahrt.info/en/facts_figures/statistics/locked_through_vessel_units/ (Read 17.06.2014)

[57] c.f. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_ec_ent_n&lang=en (read 17.06.2014)

[58] c.f. Yearbook of transport , posts and telecommunications in 2013, 2013

transport on Slovakian waterways. This information has been taken from the “Ship waste management concept” of Slovakia, a document of the WANDA project.[59]

As in the Austrian study, another point is the amount transported by the vessels. However, in this case the data found in not as current and the most recent year found is 2012. The amount carried by self-propelled barges in 2012 was of 323 thousands of tonnes and by non self-propelled barges was of 2,265. Regarding to tanker vessels, self-propelled barges carried an amount of 469 thousands of tonnes in 2012 and non self-propelled tanker barges 228 thousands of tonnes.[60]

5.3 Hungary

Most of the related data found about Hungary was recorded until 2010. However, it was possible to find detailed data about the fleet of this country.

Hungary’s freight fleet in 2010 consisted in 463 vessels. The distribution was done between the different types of vessels. 80 units of self-propelled vessel were recorded. On the other hand 53 tugs and 26 push vessels were also recorded. The number of towed barges was of 13 vessels and the one of pushed vessels reached 291 units. [61]

The just mentioned vessels could also be differently distributed, regarding to their carrying. The amount of dry bulk cargo vessels was of 378 units, while 6 were used for liquid transportation. Tugs and pusher vessels constitute 79 vessels.

In this case the amount transported by the vessels was also considered. Nevertheless, the data is more current than the one found for most of the analysis of the fleet of the country, being from 2012 and found in the database Eurostat. Self-propelled barges carried in 2012 an amount of 2,710 thousands of tonnes and non self-propelled barges 4,552. Regarding to tanker vessels, self-propelled barges carried an amount of 650 thousands of tonnes in 2012 and non self-propelled tanker barges 197 thousands of tonnes.[62]

In relation to the movements done by the vessels, more recent data was found. In order to be coherent with the other information provided of the country, the data from 2010 will be shown, as well as the one of 2012. The total movements done by Hungarian vessels were 10,311 in 2010 and 8,256 movements in 2012. These

[59] c.f. Waste Management for Inland Navigation on the Danube, 2012
[60] c.f. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_go_atyve&lang=en (Read 17.06.2014)
[61] c.f. Danube Navigation Statistics for 2010-2011 (Read 17.06.2014) http://www.danubecommission.org/index.php/en_US/statistics
[62] c.f. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_go_atyve&lang=en (Read 17.06.2014)

movements contain the ones done by loaded and empty vessel. As can be observed, a significant reduction was done between the two years, specifically of almost 20%.[63]

Furthermore, main vessel operators should also be reported. Regarding to freight transport two main companies should be mentioned: “Fluvius Company Ltd.” and “Mahart Duna Cargo Ltd”. On the other hand, the most important passenger transport operator is “MAHART Passnave Passenger Shipping Ltd.”. [64]

5.4 Comparison

In order to compare the three countries of study three main aspects are considered. Firstly the attention will be focus on the investment done by the countries in their inland waterway fleet and, secondly, the size of the fleet will be compared. Finally, the amount transported by the different vessel will also be analysed.

To start with the investment comparison, it can only be done between Austria and Slovakia, due to the non-availability of the Hungarian data. The data used in both Austria and Slovakia belongs to 2011, as non-current data from Austria was found.

Austria spent in 2011 about 23 millions of euro in inland waterway transport. 14 millions were spent on inland waterway transport infrastructure and the other 9 on the investment and maintenance expenditures on vessel in goods inland waterway transport enterprises. Slovakia’s investment on transport infrastructure in 2011 was of 3.6 millions of euro, being 1.3 on investment and 2.3 on maintenance.

To get deeper into the comparison, the investment should be compared with the Gross Domestic Product of both countries. The GDP in Austria in 2011 was of 299,240 millions of euro and in Slovakia of 68,974 millions of Euro.[65] To compare both countries, the focus will be on the investment on infrastructure. Austria’s investment represents about a 0.0047%. On the other hand, the investment of Slovakia represents a 0.0052% of their GDP. Although both percentages have the same order of magnitude, Slovakia’s investment was higher in proportion.

The fact that Austria’s investment was bigger that the Slovak Republic one can be caused by two facts. Austria’s infrastructure required more investment than the Slovakian one due to worse conditions or, the former country was aiming to modernize the infrastructure in order to delete bottlenecks or to improve its inland waterways. Regarding the wealth and the importance of inland waterway transportation in Austria the second case is expected. Also, as is showed in the

[63] c.f. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_tf_vetf&lang=en (Read 17.06.2014)
[64] c.f. Waste Management for Inland Navigation on the Danube, 2012
[65] c.f. http://epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/data/database (Read 17.06.2014)

following chapter, Austria's infrastructure is much more bigger and complex that the one of Slovakia. Therefore, not only a modernization but also a more expensive maintenance is expected.

The second part of the comparison is about the number of vessels of each country. Despite the fact that the Slovakian's analysis was done with the data of 2011, the comparison will be done with the one of 2010, in other to be coherent while comparing the data of the three countries.

In 2010, Austria recorded 176 vessels, Slovakia 223 and Hungary 463. It can be seen that the fleet of Hungary is significantly bigger than the other two. It should also be considered, that even if the Danube is the most important and most navigated river in Slovakia, this number is recorded between the Danube and its tribute, the Vah River.

It is also interesting to compare the tonnes of goods transported by the different types of vessel. Data from 2012 is used to be coherent with the three countries. Starting with self-propelled vessel, Austria was the country that transported more weight, followed by Hungary. Slovakian weight was considerably smaller. On the other hand, non-self propelled vessels transported more weight in Hungary. Austria's amount carried was similar to the Hungarian but Slovakia was again further than the other. Furthermore, weight carried by self-propelled tanker barges was dominated by Austria. This country was again the one carrying more tonnes by non self-propelled tanker barges. However, in this case was Slovakia the follower. Slovakian and Hungarian importance is way smaller than the Austrian in this type of vessel.

Even if the number of vessel recorded is from 2010, a conclusion can be draw considering the last two aspects compared. Austria was the country transporting more tonnes of goods but also the one with a smallest fleet. It is also the richest country with the highest GDP per capita. The just mentioned facts could express that the Austrian fleet is the most powerful one, as is transporting more with fewer vessels. It would not also be surprising as Austria has important trades with Western Europe countries. On the other hand, the difference between Slovakia and Hungary is not that obvious. Hungary is bigger and is also transporting a higher weight of goods with a bigger fleet. However, according to Eurostat the GDP per capita is lower than the Slovakian.

Moreover, it should also be considered that the weight transported follows the "territoriality principle", which means that the data that should appear on the database should be the transport performance that takes place on the territory of the country, regardless of the nationality of the vehicle or vessel[66]. Therefore, even if Austria has registered fewer vessels, the transportation could have been done by

[66] c.f. http://epp.eurostat.ec.europa.eu/tgm/web/table/description.jsp (Read 17.07.2014)

vessels registered in other countries. In this case, the number of vessel registered would represent a data to study, but not an indicator of the power of the fleet.

Last but not least the containerization of the fleet has been considered. Due to the non-availability of the data, the containerization of the fleet could not be reported. However, it is expected that a big proportion of the goods transported through the Danube have been moved in containers. This fact can be expected by the large number of dry vessel, which can also carry containers. F.Iannone said in an article that containers have lately received a great deal of attention due to several issues, such as the continuous growth of international trade, the introduction of bigger ships and the productive systems through the adoption of innovative practices in inland intermodal distribution.[67] Furthermore, another article said that approximately 90% of all non-bulk cargo is carried by container vessels, as it enables liner shipping companies to stow their vessels fast[68]. Even if this article is more specialized in sea transport, extrapolating can be said that containers also represent a dominant type of transport in the river transportation.

[67] c.f. Iannone, F. (2012), p. 1426
[68] c.f. Delgado, A.; Moller Jensen, R. M.; Janstrup, K.; Rose, T. H.; Andersen, K. H. (2012), p. 251

6 Current inland waterway infrastructure

The Danube has its source in Germany and flows through a total of ten countries with a length of 2,857 km. As already mentioned, the European Union has defined it as Pan-European Transport Corridor VII, in the Framework of the Trans-European Networks.

The European Agreement on Main Inland Waterways of International Importance has given categories to the European inland waterways. The bottlenecks and missing links have also been reported. According to the just mentioned agreement, just the waterways categorized as class IV or more are considered to be E waterways. Furthermore, new waterways are recommended to be of class Vb or more and modernizations should meet at least class Va. A length of 29,131 km has been reported, being almost a 9% categorized under class IV.[69] In addition, according to Aronietis, Pauwels, Vanelslander, Gadziński, Golędzinowska and Wasil (2011), it is necessary to reach at least class IV to make inland waterway transport fully competitive against the other modes of transport, road and railways.[70]

Moreover, a definition of bottlenecks is provided. It is included in order to make this part of the project more comprehensible. The European Agreement on Main Inland Waterways of International Importance has defined the bottlenecks of the European waterways as “Those sections of the European waterway network of international importance that have parameter values being substantially lower than target requirements”. Besides, bottlenecks are classified into basic bottlenecks, those that are categorized under class IV, and strategic bottlenecks, other section satisfying the basic requirements of class IV but need to be modernized to improve the structure of the network or the economic capacity of inland navigation traffic. On the other hand, missing links are the parts of the future network of inland waterways of international importance non-existing at present.[71]

Focusing on the Danube, missing links have been reported in Austria, Croatia, Romania, Slovakia, Czech Republic and Poland. Although the Danube River does not flow through the last two countries, the missing link is the Danube-Oder-Elbe Connection, which is affecting them. Basic bottlenecks are only reported in Germany and Ukraine. In relation to strategic bottlenecks, the ones of Austria, Bulgaria, Hungary, Romania, Serbia and Slovakia are reported. Bottlenecks concerning to the countries of study will be developed in the following pages. [70]

[69] c.f. Inventory of Most Important Bottlenecks and Missing Links in the E Waterway Netwoork, 2013
[70] c.f. Aronietis, R; Pauwels, T.; Vanelslander, T.; Gadziński, J.; Golędzinowska, A.; Wasil, R. (2011), p. 60
[71] c.f. Inventory of Most Important Bottlenecks and Missing Links in the E Waterway Netwoork, 2013

Since the Danube-Oder-Elbe Connexion is a missing link affecting several countries, a short description of the project is provided. The Danube-Oder-Elbe is a project that has been thought for many years but is now stronger, since the European Commission included it in 1994 in its plan for a European net infrastructure and a Trans-European network. The most interested countries are Austria and the Czech Republic due to the fact that it enables them a connection to the Baltic Sea. Even if the construction of the Danube-Oder Canal has a relative competitive price, the Elbe would require high technical efforts and a huge investment. The environmental changes should also be considered, as it is considered to be a threat. [72]

Despite the just mentioned impediments should be eliminated, other infrastructure is found in the Danube River, what makes it able to offer a highly reliable, safe and environmentally-friendly way to transport mass quantities of goods.

Nowadays, there are 18 locks on the Danube, which are also river power plants that produce energy by impounding the water and making use of the river's slope. Five of them are located in Germany, another one on the border between Germany and Austria, nine in Austria, one in Slovakia and the two last ones, known as Iron Gates, are part of the boundary between Romania and Serbia. On the other hand, there are two other locks on the Danube-Black Sea Canal, Cernavodă and Agigea. Most of the locks mentioned, but for four of the located in Germany, have 2 lock chambers, enabling the simultaneous locking of upstream- and downstream-headed vessels. [73]

In addition, there are three artificial waterways built on the Danube River. The Rhine-Main-Danube canal, located in Babaria, Germany, is the navigable artery between the Rhine Delta and the Danube Delta. The Danube-Black Sea Canal, that links the North Sea to the Black Sea, is located between Cernavodă and Constanţa, in Romania. Finally, the Danube-Tisa-Danube Canal, in Serbia. This last one was mainly built to control water quantities of the Danube and support water supply. It has 51 structures: 24 gates, 16 locks, 5 safety gates and 6 pumping stations. [74]

Concerning the bridges, the Danube has 128 built and two more under construction. These bridges are distributed across its entire course, being more than the 60% located in Germany and Austria. [75]

Another point related to the Danube River's infrastructure is ports. Along with waterways and inland navigation vessels, ports play a key role in the inland navigation system. There are over 70 ports and transhipment sites on the Danube in

[72] c.f. http://www.flussbuero.de/bund_flussbuero/home/fluesse/donau_oder_elbe_kanal/ (Read 19.06.2014)
[73] c.f. Manual on Danube Navigation, 2007
[74] c.f. http://www.donauschifffahrt.info/en/facts_figures/the_danube_as_a_major_route_of_transport/locks/ (Read 19.06.2014)
[75] c.f. http://www.donauschifffahrt.info/fileadmin/group_upload/8/Downloads/2013-09-09__Danube_bridges _via-donau_EN.pdf (Read 19.06.2014)

its entire course. However, only 40 are considered to be inland ports of international significance. The two countries with a higher number of ports are Austria and Romania, followed by Hungary, Serbia and Bulgaria. The average distance between the E-ports, ports of international significance, is of 60 km approximately. [76]

In addition, some aspects about ports should be taken into account. According to Notteboom (2010), European port scene is becoming more diverse in terms of number of ports, leading to more routing options to shippers and to a lower concentration index.[77] This fact can be observed in the list of ports of the countries of study, where pots oriented to different applications are found. On the other hand, it should also be considered that ports and port companies must demonstrate a high level of environmental performance in order to ensure community support and keep the licences to operate. The just mentioned aspects of ports lead to think of a changing infrastructure, the one is developing to reach the market expectations. In this sense, drastic port reform schemes in some European countries, many of east Europe, have been considered to be needed. These reforms could imply an increase in efficiency and competitiveness of the ports concerned. The European Commission has taken steps towards a European port policy. Finally, it should also be remarked that port authorities around Europe have gained a more autonomous status via commercialization, corporatization and privatization processes.[78] Again, an evolution following the market requirements and direction seems to be happening.

Moreover, how weather events are affecting the river infrastructure should also be considered. Ice may cause damage on navigation, but can also be dangerous to the waterway infrastructure: locks may not be operated due to ice jams clogging the lock or due to freezing of moving parts and mooring devices. Long-lasting heavy precipitations or strong snow melting can also cause damages on the infrastructure, being the worst-case scenario, flooding endangering the property and lives of human beings.[79]

6.1 Austria

Austria is currently following the National Action Plan on Danube Navigation (NAP). This plan has been included in Austria's governmental programme since 2007 and is jointly implemented by the Federal Ministry for Transport, Innovation and Technology and via donau.[80]

[76] c.f. Manual on Danube Navigation, 2007
[77] c.f. Notteboom, T. E. (2010), p. 574
[78] c.f. Notteboom, T. E. (2010), p. 569
[79] c.f. Schweighofer, J. (2014), p. 37
[80] c.f. http://www.bmvit.gv.at/service/publikationen/verkehr/schifffahrt/downloads/nap_folderEN.pdf (Read 19.06.2014)

Focusing in infrastructure, this plan aims to maintain and improve the waterway infrastructure. Its four main points are remove bottlenecks on the Austrian Danube, minimize lock closing times due to revision works, ensure an adequate waterway maintenance and management and support an integrative improvement of fairway conditions on the entire Danube. [76]

According to Eurostat database Austria has 351 km of inland waterways[81], all of them in the Danube. As already mentioned above, Austrian Danube has 9 locks and no canals. It also has 42 bridges.

The following table shows the 9 locks located on the Danube in Austria, providing information of the kilometre in which they are located and the dimensions of the Lock Chambers, length per width in meters. All of them have two lock chambers.

