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An investigation into specializations of economies

DIPLOMA THESIS

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Vienna, 9th August, 2017

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Erklärung zur Verfassung der Arbeit

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Kurzfassung

Industriespezialisierungen von Ländern, speziell der fünf größten Nationen in Europa (Deutschland, Frankreich, Italien, Spanien und das Vereinigte Königreich), sind die wichtigsten Treiber in der Wirtschaft, tragen am meisten zur heimischen Wirtschaft bei und veranschaulichen ihre Stärke in Europa. Sie haben sich im Laufe der Jahre entwickelt und verändert, meist wurden Produktionen und Dienstleistungen in andere Länder ausgelagert, die ein niedrigeres Lohnniveau sowie weniger Regulierungen festgelegt haben.

Den Warenhandel zwischen Staaten stellen Input-Output-Tabllen (I/O) am besten dar, dadurch kann man jegliche Produktionsschritte von Waren nachverfolgen. Da diese Güter internationale Grenzen öfters überqueren, ist es schwierig den komparativen Vorteil von Sektoren anhand der Exporte zu messen. Diese Berechnungsart wird durch den Ansatz der Globale Wertschöpfungskette (GWK) ersetzt, um die Wertschöpfung in den unterschiedlichen Sektoren und Ländern zu identifizieren, hierfür ist die Welt-Input-Output-Tablle (WIOT) am geeignetsten.

In dieser Arbeit wird ein Modell vorgestellt, welches Industriespezialisierungen von Wirtschaftsnationen anhand der GWK aufzeigt. Mit Hilfe der GWK werden die Anteile der Sektoren an der Gesamtwirtschaft, sowie zusätzlich einige andere Maße aus der Volkswirtschaft berechnet. Das Modell wird dahingehend entwickelt, dass das Forschungsumfeld auf andere vorhandene Länder und Sektoren erweiterbar ist. Da nur Daten bis 2014 vorliegen, muss das Modell auch in der Lage sein, Prognosen anhand zuverlässiger Methoden zu berechnen, um kurzfristige Vorhersagen erstellen zu können.

Die WIOT umfasst 44 Länder und 56 Sektoren, daher ist es notwendig Programme zu schreiben, die diese Daten vorab transformieren, jene Daten zu importieren, die für die Vorhersagen nötig sind, um die jeweiligen Jahresperioden zu berechnen, sowie die wichtigsten Daten aus dem Modell zu extrahieren um diese dann zu visualisieren. Vorab werden noch die historischen Entwicklungen der Nationen und deren Sektoren untersucht und wichtige Erkenntnisse hervorgehoben, um im Anschluss den Aufbau der WIOT, sowie den technischen Ansatz der GWK zu beschreiben.

Die resultierenden Daten beweisen und validieren die Funktionalität dieses Modells basierend auf gängigen statistischen Methoden. Außerdem belegen sie die Erweiterungsmöglichkeiten, mit ein paar Ausnahmen, um Industriespezialisierungen zu finden und kurzfristige Vorhersagen treffen zu können.

Abstract

Industrial specializations of a country, are the economic factors that drive and contribute the most to the national economy and demonstrate their importance in the European Union (EU). Industries have emerged over time and have shifted certain production or services' activities to certain countries, when outsourcing is relevant due to lower loans or less strict regulations.

Input-Output (I/O) tables show how goods are traded within countries and can be traced through all production steps. These goods cross international borders multiple times, therefore a comparative advantage of industries based on commonly used export values is not reliable any more. This approach is replaced by the better known Global value chain (GVC) to identify the value added in different countries and steps. The GVC concept is measured within global I/O tables, in particular the World Input-Output Table (WIOT). This dataset is limited regarding the availability of data, the customizability and its possible extensions. There are multiple data sources which are not interconnected at the moment but have the capability to increase the research opportunities using the WIOT.

This thesis introduces a model for discovering industrial specializations of national economies, especially those of the five biggest European countries, based on the GVC. This will be done with the WIOT to measure their contribution to the overall economy and compute economic key figures for the economy itself. The model is extended to take any amount of countries which are available in the WIOT and any kind of sectors to set up the research context. As the data only exists till 2014 it is mandatory to develop a model to calculate and forecast future years in a reliable way to be able to determine the development in short-term outlooks.

As the WIOT includes 44 countries and 56 sectors, it is necessary to develop transformation scripts first and import the data needed for forecasts into the model, to be able to compute each period and extract the important data out of the model visualized in figures. To better understand the data and the development of industrial sectors the historical facts of the top five countries are highlighted and discussed before describing the structure of the WIOT and the technical approach of the GVC income.

The obtained data prove the functionality of the model and validate the results based on