Name of the lock	River km	Dimensions (m)
Aschach	2,162.67	230 x 24
Ottensheim	2,146.82	230 x 24
Abwinden	2,119.54	230 x 24
Wallseee	2,095.06	230 x 24
Persenbeug	2,060.42	230 x 24
Melk	2,038.06	230 x 24
Altenwörth	1,980.11	230 x 24
Greifenstein	1,949.20	230 x 24
Freudenau	1,921.05	275 x 24

Table 1: List of locks of the Austrian Danube [82]

Concerning the bridges, a list of the 42 Austrian bridges is provided in the annex. Summarizing, more than a 45% is used for road, a 9,5% is used for rail and road/rail. Pedestrian bridges represent a around a 7%, locks 21,4%. Subway and pipelines are the less used. On the other hand, 12 of 42 bridges can just be crossed in one direction, while 30 can be cross in both directions. [83]

Finally, the last infrastructure to be mentioned is the ports of Austria. This country has all together 14 ports and transhipment areas. 7 of them are public ports, located in Linz, Enns, Krems and Vienna. It also has 3 private ports and 4 transhipment areas. The following table shows a list of the Austrian ports and transhipment areas, their location and their type. Previously, an explanation of the differences between the just mentioned types is provided. [84]

[81] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_if_infrastr&lang=en (Read 19.06.2014)
[82] source: Manual on Danube Navigation, 2007
[83] c.f. http://www.donauschifffahrt.info/fileadmin/group_upload/8/Downloads/2013-09-09__Danube_bridges _via-donau_EN.pdf (Read 19.06.2014)
[84] c.f. http://www.danubeports.info/index.php (Read 19.06.2014)

According to via donau, a port is a transhipment point that has at least one port basin. Transhipment areas are transhipment points lacking a port basin. The term public port can be used either to describe a port for identifying a particular owner, or to refer to the port's accessibility to all vessel owners under equal conditions. Public ports are owned by the federal, provincial or municipal government. [78]

Name of port	Km	Type of port
Aschach	2,160	Transhipment site
Linz commercial port	2,131	Public port
Linz oil port	2,128	Public port
Linz voestalpine industrial port	2,127	Private port
Linz Felbermayr heavy cargo port	2,125	Private port
Enns	2,112	Public port
Ybbs	2,058	Private port
Pöchlarn	2,044	Transhipment site
Krems	1,998	Public port
Pischelsdorf	1,972	Transhipment site
Korneuburg	1,942	Transhipment site
Vienna Freudenau	1,920	Public port
Vienna Albern	1,918	Public port
Vienna Lobau oil port	1,917	Public port

Table 2: Ports of Austria [85]

As already mentioned in the introduction of the chapter the port scene of Austrian ports is diverse. Not only the three different types of ports are reported, but also the main use of the different pots is diverse.

Austria has also five port entrances. A table is provided to give more information about this infrastructure.

Name of port entrace	Main Use	Km of the Danube	Direction
Port of voest Liez	Rail/Pipeline	2,127.16	D+U
Port of Krems	Road	1,999.70	D+U
Port of Wien-Freudenau	Road	1,920.76	D+U
Port of Wien-Freudenau	Rail	1,920.74	D+U
Oil port Lobau	Pipeline	1,916.80	D+U

Table 3: Ports entrances of Austria[86]

As mentioned above some bottlenecks can be found in Austria. In this country a strategic bottleneck was reported, from the 2,037 km to the 2,005 km and from 1,921 km to 1,873 km. The problem is the low fairway depth, being in some locations down

[85] source: Waste Management for Inland Navigation on the Danube, 2012.
[86] source: http://www.donauschifffahrt.info/fileadmin/group_upload/8/Downloads/2013-09-09__Danube _bridges _via-donau_EN.pdf (Read 19.06.2014)

to 2.20 m. On the other hand, a missing link is reported, the Danube-Oder-Elbe Connection.[87]

The strategic bottleneck just mentioned is related to the low navigable water level (LNWL), which is used to define the water level reached or exceeded at the Danube water gauge on an average of 94 per cent of days in a year over a reference period of several years. [88]

6.2 Slovakia

The Slovakian Danube has a length of 172 km, being all of them of international importance. Also the Vah has 78 km of navigable waterways. The Danube kilometres include 39 km of canals and the rest are considered under the category of navigable rivers and lakes, according to Eurostat. [89]

The country of study has one lock, Gabčíkovo, located in the kilometre 1,819.15 of the Danube River. The dimensions of its lock chambers are 280 meters long and 34 meters wide and it has two lock chambers[90]. This dam has two constructions, a food gate and a power plant. This last one has an installed energy of 720MW. It should also be said that this project was originally prepared in cooperation with Hungary, Gabčíkovo-Nagymaros. However, the Hungarian Republic stopped their works in Nagymaros.[91] Even if a complete study concerning this lock and the environmental and political implications of both countries could be interesting, the topic is too extensive and therefore is out of scope of this thesis.

Concerning the bridges, Slovakia has 6 bridges and 4 more shared with Hungary. The following two tables show the both type of bridges, according to their nationality.

Name of the bridge	Main Use	Km of the Danube	Direction
Most Lafranconi	Road	1,871.35	D+U
Nový most	Road	1,869.10	D+U
Starý most	Road/Rail	1,868.14	D
Most Apollo	Road	1,867.30	D+U
Prístavný most	Road/Rail	1,866.40	D+U
Schleusenbrücke Gabčíkovo	Lock	1,819.30	D+U

Table 4: Danube bridges in Slovakia [92]

Name of the bridge	Main Use	Km of the Danube	Direction

[87] c.f. Inventory of Most Important Bottlenecks and Missing Links in the E Waterway Netwoork, 2013
[88] c.f. Schweighofer, J. (2014), p. 26
[89] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_if_infrastr&lang=en (Read 19.06.2014)
[90] source: Manual on Danube Navigation, 2007
[91] c.f. Gabčíkovo Part of the Gabčíkovo-Nagymaros Hydropower Project and Joint Slovak-Hungarian Monitoring of Environmental Impact, 2001
[92] source: http://www.donauschifffahrt.info/fileadmin/group_upload/8/Downloads/2013-09-09__Danube_bridges _via-donau_EN.pdf (Read 19.06.2014)

Medve-híd/Most Medve	Road	1,806.35	D
Komáromi-híd	Rail	1,770.40	D
Komáromi-híd	Road	1,767.80	U
Esztergom	Road	1,718.80	U

Table 5: Danube bridges shared between Hungary and Slovakia[93]

It could also be added that most the Slovakian bridges are located in Bratislava, but the one of the above described lock of Gabčíkovo. Is should also be mentioned that all the shared bridges can only be crossed in one direction, downstream (D) or upstream (U), meanwhile most of the Slovakian are prepared for both directions.

Nowadays Slovakia has three ports, according to via donau. In terms of transhipment the most important ones are the ones located in Bratislava and Komárno. The first one is located in the Danube River kilometre 1,865.00 and its owner is the company Slovak Shipping and Port JSC. Komárno is located in the 1,767.10 km of the river and is owned by the same company. The third freight port of Slovakia is located in Štúrovo, more specifically in the 1,722.00 km. It is owned by Smurfit Kappa Štúrovo, a.s..[94]

The port entrances should also be mentioned as part of the infrastructure. Two are reported in the port of Bratislava and a third in the port of Komárno. The following table gives more information about these port entrances.

Name of port entrance	Main Use	Km of the Danube	Direction
Port of Bratislava (Prístavny most)	Road/Rail	1,866.25	D+U
Port of Bratislava- Pálenisko	Pipeline	1,865.40	D+U
Port of Komárno	Road	1,767.00	D+U

Table 6: Danube port entrances[95]

As in the case of Austria, Slovakia has also bottlenecks. This constrains are separated into the groups of Strategic bottlenecks and Missing links. There are currently two strategic bottlenecks reported and both due to the same problem: “insufficient depth at low water level and insufficient height under bridges”. The first one reported is from Devín, kilometre 1,880.26 of the Danube River, to Bratislava, kilometre 1,867.00. At the 1,868.14 km, Bratislava, the height is of 7.59 m, while at the lock of the Gabčíkovo Hydro Electrical Complex is of 8.90 m, at the 1,819.30 km. It is required to upgrade to 9.10 m. The second strategic bottleneck is located form Sap, kilometre 1,811.00, to the mouth of the Ipel’River at the 1,708.00 km.[96]

[93] source: http://www.donauschifffahrt.info/fileadmin/group_upload/8/Downloads/2013-09-09__Danube_bridges _via-donau_EN.pdf (Read 19.06.2014)
[94] c.f. http://www.danubeports.info/index.php?id=1291&L=5 (Read 19.06.2014)
[95] source: http://www.donauschifffahrt.info/fileadmin/group_upload/8/Downloads/2013-09-09__Danube_bridges _via-donau_EN.pdf (Read 19.06.2014)
[96] c.f. Inventory of Most Important Bottlenecks and Missing Links in the E Waterway Netwoork, 2013

In this case, the insufficient depth at low water level is also related to the low navigable water level. On the other hand, the insufficient height under bridges is caused by the contrary case: the highest navigable water level (HNWL). The HNWL is defined as the water level reached or exceeded at a Danube water gauge on an average of one per cent of days in a year over a reference period of several years. The authority responsible for the waterway section can impose a ban on navigation.[97] When the HNWL is exceeded, not only a risk of flooding exists, but also not sufficient height between the water and the bridges.

Two missing links are also reported. The first one is the already defined Danube-Oder-Elbe Connection. The second is the Váh-Oder link, which does not affect the Danube River and its navigation. [90]

6.3 Hungary

According to funding database supported by the European Union, the Hungarian navigable waterways have a length of 1,368 km, being 530 km of international importance.[98]

The major Hungarian inland waterways, including rivers and canals, are the following: Danube, with a length of 419 km, Tisza, 525km, Dráva, 128 km, Bodrog, 51 km and Körös, with 124 km. In addition, 142 km of the Danube River are shared with Slovakia in the left bank. [98]

No locks are built in the Hungarian Danube; however, one lock in a tributary is reported. It is located in the RDS Ráckevei (Soroksári) Dunaág. The upper lock was built on the territory of Budapest and under lock near the Tass. [99]

Concerning the bridges, 15 are reported on the Hungarian territory. On the other hand, four more are shared with Slovakia, which have already been mentioned. The following table shows a list of the Hungarian bridges with information about their location, km of the Danube River, their main use and their direction, being upstream represented with a U and downstream with a D.[100]

Name of the brigde	Main Use	Km of the Danube	Direction
M0 Északi (Budapest North)	Road	1,659.74	D+U
Újpesti-híd (Budapest)	Rail	1,654.50	D
Árpád-híd	Road	1,651.40	D

[97] c.f. Schweighofer, J. (2014), p. 26
[98] c.f. http://www.naiades.info/funding/policy.php?id=424&path=214,257&f_lang=EN&country=HU (Read 19.06.2014)
[99] c.f. National Strategy Plan for Optimization of Waterway Maintenance, 2011.
[100] c.f. http://www.donauschifffahrt.info/fileadmin/group_upload/8/Downloads/2013-09-09__Danube_bridges _via-donau_EN.pdf (Read 19.06.2014)

Margit-híd	Road	1,648.70	D
Lánchíd (Széchenyi) (Budapest)	Road	1,647.00	D+U
Erzsébet-híd (Budapest)	Road	1,646.00	D+U
Szabadság-híd (Budapest)	Road	1,645.30	D+U
Petöfi-híd (Budapest)	Road	1,644.30	D+U
Lágymányosi-híd (Budapest)	Road	1,643.20	D
Déli-híd (Budapest)	Rail	1,643.10	D
M0 híd (Budapest South)	Road	1,632.81	D
Pentele-híd (Dunaújváros-Dunavecse)	Road	1,571.70	D+U
Dunaföldvári-híd (Dunaföldvár)	Road/Rail	1,560.55	D
Szekszárdi-híd (Szent László) (Bogyiszló)	Road	1,498.80	D
Bajai-híd (Türr István) (Baja)	Road/Rail	1,480.22	D

Table 7: Hungarian Danube bridges [101]

Observing the table it can be said that most of the bridges are located in Budapest, the capital of Hungary. It is also remarkable that none of the Hungarian bridges are only to go upstream, being 9 of them just to go downstream.

Regarding to the port infrastructure, Hungary has 12 freight ports. Most of them are private, but the Baja port, which is owned by the Hungarian State. This port is considered to be the logistics port of the region. The following table shows information about the ports of this country. All these ports are located at the Danube River. [102]

Name of the port	Km of the Danube	River side
Györ-Gönyü	1,794.00	Right bank
Budapest Szabadkikötö	1,640.00	Left bank
Budapest Ferroport	1,639.70	Left bank
Dunaújváros-Dunoferr	1,579.00	Right bank
Dunaújváros-Centroport	1,580.00	Right bank
Dunavecse	1,572.00	Left bank
Paks	1,528.00	Right bank
Bogyiszló	1,503.00	Right bank
Baja	1,479.00	Left bank
Mohács-Bóly Zrt Dunai Kikötö	1,450.00	Right bank
Mohács-Kreativ Stúdió Kft. Kikötö	1,499.00	Right bank
Mohács-Agroptim-Margittasziget	1,466.00	Left bank

[101] source: http://www.donauschifffahrt.info/fileadmin/group_upload/8/Downloads/2013-09-09__Danube _bridges _via-donau_EN.pdf (Read 19.06.2014)
[102] c.f. http://www.danubeports.info/index.php?id=1278 (Read 19.06.2014)

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Table 8: Danube ports of Hungary [103]

Focusing on the size of the Hungarian ports of the Danube, the port " Budapesti Szabadkikötö is the biggest, with an area of 1,520,000 m^2 and 9 berths. The second port in size according to its area is the "Gyö-Gönyü" port, with an area of 1,100,000 m^2 and 7 berths. On the other hand, the public port of Baja has 9 berths and an area of 208,795 m^2.[104]

Last but not least, Hungary has also constrains in the course of the Danube on its territory. They are classified under the category strategic bottlenecks. The first one is located in the joint Slovak – Hungarian section, from the kilometre 1,810.0 km to the 1,708.20 km. These constrains are low maximum draught during dry seasons, registered 1.5 m, and low height under bridges at a high navigable water level. More specifically, the height of the road bridge Medved'ov is 8.85 m between pillars II and III, the railway bridge Komárno has a height of 8.65 m between pillars IV and V and 8.68 between the III and IV. The height of the road bridge Komárno is 9.08 m at centre point of the arches between pillars II and III and III and IV. To solve these constrains the draught should be upgraded to 2.50 m and the height under bridges to 9.10 m. The second strategic bottleneck is located between the kilometres 1,709.2 and 1,433.0 of the Danube River. There is a constrain due to the low maximum draught, of 1.50m, registered in the course of years up to November 2011.

[103] source: http://www.danubeports.info/index.php?id=1278 (Read 19.06.2014)
[104] c.f. http://www.danubeports.info/index.php?id=1278 (Read 19.06.2014)

7 Analysis of the inland waterway transportation of the regions of study

In order to reach the aim of the project and to be able to analyse the goods transported through the Danube River, serious and rigorous data has been used. However, it was not possible to find all the expected data of the three countries of study.

The following analysis will focus on the goods transported. This will be done from different points of view. The different modes of traffic and types of good will be distinguished, as well as the nationality of the vessels. If possible, the loading and unloading regions will also be provided.

As a comparison is intended, this analysis will be done with the most current data found of all the countries. In the case of Austria accurate data was founded until 2013. In the case of Slovakia the latest data is from 2012. However, the data found about Hungary is not that actual, being most of it from 2011. On the other hand, the data available from Hungary from 2012 is also going to be used. As already said, the data used is the most recent one found in the three countries. For this reason this analysis will be based on data from 2012 and 2011.

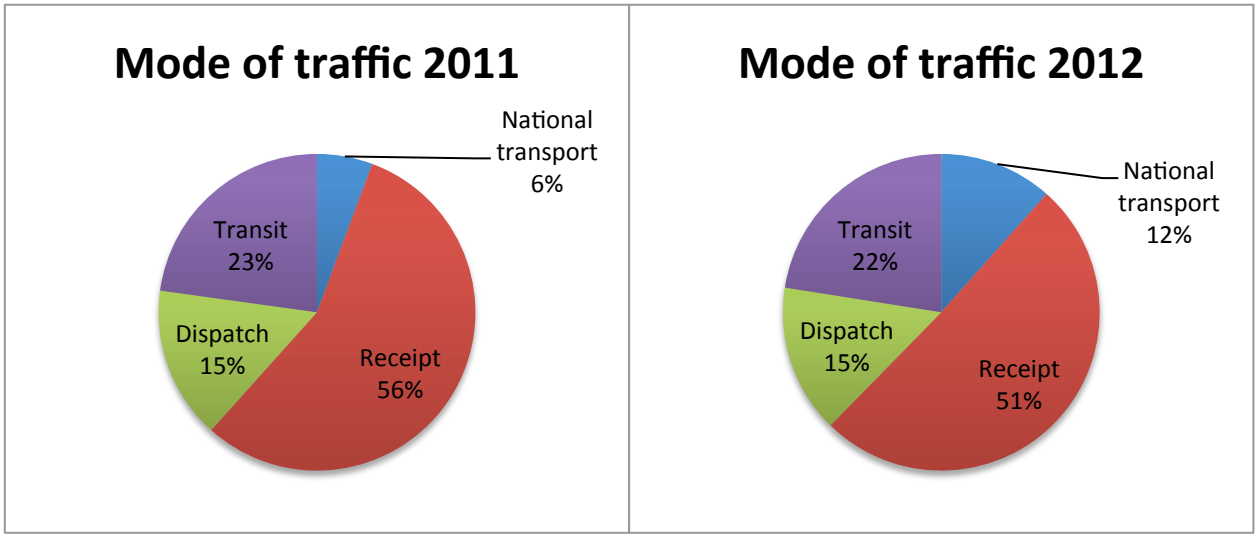
7.1 Austria

The total of goods transported in Austria during the years 2011 and 2012 were 462,465,117 tonnes and 445,298,388, respectively. As said in the modal split chapter, inland waterway transportation represents just a small part of all the weight transported. In this case, the amount of goods transported in Austria in 2011 was 9,943,288 tonnes and in 2012 10,714,007 tonnes. An increase was produced, more specifically, of almost an 8%.[105]

In order to develop a complete and accurate analysis, several graphics and tables have been done.

The first aspect to analyse is the mode of traffic of inland waterway transportation in Austria. This term refers to a classification done according to the type of destination or origin of the goods transported. The four types are: national transport, receipt, dispatch and transit. The following two graphics show the distribution of the mode of traffic in the years 2011 and 2012.

[105] c.f. http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)



Graphic 11 and 12: Distribution of the mode of traffic in inland waterways in Austria in 2011 and 2012 [106]

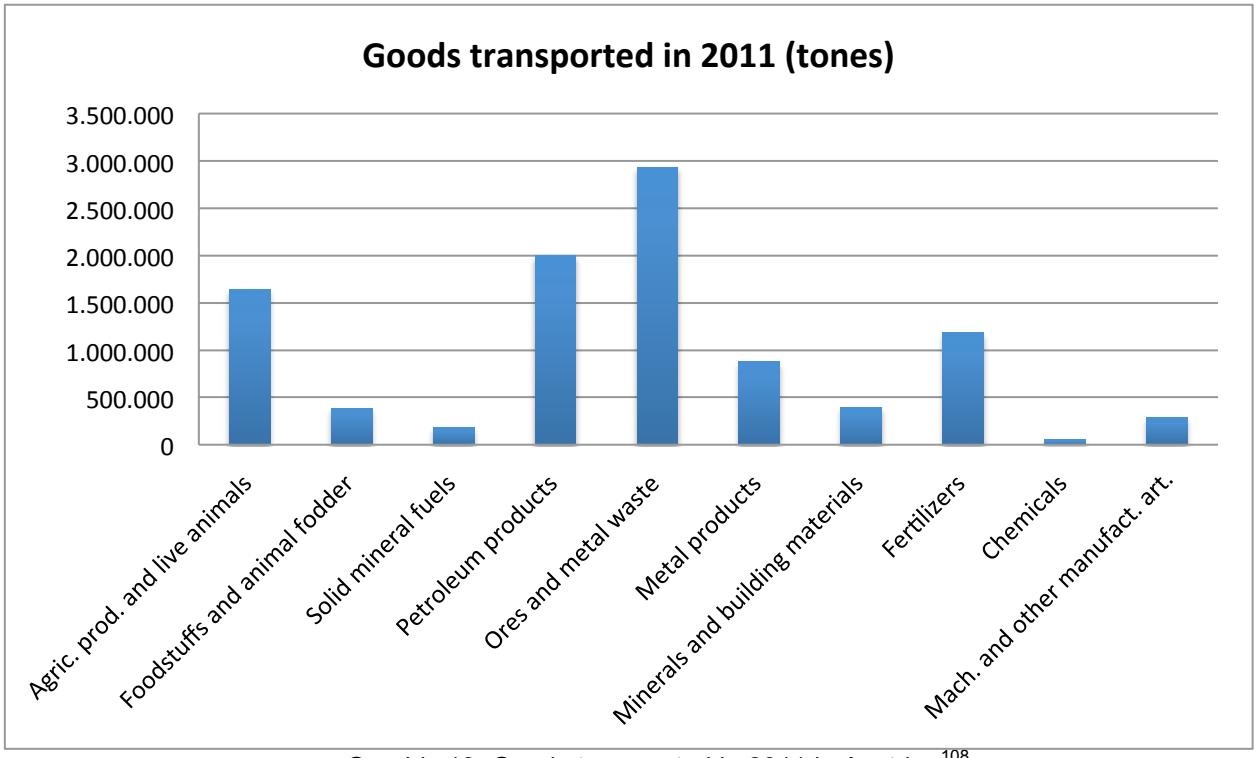
As it can be observed, in both years the most important mode of traffic was receipt. This means that most of half of the goods transported through inland waterways came from other countries to Austria. It can also be observed that dispatch and transit remained almost constant in the two analysed years. In addition, national transport suffered a significant increase, being in 2012 twice bigger than in 2011.

Nevertheless, inland waterway transportation can be analysed from different points of view. According the types of goods transported a table and a graphic are provided from years 2011 and 2012.

MODE OF TRAFFIC	National transport	Receipt	Dispatch	Transit	TOTAL
TYPE OF GOOD					
Agricultural products and live animals	10,652	557,638	94,921	979,027	1,642,238
Foodstuffs and animal fodder	-	295,069	33,448	59,598	388,115
Solid mineral fuels	-	173,838	-	9,300	183,138
Petroleum products	431,298	997,307	403,186	163,321	1,995,112
Ores and metal waste	204	2,930,486	4,327	-	2,935,017
Metal products	26,586	188,488	322,377	340,240	877,691
Minerals and building materials	93,856	193,114	30,649	78,308	395,927
Fertilizers	2,366	190,956	618,928	372,019	1,184,269
Chemicals	-	28,312	8,248	15,612	52,172
Machinery and other manufact. Articles	225	9,014	29,637	250,732	289,608

Table 9: Goods transported in 2011 in Austria [107]

[106] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)



Graphic 13: Goods transported in 2011 in Austria [108]

Observing both the table and the graphic some conclusions can be extracted. The most transported type of good, according to the weight, is “Ores and metal waste”, followed by “Petroleum products” and “Agricultural products and live animals”.

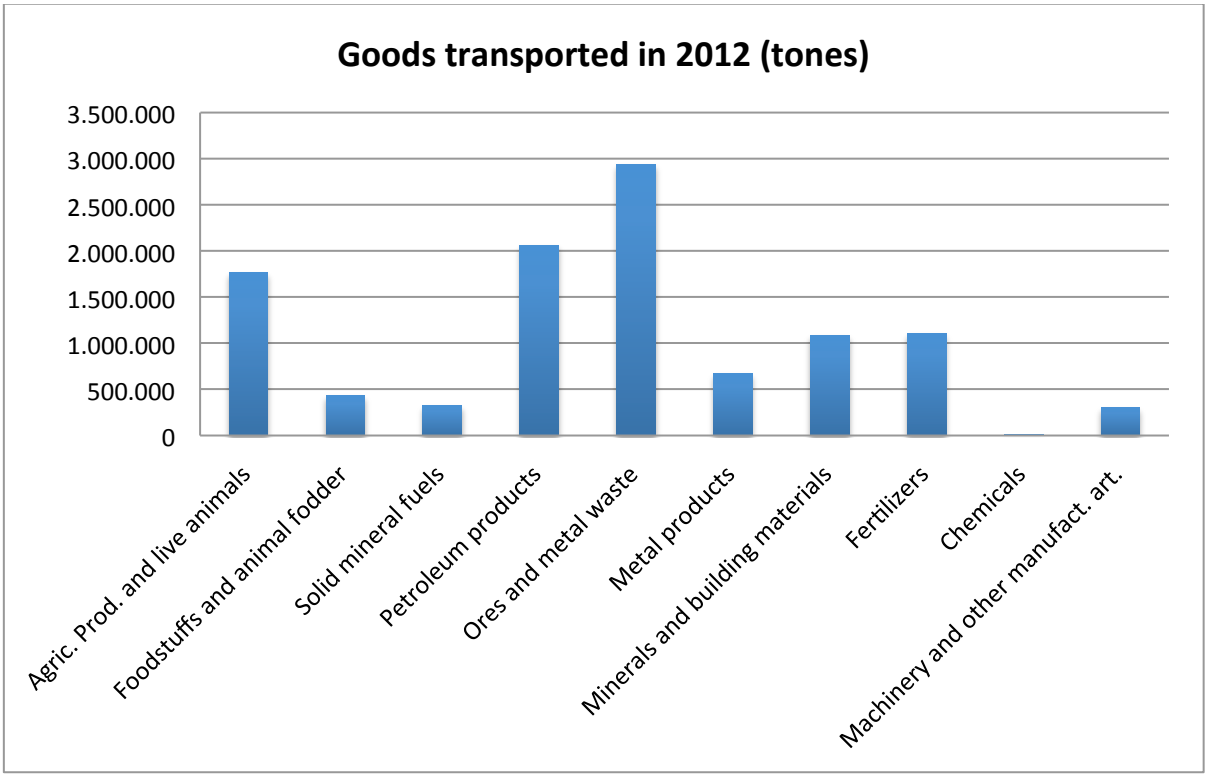
In relation to the mode of traffic, a different type of good dominates in each mode. The most transported type of good in 2011 inside Austria was “Petroleum Products”. The most received one was “Ores and metal waste” and the most dispatched one “Fertilizers”. On the other hand, the most dominant type of good that crossed Austria was “Agricultural products and live animals”.

MODE OF TRAFFIC	National transport	Receipt	Dispatch	Transit	TOTAL
TYPE OF GOOD					
Agricultural products and live animals	15,341	393,137	116,544	1,245,667	1,770,689
Foodstuffs and animal fodder	2,016	278,447	39,395	113,483	433,341
Solid mineral fuels	-	307,600	-	22,507	330,107
Petroleum products	467,794	913,547	502,899	177,068	2,061,308
Ores and metal waste	320	2,941,376	-	-	2,941,696
Metal products	23,926	166,866	300,753	179,602	671,147
Minerals and building materials	728,967	233,359	22,291	104,339	1,088,956
Fertilizers	1,393	143,800	598,495	363,477	1,107,165

[107] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)
[108] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)

Chemicals	-	1,561	3,942	1,790	7,293
Machinery and other manufact. Articl es	354	59,150	39,382	203,419	302,305

Table 10: Goods transported in 2012 in Austria [109]



Graphic 14: Goods transported in 2012 in Austria [110]

The data reported on 2012 is similar to the one of 2011, especially regarding to the dominances of goods in the different modes of traffic. Again the type of good most transported is “Ores and metal waste”, being “Petroleum products” and “Agricultural products and live animals”, second and third, respectively.

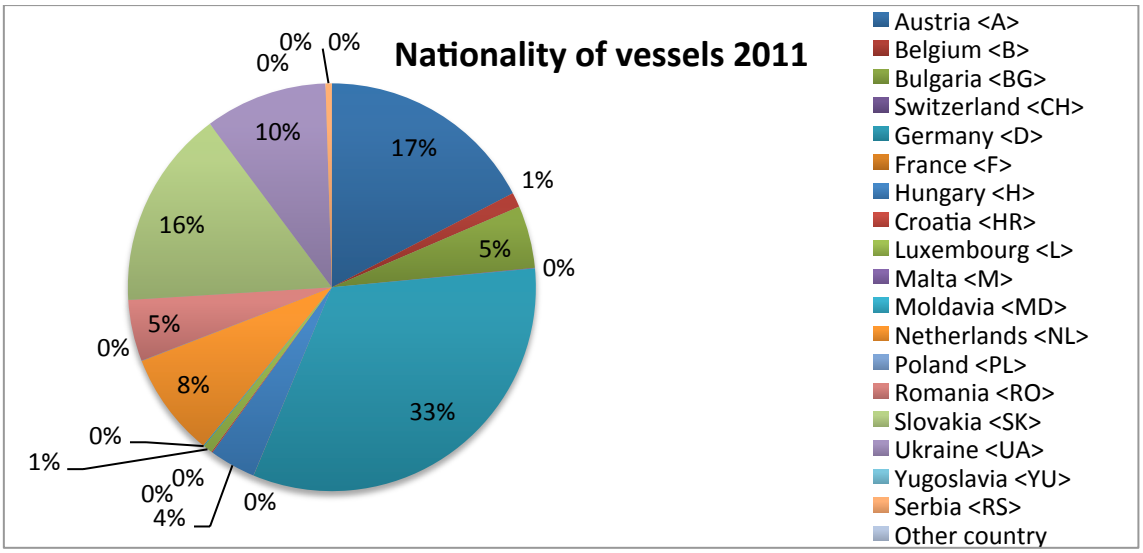
The most dominant type of good transported in Austria in 2012 was different than the one of 2011. “Mineral and building materials” was the most transported in national transport. On the other hand, receipts and dispatches were dominated by the same type of good in both years, being “Ores and metal waste” and “Fertilizers”. Furthermore, “Agricultural products and live animals” was the type of good recorded in Austria with a different destination.

As mentioned above, the weight transported as national transport in Austria by inland waterways was double in the second year of study. Also, the dominance of the type of good in this mode of traffic changed from “Petroleum Products” to “Mineral and building materials”. The increase has been caused by a rise of the weight transported

[109] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)
[110]

of this second type of good, being in 2012 almost eight times higher than in 2011. Even if the use of the building material and mineral transported is unknown and out of scope of the project, a big necessity of this type of good is expected to have been in Austria, caused by the aim of building new building or other similar causes. It should also be mentioned that the group “Mineral and building materials” has increased its importance in all the modes of traffic but dispatch, fact that reinforces the hypothesis of a bigger necessity of this type of good that in the previous year.

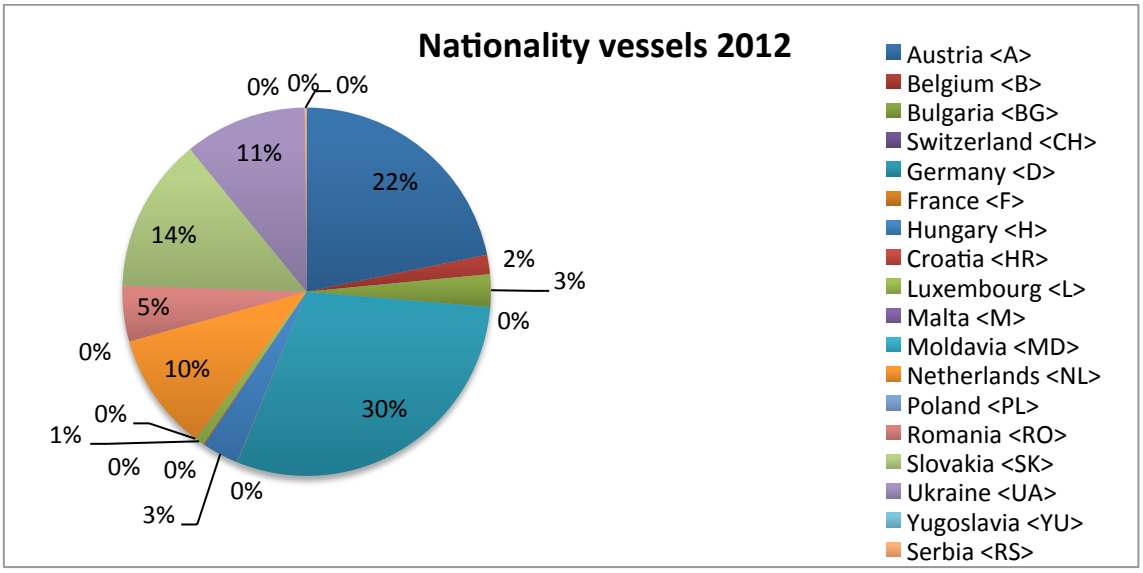
It is also interesting to analyse the nationality of the vessels flowing through the Austrian Danube. Even if two graphics are provided to visualize the proportion of the nationality of the vessels, a more detailed table can be found in the annex. It gives information about the tonnes transported by the vessels of the different countries, as well as the percentage that each country represents. In addition, this data is also classified into the four modes of traffic.



Graphic 15: Nationality of vessels 2011 [111]

As seen in the graphic about the nationality of the vessels, just a 17.37% of the vessels are Austrian. In addition, most of the vessels flowing in the Austrian Danube are from Germany. Slovakian vessels play also an important role, being almost 16% of them of this country. On the other hand, less than 4% of the vessels are Hungarian.

[111] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)



Graphic 16: Nationality of vessels 2012 [112]

This graphic shows an increase in the use of Austrian vessel, comparing to 2011, being this last year of 21.87%. In 2012 Germany was still the most dominating country, but it suffered a reduction of almost a 3%. Slovakia is still important, according the nationality of vessels, and Hungary represents around a 3%. The Netherlands also increased their importance.

A different lecture about the nationality of the vessel can be done. As said in the chapter related to the fleet of the countries of study, it is not mandatory to register the vessels in Austria. Therefore, it is not surprising that ship owners prefer to register their vessels in cheaper countries. According to this assumption, a significant proportion of the vessels registered in Slovakia are understood to belong to Austrian operators, due to the fact that the Slovak Republic is the following country in the course of the Danube and is expected to be cheaper for the ship companies.

Another important aspect to analyse is the direction of the vessels while flowing through the Austrian Danube. The following table gives information about this aspect. Despite the fact that this aspect could provide important information it has only been developed for Austria, due to the non-availability of data from the other two countries of study.

MODE OF TRAFFIC	National transport	Receipt	Dispatch	Transit	TOTAL
	Direction of travel				
2011	Upstream	439,504	4,346,824	785,336	1,858,635	7,430,299
	Downstream	125,684	1,217,398	760,386	409,522	2,512,990
2012	Upstream	479,374	4,169,834	768,098	1,999,642	7,416,948
	Downstream	760,737	1,269,010	855,603	411,709	3,297,059

[112] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)

Table 11: Direction of travel of the vessels and tonnes transported [113]

It can be observed that the most important flow along the Austrian part of the river is going upstream and with transit finality. It is also remarkable that the amount of tonnes carried inside Austria with a downstream direction was considerably increased. Focusing on this increase in the downstream direction, a relation with the types of goods transported has been found. As mentioned in the previous pages of this chapter a significant increase of “Mineral and building materials” was reported in 2012 in national transport. Concurrently an important increase is also reported in the downstream direction of the national transport. The expected hypothesis is that this increase of goods flowing downstream was caused by the mentioned type of good. Considering that the port of Linz is the most important port of the country it is expected that most of the minerals and building materials were loaded there. The unloading region is not that obvious. Regarding the region where more buildings are expected to be built, Vienna would be the chosen region. However, Upper Austria itself is another powerful candidate, as it unloaded more weight than the other Austrian Danube regions loaded in this same region.

On the other hand, most of receipts are in an upstream direction while the dispatches are done in both directions in a similar proportion.

Furthermore, the loading and unloading regions of the goods transported give also important information. An extended table is provided in the annex. Despite the fact that this project is especially focused on Austria, Hungary and Slovakia, loading and unloading data from the European Union countries is provided.

Loading and unloading in Austria is separated into three regions: Lower Austria, Upper Austria and Vienna. Significant information about the loading and unloading of the just mentioned Austrian regions is given.

In 2011 in Lower Austria 299,256 tonnes were loaded. In the category of national transportation, goods were unloaded in Upper Austria and Lower Austria itself, this last one in a much bigger proportion than the other one. Not receipts or transit were recorded. On the other hand, the country that received more tonnes of goods coming from Lower Austria was Romania, with 45,330 tonnes. Netherlands and Germany were the second and third, with 24,816 tonnes and 24,444 tonnes, respectively. [114]

In 2012, Lower Austria recorded 168,442 tonnes loaded, experimenting a significant reduction in the unloaded weight in Lower Austria, 26,452 tonnes in 2012, and an increase in Upper Austria, 7,544 tonnes. Dispatch information was also found and this year Romania was still the most important receiver of goods loaded in Lower

[113] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)
[114] c.f. http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)

Austria, 33,794 tonnes. A significant reduction was reported. Germany and the Netherlands switched positions but their values of goods unloaded remained almost constant. [114]

The region of Austria that loaded more tonnes of goods in both 2011 and 2012 was Upper Austria. The capital of this region is Linz, and considering that the most important port of Austria is located in this city, a bigger amount of weight loaded is expected. In 2011 in total 1,012,705 tonnes were carried and in 2012 1,662,500. It can be seen that a significant increase was done, of almost a 65%. [114]

Concerning the national transport, significant differences were reported in the two studied years. In 2011 the goods loaded in Upper Austria were unloaded in Lower Austria, 30,791 tonnes and Upper Austria, 36 tonnes. Nevertheless, in 2012 37,154 tonnes were unloaded in Lower Austria, 686,534 in Upper Austria and 597 in Vienna. The most surprising thing is the high increase of tonnes unloaded in Upper Austria coming from this same region. In order to assure that the data was correct other databases have been checked. However, no other information has been found and therefore, also due to the reliability of the current database, this information in considered correct. On the other hand, as mentioned before, this increase could be caused by the big amount of "Minerals and building materials" transported. [114]

The dispatch loaded in Upper Austria was unloaded in the following countries. Germany received 366,320 tonnes in 2011 and 289,501 in 2012, making it the most important country in receiving goods from this region. The second and third countries were Belgium and the Netherlands, with respectively 191,974 and 138,866 tonnes in 2011 and 171,683 and 141,074 tonnes in 2012. [115] This result is not surprising. As already mentioned Linz is the most important freight port of Austria, and as can be observed, is the one loading more tonnes of goods to transport them to other important countries of western Europe through the Rhine-Main-Danube Canal. It should also be reminded that these three countries are the ones with a highest proportion of the modal split of inland waterway transportation, with Romania and Bulgaria, in Europe (as shown in graphic 9), and the fact that the port of Linz is the one transporting more goods there reinforces it as the most important port of Austria.

Finally, the third region of study of Austria is its capital, Vienna. For this region 868,951 tonnes in 2011 and 1,032,899 tonnes in 2012 were recorded. It can be observed that more tonnes were loaded in the second year. Despite the fact that the other two Austrian regions didn't load high weight to be transported to Vienna, in the capital were loaded more tonnes to these destinations, especially in 2012. In other words, in 2011 540 tonnes were loaded in Vienna and unloaded in Lower Austria and 393,398 tonnes in Upper Austria. In 2012 16,757 tonnes were unloaded in Lower

[115] c.f. http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)

Austria, being this last weight more than thirty times higher than the one of 2011. Also, 403,647 tonnes were loaded in Vienna and unloaded in Upper Austria in 2012. [115]

Furthermore, the load from Vienna was unloaded in several European countries. The main receiver was Hungary, with 268,548 tonnes in 2011 and 286,410 tonnes in 2012. Slovakia was the second country in importance with 133,737 tonnes unloaded in 2011 and 100,981 in 2012. The third country was Germany but the load unloaded in this country coming from the Austrian capital was considerably smaller that the one of the just mentioned countries.[115] In this case, the data found was also expected. Although the most important port of Austria is located in Linz, the port of Vienna is also very important, especially regarding to the transport to east Europe. Slovakia and Hungary are the following countries in the course of the Danube and, as the port of Vienna is the closest to these countries, it is not surprising that these two countries are the ones unloading more loads from this port.

Loading and unloading goods can also be analysed from another point of view. In this case, the goods have been carried from other countries to be unloaded in the three regions of Austria. Nevertheless, Austria was in some cases a transit country, while the goods were received in other European countries. The following tables represent the weight loaded in the different European countries and unloaded in the three regions of Austria. A table for both 2011 and 2012 is provided. In addition, two graphics of the proportion of weight sent to Austria by the different European countries are provided.

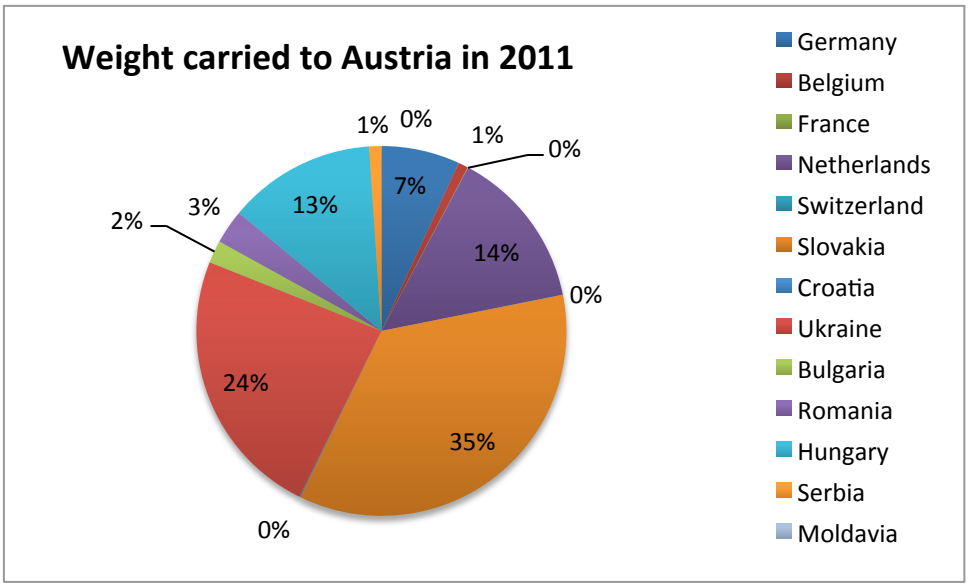
2011	UNLOADING REGION			
LOADING	**Lower Austria**	**Upper Austria**	**Vienna**	**TOTAL**
Germany	210,099	166,647	5,325	382,071
Belgium	34,969	3,907	9,049	47,925
France	-	1,374	880	2,254
Netherlands	112,806	658,788	12,359	783,953
Switzerland	-	1,194	-	1,194
Slovakia	436,380	1,478,592	51,636	1,966,608
Croatia	3,690	-	1,101	4,791
Ukraine	113,275	1,203,231	4,891	1,321,397
Bulgaria	20,681	83,271	6,105	110,057
Romania	132,429	29,529	3,442	165,400
Hungary	427,117	257,875	33,900	718,892
Serbia	12,626	16,314	30,737	59,677
Moldavia	-	-	-	-
TOTAL	1,504,072	3,900,720	159,425	**5,564,219**

Table 12: Tonnes transported from European countries to Austria in 2011 [116]

Analysing the table it can be said that the country that sent more tonnes of goods to Austria in 2011 was Slovakia, with an amount of 1,966,608 tonnes. The second was Ukraine with 1,321,397 tonnes. On the other hand, Austria unloaded a total of 5,564,219 tonnes. Focusing on the regions, Lower Austria received goods mostly from Hungary and Slovakia, followed by Germany. It is remarkable that these three countries are the previous and following in the course of the Danube River. Upper Austria was the region that unloaded more tonnes of goods. The main provides were again Slovakia and Ukraine, with 1,478,592 tonnes and 1,203,231 tonnes, respectively. Finally, Vienna was the region that received less weight, 159,425 tonnes. In this case were Slovakia and Hungary the most important providers.

Comparing the loads and unloads between the Austrian regions and the just mentioned European countries an interesting fact has been remarked. Most of the goods transported from Austria to Slovakia were loaded in Vienna. Concurrently, the majority of the goods transported from the Slovak Republic to Austria were unloaded in Upper Austria. The main hypothesis reached is that Austrian operators use the port of the capital due to the proximity to the Slovakian border, probably to safe fuel and time. However, Slovakian operators unload their loads in the port of Linz. This is probably encouraged by the huge storage area for the different types of goods[117].

The following graphic represents the proportion of weight sent of each European country connected to Austria by inland waterways.



[116] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)

[117] c.f. http://www.worldportsource.com/ports/commerce/AUT_Port_of_Linz_2858.php (Read 20.06.2014)

Graphic 17: Percentage of weight sent by European Countries to Austria in 2011 [118]

Generally, Slovakia was the most important sender of goods to Austria, regarding to the tonnes transported. More than a third of the weight received was carried from this country. The second country in importance was Ukraine. Comparing the table and the graphic it is observed that the most important unloading of this country was in Upper Austria, while its role in the other Austrian regions is much less important. Third and fourth were the Netherlands and Hungary.

A parallel analyse has been done of the year 2012.

2012	UNLOADING REGION			
LOADING	**Lower Austria**	**Upper Austria**	**Vienna**	**TOTAL**
Germany	125,062	183,398	12,127	320,587
Belgium	61,877	15,894	14,733	92,504
France	461	-	3,634	4,095
Netherlands	91,663	749,521	10,639	851,823
Switzerland	-	-	-	-
Slovakia	288,246	1,355,414	14,354	1,658,014
Croatia	2,097	-	-	2,097
Ukraine	206,560	1,048,292	-	1,254,852
Bulgaria	33,305	33,661	5,074	72,040
Romania	133,360	291,620	4,062	429,042
Hungary	410,610	274,990	57,549	743,149
Serbia	-	75	10,566	10,641
Moldavia	-	-	-	-
TOTAL	1,353,241	3,952,865	132,738	**5,438,844**

Table 13: Tonnes transported from European countries to Austria in 2012 [119]

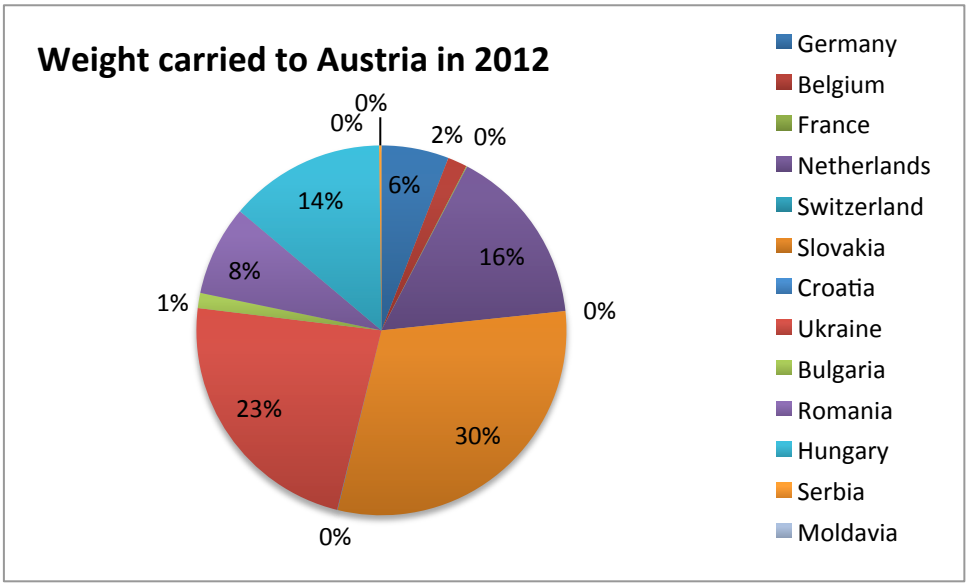
In 2012 the total amount of tonnes received in Austria was 5,438,844. This represents an increase of 1.4% in comparison to 2011. As happened in 2011, the region that unloaded more weight was Upper Austria, followed by Lower Austria. This region, which Linz is its capital, was also the one that sent more goods in the years 2011 and 2012. This fact reaffirms Linz as the most important port of Austria.

Lower Austria unloaded 1,353,241 tonnes in 2012 and Hungary was the main provider. This region suffered a reduction of a 10% in the weight downloaded in comparison with 2012. It is also remarkable that Germany was no longer the third country as in 2011 but the fifth, gaining importance Ukraine and Romania. Slovakia was again the second most important country in this region. Nevertheless, Upper Austria recorded a weight of 3,952,865 tonnes unloaded. This represents an increase of a 1.3%. Slovakia and Ukraine were again the countries that sent more goods, in

[118] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)
[119] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)

tonnes, to this part of Austria. On the other hand, Vienna unloaded 5,438,844 tonnes. The capital of Austria suffered a significant reduction, of almost a 17% comparing to 2011. Hungary was, by far, the country that sent more goods to Vienna, followed by Slovakia and Belgium.

A graphic to help the visualization of the role of the countries in the sending of tonnes of goods to Austria through the Danube Rives was also done.



Graphic 18: Percentage of weight sent by European Countries to Austria in 2012 [120]

The following information can be extracted from the graphic. Slovakia was again the country that dispatched more weight of goods to Austria. However, a reduction of almost a 5% was recorded. The second was Ukraine and the third Netherlands. This last one increased its dispatches around a 1.5%. Hungary played also an important role.

7.2 Slovakia

An analysis about Slovakia has also been done. In this case the data was taken from a publication of the Statistical Office of the Slovak Republic, “Yearbook of Transport, Posts and Telecommunications in 2013”. As said in the introduction of the chapter, the found data is until the year 2012 and therefore the analysis is focused on the years 2011 and 2012.

In order to follow a structure as similar as possible to the analysis of Austria, the starting point is the total freight transported in Slovakia during the two years of study and the proportion of the inland waterway mode. In 2011 178,733 thousand tonnes

[120] source: http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)

were transported in Slovakia, being almost the 1.4 %, 2454 thousand tonnes, transported by inland waterways. In 2012 the total freight transported was 7,145 thousands of tonnes, of which 2,472 by inland waterways. This represents a 1.4 %. It can be observed that the total amount transported was reduced in the second year of study; meanwhile the inland waterway transportation suffered an increase.[121]

It is also interesting to study the mode of traffic of the goods transported. This part has been done from two different points of view: the goods transported by operators which have a license and by all providers of the inland waterway transport on the territory of the Slovak Republic regardless of their registration country of ship. A table for each classification is provided.

	National Transport	Import	Export	Transit	Cross trade transport	TOTAL
2012	38	95	1,595	323	421	2,472
2011	58	119	1,674	352	251	2,454

Table 14: Goods transported in Slovakia by operators with license in thousands of tonnes [122]

Regarding to the operators that have a license, the mode of traffic has been classified in five categories. It is important to distinguish between the terms “transit” and “cost trade transport”. Thus, the OECD Statistic Platform has been checked. “Transit” refers to “inland waterways transport through a country between two places (a place of loading/embarkment and a place of unloading/disembarkment) both located in another country or in other countries provided the total journey within the country is by an inland waterway transport vessel and that there is no loading or unloading in that country”. On the other hand, the term “cross trade transport” refers to “international inland waterways transport performed by an inland waterway transport vessel registered in a third country”.[123]

Focusing on the data provided in the table, an increase is observed in the total amount of goods transported by operators with a license from 2011 and 2012. However, this increase was only produced by a rise in the tonnes of cross trade transport, meanwhile all the other categories suffered a reduction in weight transported.

The following table provided gives information of the thousands of tonnes of goods transported considering all providers of the inland waterway transport on the territory of the Slovak Republic regardless of their registration country of ship. In this case just four indicators and the total addition are used.

[121] c.f. Yearbook of transport, posts and telecommunications in 2013 (2013)
[122] source: Yearbook of transport, posts and telecommunications in 2013 (2013)
[123] http://stats.oecd.org/glossary/detail.asp?ID=4179 (Read 20.06.2014)

	National transport	Import	Export	Transit	TOTAL
2012	38	168	2,756	5,280	8,242
2011	58	224	2,997	4,932	8,211

Table 15: Goods transported in Slovakia by all providers of the inland waterway transport regardless of their registration country of ship. Expressed in thousands of tonnes [124]

Comparing the results of the years 2011 and 2012, again a total increase is reported in the second year. In this case, the only increase is done in the amount of weight of goods transported in the transit mode.

It should also me mentioned the importance of the transit mode of traffic, which was expected. Slovakia is located between Austria and Hungary and therefore its waterways are crossed to develop the transportation between west and east Europe. Therefore, it is not surprising that Slovakian waterways are more used to haulage between other countries than shipping with it.

In addition, a comparison of the two tables done by the two different criteria is also interesting. The national transport in Slovakia was only developed by Slovak vessels with license, while the other modes of traffic were also developed by foreign ships. Another aspect is that the total amount of goods transported by Slovak vessels that have a license represent just a third of total amount of goods transported through inland waterways in the country.

Furthermore, the average of transport distance of freight transport recorded in Slovakia in 2011 and 2012 by enterprises with transport as prevailing activity was 461.7 km and 465.6 km, respectively. [125] In other to extract a conclusion it should be reminded that the Slovakian Danube has a length of 172 km.[126] It can be observed that the average distance travelled is much higher than the length of the Danube River in this country and that, as a result, the international shipping results to be again much more important than the national.

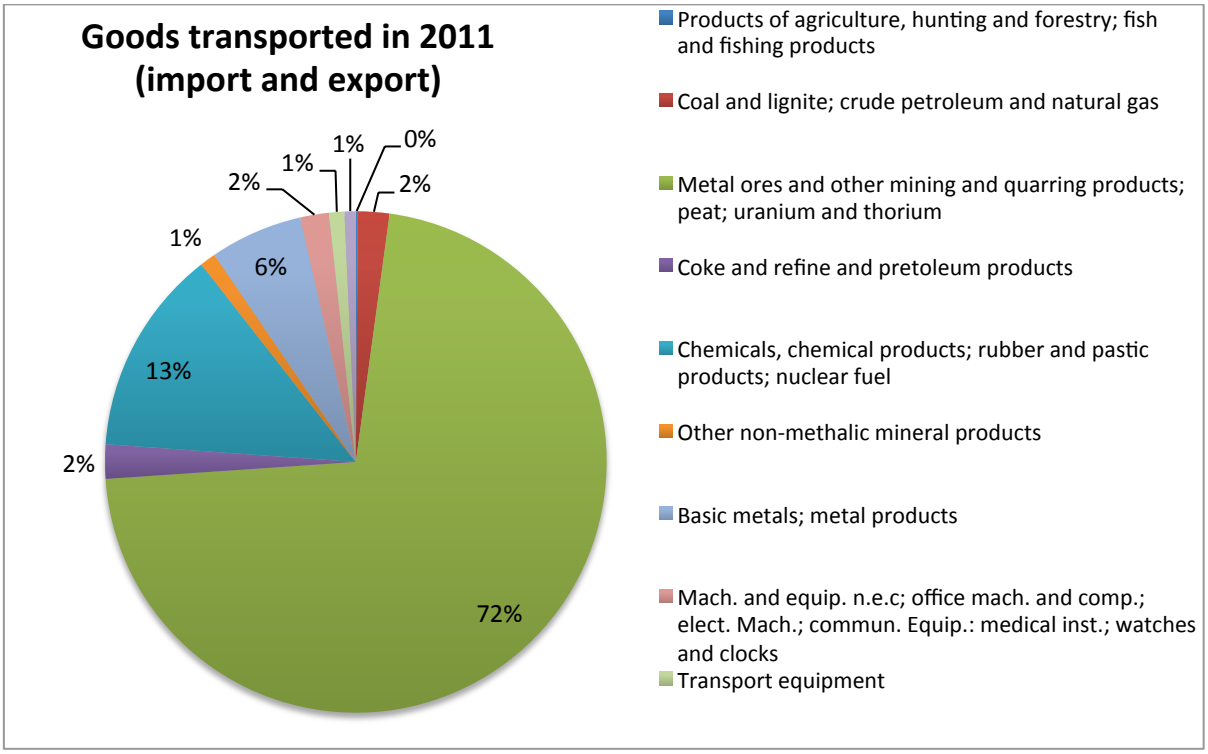
The analysis of the types of good transported was also done. In this case the data found was the transport of goods of inland waterway public transport by individual types of goods for enterprises with the number of employees 20 and more. However, the classification could only be done for the import and export mode. Tables and graphics are provided.

2011 (tonnes)			
TYPE OF GOOD	IMPORT	EXPORT	**TOTAL**
Total	34,102	1,632,058	**1,666,160**
Products of agriculture, hunting and forestry; fish and fishing products	-	2,205	2,205

[124] source: Yearbook of transport, posts and telecommunications in 2013 (2013)
[125] c.f. Yearbook of transport, posts and telecommunications in 2013 (2013)
[126] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_if_infrastr&lang=en (Read 19.06.2014)

Coal and lignite; crude petroleum and natural gas	1,500	32,200	33,700
Metal ores and other mining and quarrying products; peat; uranium and thorium	-	1,195,734	1,195,734
Coke and refine and petroleum products	-	36,807	36,807
Chemicals, chemical products; rubber and plastic products; nuclear fuel	-	221,727	221,727
Other non-metallic mineral products	17,063	-	17,063
Basic metals; metal products	-	99,569	99,569
Machinery and equipment n.e.c; office machinery and computers; elect. Machinery; common. Equipment: medical inst.; watches and clocks	2,000	28,772	30,772
Transport equipment	1,433	15,044	16,477
Other goods n.e.c.	12,106	-	12,106
TRANSIT			267,950
CROSS-TRADE TRANSPORT			94,494

Table 16: Goods transported in 2011 in Slovakia [127]



Graphic 19: Goods transported in 2011 in Slovakia [128]

The table and the graphic provide the following information. As already mentioned, even if the data taken included not the same operators, export is much more important in Slovakia's transport than import. More than a 70% in weight of the goods transported belonged to the group "Metal ores and other mining and quarrying products; peat; uranium and thorium". It can be observed that these goods where exported but not imported. The second most important group of goods was

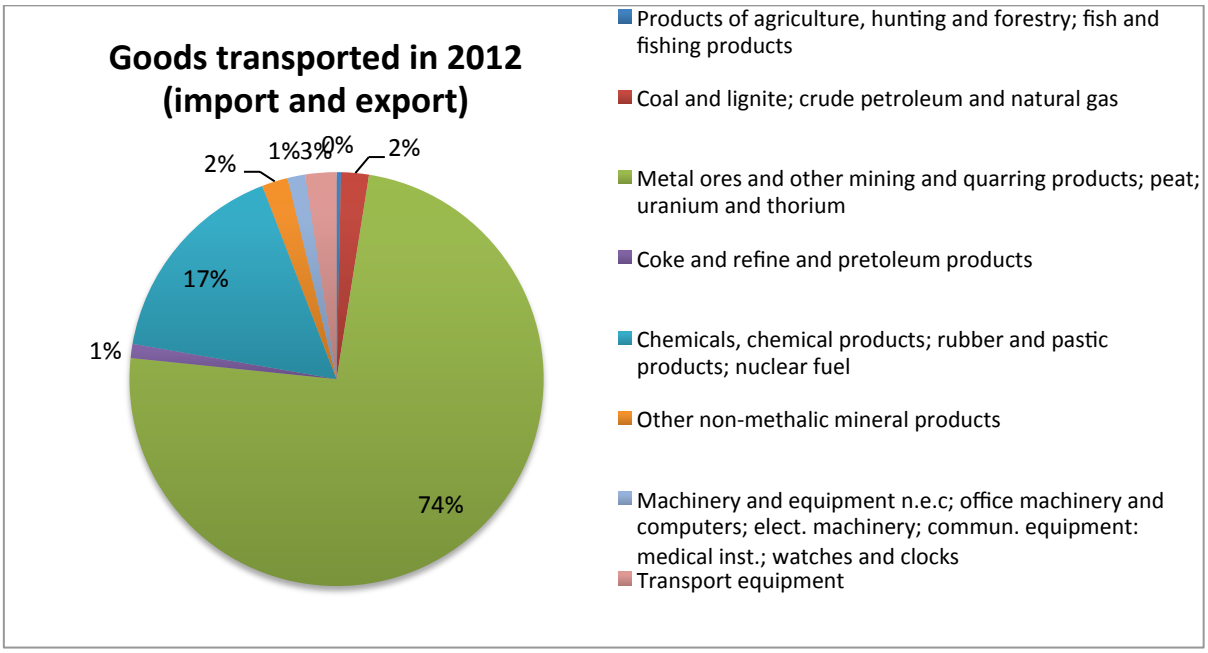
[127] source: Yearbook of transport, posts and telecommunications in 2013 (2013)
[128] source: Yearbook of transport, posts and telecommunications in 2013 (2013)

"Chemicals, chemical products; rubber and plastic products; nuclear fuel", again only for exporting. The most important imported good was "other non-metallic mineral products".

Moreover, the table and the graphic where also developed using the data of 2012.

2012 (tonnes)			
TYPE OF GOOD	IMPORT	EXPORT	**TOTAL**
Total	35,231	1,552,661	**1,587,892**
Products of agriculture, hunting and forestry; fish and fishing products	1,000	4,441	5,441
Coal and lignite; crude petroleum and natural gas	0	34,448	34,448
Metal ores and other mining and quarrying products; peat; uranium and thorium	1,003	1,175,865	1,176,868
Coke and refine and petroleum products	0	17,477	17,477
Chemicals, chemical products; rubber and plastic products; nuclear fuel	0	260,873	260,873
Other non-metallic mineral products	32,228	0	32,228
Machinery and equipment n.e.c; office machinery and computers; elect. Machinery; common. Equipment: medical inst.; watches and clocks	1,000	20,843	21,843
Transport equipment	0	38,723	38,723
TRANSIT			183,588
CROSS-TRADE TRANSPORT			246,105

Table 17: Goods transported in 2012 in Slovakia [129]



Graphic 20: Goods transported in 2012 in Slovakia [130]

Again in 2012 the most transported good was "Metal ores and other mining and quarrying products; peat; uranium and thorium". Nevertheless, this group gained importance, representing more than a 74% in 2012 in comparison to the 71.8% in

[129] source: Yearbook of transport, posts and telecommunications in 2013 (2013)
[130] source: Yearbook of transport, posts and telecommunications in 2013 (2013)

2011. The second most important group of goods, again “Chemicals, chemical products; rubber and plastic products; nuclear fuel”, gained importance form a 13.3% to a 16.4% in 2012. Similarly to 2011, the most imported type of good in 2012 was “Other non-metallic mineral products”.

It is also remarkable that in the table and graphic of 2011 ten different types of goods were considered, while in 2012 just eight were found. This difference is resulting from the non-availability of the data of the two missing groups in 2012.

The analysis of the nationality of the vessels navigating in the Slovak Republic inland waterways need also to be done. Therefore, the information of the homeland country of the vessels will be known and also the information given in the table 18 will be completed. The following table contains the just mentioned information of the years 2011 and 2012.

	2011		2012	
	Import and Export	Transit	Import and Export	Transit
Belgium	-	36	-	100
Bulgaria	21	474	22	304
Netherlands	80	362	41	619
Hungary	-	300	-	235
Germany	514	1,248	419	1,326
Austria	1,065	742	1,056	810
Romania	56	437	71	410
Slovakia	1,408	352	1,236	310
Serbia	-	47	-	17
Ukraine	37	874	34	1,094
TOTAL	**3,221**	**2,924**	**4,932**	**5,280**

Table 18: Nationality of the vessel and goods transported in thousands of tonnes [131]

In the first place it should be mentioned that the total amount expressed at the end of each column does not correspond with the exact result of the addition of the components of the columns. This is probably due to the fact that the information of each country is expressed in thousands of tonnes, and therefore approximations have been done.

In order to study the information contained in the table, it should be added that the national transport was developed by vessel registered in Slovakia. As shown in the table, Austrian and Slovakian vessel mainly developed importations and exportations, while the main country of registration of vessels in transit was Germany, followed by Ukraine. In general, imports and exports got reduced and transit increased. As assumed in the Austrian part of the chapter, a proportion of the vessels

[131] source: Yearbook of transport, posts and telecommunications in 2013 (2013)

registered in Slovakia are expected to belong to Austrian operators. Therefore, the transit of goods developed by Slovakian vessels could be explained.

Besides the nationality of vessels, the imports and exports developed by the different countries are also analysed. Therefore a table for the imports and the exports has been developed with the information of the relevant countries.

IMPORT			EXPORT		
	2011	2012		2011	2012
Bulgaria	-	1,000	**Netherlands**	-	-
Netherlands	-	-	**Croatia**	-	-
Hungary	1,433	1,000	**Hungary**	4,963	29,466
Germany	-	-	**Germany**	229,812	272,873
Austria	29,169	33,231	**Austria**	1,360,725	1,215,411
Romania	1,500	-	**Romania**	13,670	34,911
Serbia	2,000	-	**Serbia**	22,888	-
TOTAL	34,102	35,231	**TOTAL**	1,632,058	1,552,661

Table 19: Tonnes imported and exported by the different countries in 2011 and 2012 [132]

According to the information provided in the table, Austria is the most important country regarding to imports and exports. The amount of goods transported represents 85.5% and 94.3% of the total of goods imported to Slovakia in 2011 and 2012. The percentages of the tonnes exported to Austria in these two years are: 83.4% and 78.3%. The imports coming from the neighbour country were significantly increased and the exports decreased. As mentioned in the Austrian part of the chapter, Slovakia is also Austria's major importer and exporter, regarding to the weight transported through the Danube River. Comparing the analysis done for the two countries a conclusion has been extracted. Most of the goods imported to Slovakia came from Austria and most of the goods exported were transported to the same country. However, comparing both weights, it can be said that the amount transported from the Slovak Republic was more than ten times higher than in the other direction by the mode of transport of study. Therefore it can be said that Slovakian imports play a reduced role in inland waterway transportation. On the other hand, it would also be interesting to study the other direction of the just mentioned assumption. The importance of inland waterways in the Slovakian importations is out of scope and just the information given in the modal split is provided. Nevertheless, it should be mentioned that the modal split refers just to inland modes of transport and uses the performance of the mode of transport and not the weight carried.

[132] source: Yearbook of transport, posts and telecommunications in 2013 (2013)

7.3 Hungary

Even if the analysis of the inland waterway transport of this country was intended to be parallel, or at least similar, to the one of the Austria and Slovakia, due to the non-availability of the data, only some aspects could be analysed.

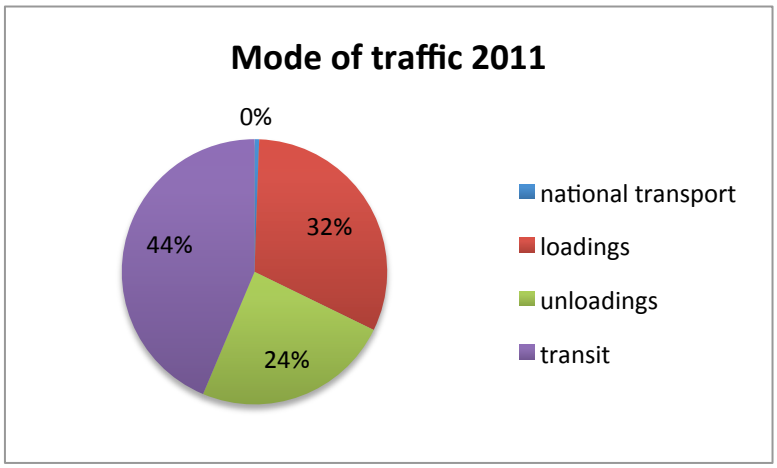
In order to develop the study, most of the data was taken from "KSH", Hungarian Central Statistical Office. Also, as already mentioned in the introduction of the chapter, the Hungarian data is not as current as the one of the other two countries, and therefore most of the analysis has been done with data from 2011.

In 2011 an amount of 263 millions of tonnes were transported in Hungary and a 2.7% of it, 7,187 thousands of tonnes, through inland waterways. [133]

The importance of the modes of traffic in weight in this country could be calculated and, as a result, a graphic and a table are provided.

	National transport	International transport		Transit	TOTAL
		Loading	Unloading		
2011	37	2,076	1,581	2,863	7,187

Table 20: Thousands of tonnes of goods transported in Hungary [134]



Graphic 21: Distribution of the mode of traffic in inland waterways in 2011 [135]

In the case of Hungary, more than half of the transport was international transportation, separated into the goods loaded and unloaded in the country. It can be observed that the loading was more important than the unloading, fact that expresses a bigger proportion of exports than imports. It is also remarkable the importance of the transit across Hungary, with a percentage of 39.8%.

[133] c.f. http://www.ksh.hu/docs/eng/xstadat/xstadat_annual/i_odmv003.html (Read 20.06.2014)
[134] source: Decrease in domestic goods transport – stagnant passenger traffic, Transport performances, 2011.
[135] source: Decrease in domestic goods transport – stagnant passenger traffic, Transport performances, 2011.

Following this direction of study, the mode of traffic has been analysed from another point of view. In this case the unit of measure are the movements done by the vessels in the Hungarian inland waterways and data from 2011 and 2012 was found. This part of the analysis was done from data taken from the Eurostat database. The table below gives the just mentioned information.

		National transport	International transport	Transit	TOTAL
2011	Loaded	105	4,704	2,870	7,679
	Empty	0	0	693	693
	TOTAL	105	4,704	3,563	**8,372**
2012	Loaded	105	5,047	2,686	7,838
	Empty	0	0	418	418
	TOTAL	105	5,047	3,104	**8,256**

Table 21: Vessel movement in Hungary in 2011 and 2012 [136]

Comparing both years it can be said that a reduction in the total number of movements was suffered in 2012. It was caused by a reduction in the number of transit movements, which could not compensate the increase in the number of movements of international transport. The national transport remained constant. It should also be mentioned that none of the national or international movements where done by empty vessels. A conclusion to explain the reduction in traffic couldn't be found but as it is smaller than a 10% it is not considered to be determining. On the other hand, all the empty vessel movements were considered transit transport, representing almost a 20% of the transit movements.

In order to extract more information, the two analyses of the modes of traffic have been compared. As the data found of the weight transported was from 2011, this comparison has been done with the information of this year.

	National transport	International transport	Transit	TOTAL
Thousand tonnes	37	3,657	2,863	7,187
Movements	105	4,704	2,870	7,679
Th. Tonnes / mov.	0.35	0.78	1.00	0.94

Table 22: Mode of traffic in 2011 [137]

The last line of the table gives the information of the average of thousands of tonnes of goods transported in one vessel, considering that every movement was done by just one carrier. As a result it can be said that the national transportation vessels are the ones that carry less weight, probably because of the size of the vessel and the distance travelled. It must also be mentioned that the only transit movements considered have been the ones done with the vessel loaded. Therefore, it is

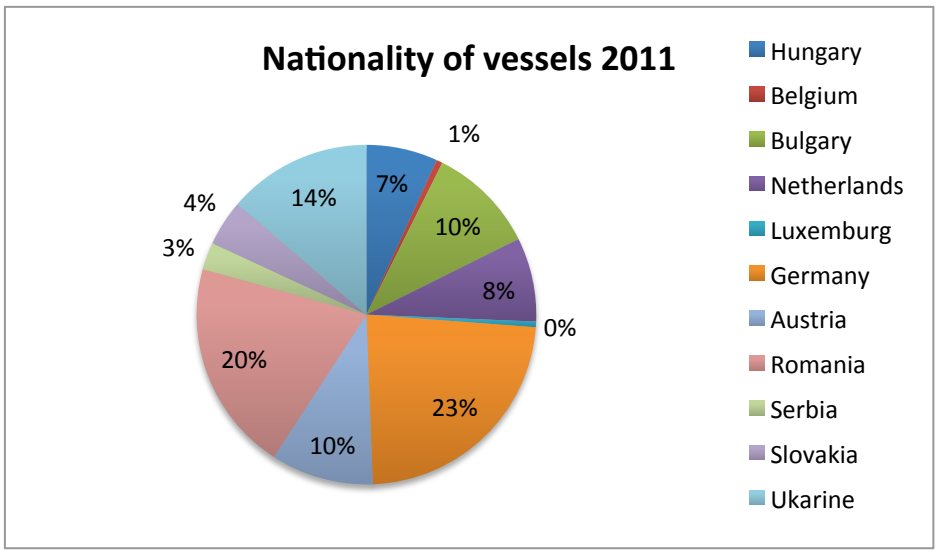
[136] source: Decrease in domestic goods transport – stagnant passenger traffic, Transport performances, 2011.
[137] source: Decrease in domestic goods transport – stagnant passenger traffic, Transport performances, 2011.

appreciable that transit vessels are the ones, in average, carrying more weight. This last fact is not surprising as a long distance travelled is expected. Considering that the Hungarian Danube has a length of 419 km[138], this is the minimum distance travelled by vessels while flowing through Hungary without loading or unloading goods. As a consequence, longer distances are expected to be travelled and big and powerful vessels are needed.

Finally, the last part of the Hungarian analysis is focused on the nationality of the vessels. In this case the data found was again only from 2011. The following table and graphic provided give more complete information.

	National transport	International transport		Transit	TOTAL
		Loading	Unloading		
Hungary	8	175	39	261	483
Belgium	-	25	5	10	41
Bulgaria	-	163	70	499	732
Netherlands	-	294	119	155	568
Luxemburg	-	23	15	-	38
Germany	1	1,001	276	373	1,651
Austria	2	239	160	292	694
Romania	-	429	656	347	1,432
Serbia	1	143	13	29	185
Slovakia	25	105	31	150	311
Ukraine	-	104	184	687	975
TOTAL	37	2,076	1,581	2,863	7,187

Table 23: Nationality of the vessels and weight transported in thousands of tonnes [139]



Graphic 22: Importance in weight of the nationality of the vessel [140]

[138] http://www.naiades.info/funding/policy.php?id=424&path=214,257&f_lang=EN&country=HU (Read 19.06.2014

[139] source: Decrease in domestic goods transport – stagnant passenger traffic, Transport performances, 2011.

As shown in the graphic, the most important nationality of the vessels in weight transported in Hungary is Germany, followed by Romania. The percentage of weight carried by Hungarian vessels is considerably small, especially comparing to the Austrian and Slovakian case.

Focusing on the detailed data it is interesting to comment the nationality of the vessels performing the national transport, especially as Hungarian vessels represent a 21.6%. In this case the non-obligation of the registration of Hungarian vessels in Hungary is unknown, albeit it could explain the small proportion of weight carried by Hungarian vessel in national transport.

The international transportation is mainly dominated by Germany and Romania. The former country has the biggest importance regarding the nationality of vessels in loading, while the second in the unloading. Furthermore, Ukraine and Bulgaria are the biggest agents in transit.

In addition, it should be mentioned that, due to the non-availability of the data, the study of the Hungarian waterways regarding the types of goods transported couldn't be developed.

7.4 Comparison

In order to sum up and compare the information given in the chapter a comparison has been developed.

Concerning the total amount of tonnes of goods transported in the three countries, Austria is by far the most important, followed and Hungary. Regarding the inland waterway transport, Austria was again the biggest transporter, transporting almost 40% more tonnes of goods than Hungary and four times the amount transported by the Slovak Republic. The comparison was done with the data from 2011.

In addition, the distribution of the modes of traffic has also been compared. In 2011 in Austria national transport represented a 6%, meanwhile this mode of traffic was much less important in the other two countries, with an importance of less than 1%. Receipts were also very important in Austria and almost negligible in Slovakia. On the other hand exports were more important in Slovakia than in the other two countries. Transit played an important role in the three countries, especially in Slovakia.

The nationality of the vessels can also be compared within the three countries. Germany was in all the cases the most, or one of the most, important countries according to this indicator. Slovakian vessels were also very important in Slovakia

[140] source: Decrease in domestic goods transport – stagnant passenger traffic, Transport performances, 2011.

and the Austrian vessels in Austria got a second position. However, Hungarian vessels performed only around a 7% of the Hungarian inland waterway transportation.

Finally, the importance in weight of the types of goods has also been compared. In this case only Austria and Slovakia have been considered and the year of study was 2012. Even if the name of the types of goods is not the same in both countries, it is not difficult to identify the corresponding group between the countries. In both cases the type of good most transported was the one transporting metal ores and other similar products.

As considered in the other chapters, climate change can also influence the types of goods transported, especially due to the fact that the production of goods and services of the sector can be affected. The most vulnerable sector by weather events is the agricultural sector. On global scale especially the increase in temperature may have a substantial impact on patterns in production and, therefore, the associated patterns in trade and freight transport. [141] This fact might not have a big repercussion in Slovakian transportation as the goods transported of this sector represent a minority of its total transportation. On the other hand, Austria can be more vulnerable to climatic change and weather events as “Agricultural products and live animals” is the third type of good in importance transported.

Furthermore, due to climatic change, the demand for energy during the winter in moderate climatic zones is expected to decline. This fact may lead to a decrease in demand of oil and coal in electricity production, having implications for transport fuels.[142] Nevertheless, it can also affect freight transport, as fewer goods will need to be transported. Again is Austria the country that could be more affected, as the types of goods related to the energy production are more important in the inland waterway transportation of this country.

[141] c.f. Koetse, M. J.; Rietveld, P. (2009), p. 210.
[142] c.f. Koetse, M. J.; Rietveld, P. (2009), p. 211.

8 Inland waterway transportation between Austria and Hungary

In the previous chapter an analysis about the inland waterway transportation of Austria, Slovakia and Hungary has been done. Nevertheless, in this chapter, a more detailed study will be performed.

As the topic of the project is the regional divergence regarding the transport flows within the Danube region, detailed data has been searched to study the amount of goods transported through this part of the river. It should also be mentioned that even if the three countries of study are relevant for the thesis, the most interesting flow of goods is the one developed between Austria and Hungary. This fact is caused by the higher GDP of the two countries and the biggest infrastructure of Austria and Hungary comparing to Slovakia. Moreover, data about the transport of goods by type of good has been found about Austria and its relationship to the other two countries of study. Therefore, a detailed analysis between the flow of goods between Slovakia and Hungary couldn't be performed due to the non-availability of the data.

In order to make the study complete and be able to take as much information as possible, the transport flow of goods between Hungary and Austria has been analysed from different points of view, going from a general perspective to the most specific one.

As a starting point, the total inland waterway transport between these two countries has been considered. In 2012 Hungary exported to Austria 743,148 tonnes of goods through the Danube River, meanwhile the exports on the other direction were 374,393 tonnes. It is appreciable that the amount of goods loaded in Hungary and unloaded in Austria are almost twice the ones loaded in Austria. Even if every type of good and mode of transport is different, generally speaking Austria received more tonnes of goods from Hungary than in the other direction. Many hypothesis can be developed to explain this fact but the one chosen is that as Hungary is considered to be cheaper that Austria, Austrian companies are importing goods from the other country to reduce costs. However, as said, this is just a hypothesis and the verification of it is out of scope of the project.

In order to analyse the role of inland waterway transportation between these two countries, a summarizing table and an analysis are provided.

	Railways	Road	Inland waterways	Total
Hungary to Austria	5,877,734	315,423	743,148	6,936,305
Austria to Hungary	1,863,033	200,140	374,394	2,437,567

Table 24: Tonnes transported between Hungary and Austria in 2012 by modes of transport [143]

Observing the table it can be said that the most important mode of transport between Austria and Hungary is railways, being in both directions significantly bigger than the other modes. The second mode of transport in importance is, also in both directions, the use of inland waterways. In order to express how different is the importance between the modes of transport the percentages of the weight carried have been calculated and written in the following table.

	Railways	Road	Inland waterways
Hungary to Austria	84.7%	4.5%	10.7%
Hungary	17.5%	78.7%	3.7%
Austria to Hungary	76.4%	8.2%	15.4%
Austria	19.4%	78.1%	2.5%

Table 25: Percentage of weight of the goods transported in 2012 [144] [145]

As already mentioned the use of railways is most important mode of transport between these two countries. It is interesting to compare the results found in table 25. It should be mentioned that the percentage of weight is not corresponding with the modal split one due to the units used. In order to develop the modal split analysis, tonnes per kilometre were used as unit. In this case, however, the unit used is tonnes and therefore just the weight carried is taken into account, independently of the distance travelled. It can be observed that in both years, the percentage of weight of each mode of transport carried in the total country does not correspond to the one of the transportation between these two countries. Regarding inland waterways, both countries report a significant difference, especially Hungary. Inland waterway transportation does not play a big role in the general transportation of the countries, but it does within these two countries. This difference in the importance is created by the fact that Hungary and Austria are connected by the Danube River and it is considered to be the European Corridor VII[146]. Therefore, these two countries take a profit of this natural waterway and get the goods transported in a more economical and environmentally friendly mode of transport. The difference is also caused by the fact that the transportation is considered with all the European countries in the total percentages of each country and not only with the countries with a direct inland waterway connection, what would represent a different proportion of each mode of inland transport, probably more similar to the one between Austria and Hungary.

Focusing again in table 24 it is also remarkable the difference of total tonnes of goods transported in each direction. The total amount transported from Hungary to

[143] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)
[144] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)
[145] source: source: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frmod&lang=en (Read 16.06.2014)
[146] c.f. http://www.corridor7.org/about-corridor-vii/ (Read 16.06.2014)

Austria was almost three times bigger than the one loaded in Austria. For all the modes of transport the weight carried from Hungary to Austria was much bigger than the one from Austria to Hungary.

The second big part of this analysis is the distribution of the total weight carried between the two countries by the different types of good. Again the data used is from 2012.

The following table is focused on the direction from Hungary to Austria.

TYPE OF GOOD	TOTAL	Railways	Road	Inland waterways
Agricultural products and live animals	1,253,382	893,341	148,560	211,481
Foodstuffs and animal fodder	119,407	80,508	37,142	1,757
Solid mineral fuels	180,091	133,732	-	46,359
Petroleum products	838,960	444,320	3,988	390,652
Ores and metal waste	1,356,148	1,347,350	7,918	880
Metal products	382,216	293,010	764	88,442
Minerals and building materials	272,446	260,128	10,986	1,332
Fertilizers	52,328	28,298	21,785	2,245
Chemicals	818,147	784,709	33,438	-
Machinery and other manufacture articles	1,663,180	1,612,338	50,842	-

Table 26: Weight carried in tonnes from Hungary to Austria in 2012 by types of good [147]

Focusing on the direction of the table above some conclusions can be taken. The type of good most transported, regarding the weight, was in 2012 “Machinery and other manufactured articles”. However, this type of good is not transported by inland waterway and, as a result, its relevance is reduced for the project. The second and third types of good more transported from Hungary to Austria are “Ores and metal waste” and “Agricultural products and live animals”. Even if the third type of good is not significant for inland waterway transportation, around a 17% of the total weight of “Ores and metal waste” is carried by this mode of transport.

Furthermore, the importance of inland waterways for the significant types of good for this mode of transport has been analysed. “Petroleum products” is the group more transported through the Danube and a 46.6% of this type of good from Hungary to Austria is transported by inland waterways. The already mentioned “Agricultural products and live animals” is the second type of good most transported in this direction, followed by “Metal products” and “Solid mineral fuels”, representing respectively 23.1% and 25.7% of the total amount of these type of goods transported between the two countries.

As mentioned in the last chapter, climate change should be taken into account regarding “Agricultural products and live animals”. As said Koetse and Rietveld

[147] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)

(2009) an increase in the temperatures can have an impact on the patterns in production and trade and freight transport, what could lead to a change in the dominance of the types of goods.[148]

A parallel analyse for the other direction has also been developed.

TYPE OF GOOD	TOTAL	Railways	Road	Inland waterways
Agricultural products and live animals	34,917	3,740	28,416	2,761
Foodstuffs and animal fodder	74,390	11,731	62,659	-
Solid mineral fuels	-	-	-	-
Petroleum products	524,687	233,210	7,419	284,058
Ores and metal waste	98,720	97,345	1,375	-
Metal products	44,412	29,986	11,493	2,933
Minerals and building materials	29,741	3,986	25,755	-
Fertilizers	84,642	-	-	84,642
Chemicals	34,004	25,799	8,205	-
Machinery and other manufacture articles	1,512,054	1,457,236	54,818	-

Table 27: Weight carried in tonnes from Austria to Hungary in 2012 by types of good [149]

The most transported type of good from Austria to Hungary is again “Machinery and other manufacture articles”. In this case none of the tonnes carried were transported by inland waterways and therefore it is again considered not relevant for the inland waterway transportation. The second most important type of good transported from Austria to Hungary is “Petroleum products”. Inland waterways are significantly important for the transportation of this type of good, as a 54.2% is brought by this mode of transport.

Focusing on inland waterways, the most transported type of good is “Petroleum products”, already mentioned. The second one is “Fertilizers”. This type of good is relevant for the mode of transport of study because it is only transported by inland waterways. In addition it should be mentioned that from Austria to Hungary only four types of goods were transported through the Danube River. “Chemicals” and “Machinery and other manufacture articles” were not carried by vessels in any on the two directions.

The third part of this analysis is about the transportation of the different types of good through the Danube within Hungary and the three Danube regions of Austria.

To start with this part, a table has been written, with the selected data, to give information about the types of goods transported and the amount of them. The importance of the different Austrian regions, regarding the receipts, also aims to be analysed.

[148] c.f. Koetse, M. J.; Rietveld, P. (2009), p. 210.
[149] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)

TYPE OF GOOD	Lower Austria	Upper Austria	Vienna	AUSTRIA
Agricultural products and live animals	105,546	105,935	-	211,481
Foodstuffs and animal fodder	-	1,757	-	1,757
Solid mineral fuels	1,750	44,609	-	46,359
Petroleum products	262,102	119,690	8,860	390,652
Ores and metal waste	-	880	-	880
Metal products	40,147	587	47,708	88,442
Minerals and building materials	-	350	982	1,332
Fertilizers	1,064	1,181	-	2,245
Chemicals	-	-	-	-
Machinery and other manufacture articles	-	-	-	-
TOTAL RECEIVED	410,609	274,989	57,550	743,148

43.148

Table 28: Goods transported from Hungary to Austria in 2012 in tonnes.[150]

Observing with detail table 28, Lower Austria is the region receiving more goods, followed by Upper Austria. In both regions two types of goods are dominating the vessel load, “Petroleum Products” and “Agricultural products and live animals”. Even if Lower Austria is unloading more tonnes of goods proceeding from Hungary, Upper Austria unloads more variety of types of good. Vienna as a receiver is not really important, except for “Metal products”, as it is the region receiving more weight.

TYPE OF GOOD	Lower Austria	Upper Austria	Vienna	Austria
Agricultural products and live animals	1,008	1,753	-	2,761
Foodstuffs and animal fodder	-	-	-	-
Solid mineral fuels	-	-	-	-
Petroleum products	-	-	284,058	284,058
Ores and metal waste	-	-	-	-
Metal products	-	951	1,982	2,933
Minerals and building materials	-	-	-	-
Fertilizers	11,895	72,368	379	84,642
Chemicals	-	-	-	-
Machinery and other manufacture articles	-	-	-	-
TOTAL DISPATCHED	12,903	75,072	286,419	374,394

Table 29: Goods transported From Austria to Hungary in 2012 in tonnes [151]

Conversely to the goods transported from Hungary, the exports performed by Austria are mainly developed in Vienna. Therefore, this region is the most important regarding dispatch. On the other hand, this difference with the other regions is produced by the big amount of “Petroleum products” transported, while the other types of goods are not being transported from this region or just in a small measure. “Fertilizers” needs to me mentioned, too. It is the second type of good in weight carried and the main type dispatched in Lower Austria and Upper Austria.

[150] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)
[151] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)

Comparing both tables, and therefore both directions of transport, an interesting aspect has been found. Concerning the transportation from Hungary to Austria, the unloading regions in order of importance are Lower Austria, Upper Austria and Vienna. However, when Austria is the exporting country, the most important region is Vienna, then Upper Austria and finally Lower Austria. On the other hand, no "Chemicals" or "Machinery and other manufacture articles" are being moved between Austria and Hungary through the Danube River. This fact has already been mentioned in the previous chapter and the following conclusion was extracted: Austria is taking a profit of Vienna as the closest Danube region.

In order to analyse the divergences between the regions of Austria within the Hungary inland waterway transportation more information has been searched. The main ports of the Austrian regions have been analysed. Starting with Lower Austria two ports have been checked, the Port of Enns and the Port of Krems. The Port of Enns is a cargo handling port with two business parks, making it the largest-industry-related facility on the upper Danube[152]. On the other hand, the Port of Krems is not that big but has a fertilizer terminal, handling fertilizer, wood pellets and de-icing products. It also offers fully automated bagging services[153]. As already mentioned, Lower Austria is the region of Austria receiving more tonnes of goods. Therefore, according to the information about the ports, it is expected that most of the goods are unloaded in the Port of Enns. However, the most exported type of good to Hungary from this region is "Fertilizers" and it is expected to be sent from the Port of Krems, as it has a specialized terminal to these goods.

The most important port in Upper Austria, which is also the most important port of the country, is the Port of Linz. This port has a state-of-the-art logistic services centre and offers modern facilities for cargo handling and storage. Furthermore, the Port of Linz's Combination Traffic Centre has a depot and container repair workshops, also the latest technical equipment to facilitate efficient loading and unloading cargo and efficient handling of combined traffic. According to the just given information it is not surprising that this port is the one loading and unloading more loads of Austria. Nevertheless, the fact that it is not the main port regarding the transport flow with Hungary is probably caused by the fact that it is working with other more important traders of Austria connected by inland waterways, such as the Netherlands, Belgium and Germany, as already said in the previous chapter. It should also be considered that the Port of Linz has also a covered warehouse space with special warehouses for frozen, refrigeration, heated and hazardous goods and is located where water, rail

[152] c.f. http://www.worldportsource.com/ports/commerce/AUT_Port_of_Enns_2856.php (Read 20.06.2014)
[153] c.f. http://www.worldportsource.com/ports/commerce/AUT_Port_of_Krems_2857.php (Read 20.06.2014)

and roads meet, enabling a rapid efficient movement of cargo.[154] These characteristics explain the big amount of “Agricultural products and live animals” unloaded in this port. In addition, the Linz Tanker Port is specialized in transport and storage of mineral oil products. Therefore, the big amount of “Petroleum products” and “Solid mineral fuel” coming from Hungary are justified to be unloaded in this port.

The third Austrian region to be compared is Vienna. The port of Vienna is comprised by the Port of Freudenau, the Port of Albern, the Port of Lobau, the Viennamarina and DDSG Port of Vienna. The first one is the largest one and has terminals for cars and containers. Both the Port of Freundenau and the Port of Albern handle bulk and general cargoes like agricultural products, metals, building materials, vehicles and containers. Also, the Port of Albern handles and stores mineral metal products.[155] As a result, it is expected that the “Minerals and building materials” and “Metal products” received in this region are unloaded in these ports, especially the last mentioned type of good, as it is the most unloaded in Vienna coming from Hungary. On the other hand, the Lobau Oil Port has an important role concerning the goods transportation between Hungary and Austria, especially as the main good exported from Austria to Hungary is “Petroleum products” and is loaded in Vienna, specifically in the Lobau Oil Port. The data used for this part of the chapter has been extracted from Wien Holding.

[154] c.f. http://www.worldportsource.com/ports/commerce/AUT_Port_of_Linz_2858.php (Read 20.06.2014)
[155] c.f. Logistics for Vienna, 2012.

9 Results and discussion

To sum up, the Danube River is divided into three parts and is considered to be the "Corridor VII" of the European Union, making it one of the ten Pan-European transport corridors, which are routes in Central and Eastern Europe that require a major investment for the following years.[156]

As just mentioned, the Danube is divided into Upper Danube, Middle Danube and Lower Danube. These three parts have different lengths and height fall and therefore different speed allowance for the vessels, being the first one the slowest part. Furthermore, the water is not equally polluted and the Danube loses water quality during its flow, being Upper Danube the less polluted sub-region.[157]

In addition, this thesis has analysed the transport flow and its related aspects of Austria, Slovakia and Hungary.

Concerning the modal split of these countries, a comparison within them and the European union has been done. Regarding the relation between the freight transport and the Gross Domestic Product of each country, Hungary has the highest value, followed by Slovakia. However, just the former country is over the media of the European Union. On the other hand, the most dominant mode of inland freight transport of the three countries of study has been road, representing inland waterways the smallest proportion in the three cases. Even if Austria, Slovakia and Hungary are located on the basis of the Danube River, the percentage of performance of inland waterway is never over 5%, being this value under the average of the European Union.[158]

The fleet of each country is different. The country with the biggest number of vessels is Hungary, followed by Slovakia. Even if Austria was the country with the smallest number of vessel, it invested more money than Slovakia in its fleet in 2011. However, the proportion of the money spent in inland waterway infrastructure in the countries comparing to their GDP was higher in Slovakia. [159]

Generally speaking, regarding infrastructure Austria is the most prepared country. It has more bridges, more locks and more ports than the other two countries of study. On the other hand its infrastructure is not free of constrains and a strategic bottleneck and a missing link are reported. Nevertheless, Slovakia has two strategic bottlenecks and two missing links and Hungary just two strategic bottlenecks. It should be

[156] c.f. http://www.corridor7.org (Read 16.06.2014)
[157] c.f. Mihic, S.; Golusin, M.; Mihajlovic, M. (2011), p.1806
[158] c.f. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frtra&lang=en (Read 16.06.2014)
[159] c.f. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=iww_ec_ent_n&lang=en (read 17.06.2014)

considered that the missing link of Austria and one the Slovakian's is not related to the Danube River.[160] Finally, Hungary is the second country of importance in relation with infrastructures.

Comparing the total inland transportation of the three countries of study is Austria again the one playing the most important role. In 2011 in Austria were transported more goods than in Slovakia and Hungary together. However, focusing in inland waterway transportation, the difference between Austria and Hungary was not that significant. The mode of traffic was not equal in the three countries. In Austria the dominant mode was receipts and in the other two countries transit. Concerning the types of goods just Austria and Slovakia could be compared and in both cases were metal products the dominant type. Furthermore, the most important country regarding the nationality of the vessels was Germany. On the other hand, Austria mainly exported to Germany, Belgium, the Netherlands, Slovakia and Hungary and imported goods mainly from Slovakia, Ukraine, the Netherlands and Hungary. Moreover, Austria represents the most important trader for Slovakia regarding inland waterways, as was the main exporter and importer. Hungarian data could not be found. [161] [162]

Last but not least, the inland waterway transportation between Austria and Hungary was analysed. Regarding the total inland transportation and inland waterway transportation, in 2012 Hungary sent more goods to Austria than in the other direction. The percentage of the total weight transported of the different inland modes of transport of Austria and Hungary did not correspond to the one that represents the goods sent from Austria to Hungary and Hungary to Austria. In the total transportation of the countries road had the biggest proportion of weight transported and in the flow within the two countries of study were the railways the most important one. Inland waterways had more importance in the transportation between the two countries than in the total of Austria and Hungary. Concerning the goods transported, the most transported type of good through the Danube between the two countries was "Petroleum Products". Nevertheless, the three Danube regions of Austria were considered and studied. Lower Austria was the region unloading more goods from Hungary and Vienna the one that sent more weight to the other country.[163]

[160] c.f. c.f. Inventory of Most Important Bottlenecks and Missing Links in the E Waterway Netwoork, 2013
[161] c.f. http://statcube.at/superwebguest/login.do?guest=guest&db=degvd_waren (Read 20.06.2014)
[162] c.f. Yearbook of transport, posts and telecommunications in 2013 (2013)
[163] c.f. http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)

10 Conclusions

The Danube River is the second largest river in Europe and is considered to be the “Corridor VII” of the European Union. Despite the importance of this waterway the countries of study of this thesis do not use it as a main way to haulage. Inland waterway transportation represents only a small proportion in the modal split of the inland transportation of Austria, Slovakia and Hungary.

The waterway infrastructure of the countries is diverse and the Austrian one is the most developed. On the other hand, the three countries still have restrictions and bottlenecks and/or missing links have been reported.

Despite the fact that Austria has also other important traders, Slovakia and Hungary are still countries to take into account, regarding inland waterway transportation. On the other hand Austria is the main importer and exporter of Slovakia.

Concerning the Austria-Hungary haulage through inland waterways the upstream direction in more dominant than the downstream, as more goods are transported from Hungary to Austria.

In conclusion, even if inland waterway transportation is not the most important mode of transport in the modal split of the countries of study, it is still an important way to transport freight between Austria, Slovakia and Hungary. As shown in the last part of the thesis, where the percentage of tonnes transported between Austria and Hungary by mode of inland transport does not correspond at all to the percentage of the average of each country. This means than the Danube River is encouraging the use of this mode of transport.

Furthermore, it would be interesting to analyse the trend of the importance of inland waterway transportation between Hungary and Austria to extract a conclusion and therefore predict if this mode of transport is increasing or reducing its importance.

On the other hand it would also be interesting to develop a parallel analysis, as the one between Austria and Hungary, between Austria and an important west Europe country, for instance Germany, Belgium or the Netherlands. This part is out of scope of the project but it could have enabled a comparison and, probably, could have given some tips and recommendations to develop and improve the Danube transportation. Even if other eastern countries are also important traders for Austria, such as Romania, the study is recommended to be done with a western country due to the fact that these countries are rich, well-developed and can represent a model for other countries.

Another conclusion that can be taken is the importance of Hungary as a trader for Austria. The most important port of Vienna is the Port of Linz, which is located in Upper Austria and this region is the one loading and unloading more goods in the country, of the three Danube regions. However, when trading with Hungary, this region is not the dominant at loading or unloading goods. The conclusion extracted is that Hungary is not a top priority country for Austria. While most of the Austrian exports are sent from the port of Linz, the ones going to Hungary are sent from the region of Vienna. On the other hand, Lower Austria is the region unloading more goods from Hungary, instead of Upper Austria.

As a recommendation, Austria should consider the developing Eastern Europe market as a source of incomes. Nevertheless, a complete study about the total importation and exportation of Austria, including all modes of transport, should be performed to understand the most important traders and, if possible, try to redirect the haulage to inland waterways, as it is considered to be the safer and most environmental-friendly mode of transport.

Nevertheless, it should also be considered that Austria is using the Danube River to transport goods to or from east Europe countries. These countries are, for instance, Romania and Ukraine, being this last one the responsible of almost a quarter of the inland waterways Austrian importations of 2011.

On the other hand, a considerable investment is needed in the countries of the Danube to solve the constraints caused by the bottlenecks and the missing links. Even if the Danube River navigation is allowed almost all the days of year there is still a risk of not flowing of the ships, especially during the summer. Therefore, an investment to reduce the impact of weather events is recommended. Nevertheless, it should be taken into account that none of the three countries of study has basic bottlenecks. As only strategic bottlenecks are reported, a modernization is needed but the waterways already satisfy the requirements of class IV.

Concerning missing links, a further study of the Danube-Oder-Elbe Connexion is also recommended. Even if this waterway is currently just a project, can have a considerable effect in the inland waterway transportation of Austria and Slovakia, especially in the former country. Considering that this canal would enable the connection from Austria to the Baltic Sea. A possible consequence of this new infrastructure is the reinforcement of inland waterway transportation as a mode of haulage.

In addition, considering that the corrections of bottlenecks are very slow and require a big investment, other ways are possible to reduce the effect. A modernization in the fleet can help to solve or avoid the infrastructure problems. Therefore, the use of the already explained NEWS is recommended, as it enables the meeting of schedules,

adaptation to draught and is resource efficient, decreasing the harmful exhaust emissions and the fuel consumption. The implementation of this new ship would solve the strategic bottlenecks of Austria and help in the ones of Slovakia and Hungary, as insufficient depth in low water levels is a problem. However, the insufficient height under bridges should be solved with another solution.

A further study of the Gabčíkovo-Nagymaros lock should be developed. Only the Slovakian part of the project was done. Even if the study of the political and environmental reasons is out of scope, a resolution of the conflict could have a good impact in the inland waterway transportation between Hungary and Slovakia.

Concerning the existing fleet of the countries of study not enough data was found. The related study could have been more detailed if the registration of the vessel had been compulsory. Also, more information about the containerization of the fleet would have help to understand the transportation of the different types of goods.

11 Appendix

11.1 Table of bridges of Austria:

Name of the bridge	Main Use	Km of the Danube	Direction
Straßenbrücke Schleuse Aschach	Road	2,194.10	D+U
Fußgängerbrücke Schleuse Aschach	Pedestrian	2,162.92	D+U
Schleusenbrücke Aschach	Lock	2,162.68	D+U
Straßenbrücke Aschach	Road	2,159.97	D+U
Schleusenbrücke Ottensheim-Wilhering	Lock	2,146.73	D+U
Nibelungenbrücke (Linz)	Road	2,146.73	D+U
Straßen- und Eisenbahnbrücke Linz	Road/Rail	2,133.83	D+U
Voest-Brücke (Linz)	Road	2,133.46	D+U
Straßenbrücke Steyregg	Road	2,127.73	D
Eisenbahnbrücke Steyregg	Rail	2,127.68	D
Schleusenbrücke Abwinden-Asten	Lock	2,119.45	D+U
Straßen- und Eisenbahnbrücke Mauthausen	Road/Rail	2,111.05	D
Schleusenbrücke Wallsee-Miterkirchen	Lock	2,094.50	D+U
Straßenbrücke Grein	Road	2,080.82	D+U
Kranbrücke Schleuse Ybbs-Persenbeug	Lock	2,060.15	D+U
Schleusenbrücke Persenbeug	Road	2,060.15	D+U
Straßenbrücke Pöchlam	Road	2,043.60	D
Schleusenbrücke Melk	Lock	2,038.12	D+U
Straßenbrücke Melk	Road	2,034.43	D+U
Straßenbrücke Stein – Mautern	Road	2,003.53	D+U
Eisenbahnbrücke Krems	Rail	2,001.51	D
Straßenbrücke Krems	Road	1,999.77	D+U
Donaubrücke Traismauer	Road	1,991.35	D+U
Schleusenbrücke Alterwörth	Lock	1,979.80	D+U
Straßenbrücke Tulln-West (Rosenbrücke)	Road	1,965.50	D+U
Straßen- und Eisenbahnbrücke Tulln	Road/Rail	1,963.15	D
Schleusenbrücke Greifenstein	Lock	1,949.23	D+U
Nordbrücke (Wien)	Road	1,932.62	U
Nordsteg (Wien)	Pedestrian	1,932.57	U
Floridsdorfer Brücke (Wien)	Road/Tram	1,931.71	D+U
Nordbahnbrücke (Wien)	Rail	1,931.20	U
U6-Brücke (Wien)	Subway	1,931.17	U
Brigittenauer Brücke (Wien)	Road	1,930.45	D+U
Reichstbrücke (Wien)	Road	1,928.90	U
Donaustadtbrücke (Wien)	Road	1.925.99	D+U
Praterbrücke (Wien)	Road	1,925.76	D+U
Ostbahnbrücke (Wien)	Rail	1,924.96	U
Kraftweksbrücke KW Freudenau	Lock	1,921.05	D+U
Fußgängerbrücke KW Freudenau	Pedestrian	1,920.87	D+U
Rohrbrücke Mannswörth	Pipeline	1,917.70	D+U

Barbarabrücke (Schwechat)	Pipeline	1,914.35	D+U
Straßenbrücke Hainburg	Road	1,886.25	D+U

Table 30: Austrian Danube bridges[164]

11.2 Nationality of the vessels and tonnes transported in 2011 and 2012:

Mode of traffic	National transport	Receipt	Dispatch	Transit	Total	%
Nationality of vessels						
Austria	349,962	1,144,264	154,247	78,700	1,727,173	17.37%
Belgium	-	52,869	25,512	36,691	115,072	1.16%
Bulgaria	540	175,660	43,439	272,640	492,279	4.95%
Switzerland	-	331	-	4,135	4,466	0.04%
Germany	159,623	1,485,539	672,656	938,426	3,256,244	32.75%
France	-	-	-	877	877	0.01%
Hungary	8,348	220,992	33,102	103,479	365,921	3.68%
Croatia	-	3,422	2,180	3,482	9,084	0.09%
Luxembourg	11,640	33,244	16,696	10,088	71,668	0.72%
Malta	-	-	-	-	-	-
Moldavia	-	2,748	2,711	2,777	8,236	0.08%
Netherlands	7,330	332,765	163,850	317,215	821,160	8.26%
Poland	-	1,632	77	849	2,558	0.03%
Romania	90	268,594	45,283	170,132	484,099	4.87%
Slovakia	27,058	1,086,041	160,706	296,739	1,570,544	15.80%
Ukraine	597	737,049	215,669	10,951	964,266	9.70%
Yugoslavia	-	-	-	-	-	-
Serbia	-	19,072	9,594	20,975	49,641	0.50%
Other country	-	-	-	-	-	-

Table 31: Nationality of the vessels and weight carried in tonnes in 2011[165]

Mode of traffic	National transport	Receipt	Dispatch	Transit	Total	%
Austria	1,030,976	1,047,672	198,290	56,304	2,333,242	21.78%
Belgium	-	66,561	34,913	79,941	181,415	1.69%
Bulgaria	-	120,985	36,341	148,022	305,348	2.85%
Switzerland	-	644	-	-	644	0.01%
Germany	138,679	1,273,772	721,277	1,060,424	3,194,152	29.81%
France	800	1,019	1,801	-	3,620	0.03%
Hungary	33,941	155,256	44,755	110,258	344,210	3.21%
Croatia	-	2,525	3,050	4,020	9,595	0.09%
Luxembourg	15,659	53,708	11,347	7,648	88,362	0.82%
Malta	-	-	-	-	-	-

[164] source: http://www.danubeports.info/index.php?id=1278 (Read 19.06.2014)
[165] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)

Moldavia	-	437	-	-	437	0.00%
Netherlands	-	388,039	161,889	558,049	1,107,977	10.34%
Poland	-	-	-	-	-	-
Romania	1,012	327,035	73,350	122,877	524,274	4.89%
Slovakia	19,044	1,024,086	165,136	245,249	1,453,515	13.57%
Ukraine	-	973,180	160,607	15,982	1,149,769	10.73%
Yugoslavia	-	-	-	-	-	-
Serbia	-	3,925	10,945	2,576	17,446	0.16%
Other country	-	-	-	-	-	-

Table 32: Nationality of the vessels and weight carried in tonnes in 2012[166]

11.3 Loading and unloading regions of the goods transported:

2011	Mode of traffic	National transport	Dispatch
Loading region	**Unloading region**		
Lower Austria	Lower Austria	101,969	-
	Upper Austria	326	-
	Vienna	-	-
	Germany <DE>	-	24,444
	Belgium <BE>	-	1,220
	France <FR>	-	1,300
	Netherlands <NL>	-	24,816
	Switzerland <CH>	-	1,055
	Slovakia <SK>	-	-
	Yugoslavia <YU>	-	-
	Croatia <HR>	-	-
	Ukraine <UA>	-	-
	Bulgaria <BG>	-	8,411
	Romania <RO>	-	45,330
	Hungary <HU>	-	15,101
	Serbia <RS>	-	5,284
	Moldova <MD>	-	-
Upper Austria	Lower Austria	30,791	-
	Upper Austria	36	-
	Vienna	-	-
	Germany <DE>	-	366,320
	Belgium <BE>	-	191,974
	France <FR>	-	5,005
	Netherlands <NL>	-	138,866
	Switzerland <CH>	-	2,660
	Slovakia <SK>	-	21,503
	Yugoslavia <YU>	-	-
	Croatia <HR>	-	4,575
	Ukraine <UA>	-	5,550

[166] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)

	Bulgaria <BG>	-	14,132
	Romania <RO>	-	65,547
	Hungary <HU>	-	69,230
	Serbia <RS>	-	96,516
	Moldova <MD>	-	-
Vienna	Lower Austria	540	-
	Upper Austria	393,298	-
	Vienna	38,228	-
	Germany <DE>	-	13,947
	Belgium <BE>	-	283
	France <FR>	-	-
	Netherlands <NL>	-	9,307
	Switzerland <CH>	-	4,140
	Slovakia <SK>	-	133,737
	Yugoslavia <YU>	-	-
	Croatia <HR>	-	-
	Ukraine <UA>	-	-
	Bulgaria <BG>	-	749
	Romania <RO>	-	5,700
	Hungary <HU>	-	268,548
	Serbia <RS>	-	474
	Moldova <MD>	-	-

Table 33: Goods transported from Austria to European countries in 2011 in tonnes[167]

2012	Mode of traffic	National transport	Dispatch
Loading region	**Unloading region**		
Lower Austria	Lower Austria	36,452	-
	Upper Austria	7,544	-
	Vienna	-	-
	Germany <DE>	-	25,057
	Belgium <BE>	-	3,926
	France <FR>	-	-
	Netherlands <NL>	-	24,987
	Switzerland <CH>	-	824
	Slovakia <SK>	-	-
	Yugoslavia <YU>	-	-
	Croatia <HR>	-	-
	Ukraine <UA>	-	-
	Bulgaria <BG>	-	12,995
	Romania <RO>	-	33,794
	Hungary <HU>	-	12,903
	Serbia <RS>	-	9,940
	Moldova <MD>	-	-
Upper Austria	Lower Austria	37,154	-

[167] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)

	Upper Austria	686,534	-
	Vienna	597	-
	Germany <DE>	-	289,501
	Belgium <BE>	-	171,683
	France <FR>	-	4,054
	Netherlands <NL>	-	141,074
	Switzerland <CH>	-	4,729
	Slovakia <SK>	-	31,603
	Yugoslavia <YU>	-	-
	Croatia <HR>	-	7,661
	Ukraine <UA>	-	4,024
	Bulgaria <BG>	-	42,678
	Romania <RO>	-	71,437
	Hungary <HU>	-	75,072
	Serbia <RS>	-	94,699
	Moldova <MD>	-	-
Vienna	Lower Austria	16,757	-
	Upper Austria	403,647	-
	Vienna	51,426	-
	Germany <DE>	-	70,326
	Belgium <BE>	-	3,507
	France <FR>	-	-
	Netherlands <NL>	-	23,570
	Switzerland <CH>	-	4,860
	Slovakia <SK>	-	100,981
	Yugoslavia <YU>	-	-
	Croatia <HR>	-	1,930
	Ukraine <UA>	-	-
	Bulgaria <BG>	-	21,391
	Romania <RO>	-	36,049
	Hungary <HU>	-	286,419
	Serbia <RS>	-	12,026
	Moldova <MD>	-	-

Table 34: Goods transported from Austria to European countries in 2012 in tonnes[168]

[168] source: http://www.statistik.at/web_en/statistics/transport/index.html (Read 20.06.2014)

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16 List of abbreviations

GDP	Gross Domestic Product
m	metre
m^2	square metre
km	kilometre
tkm	tonne – kilometre
NEWS	New generation European Inland Waterway Ship
USD	United States Dollars
CO_2	carbon dioxide
LNWL	Lowest navigable water level
HNWL	Highest navigable water level
D	Downstream
U	Upstream
D + U	Downstream and upstream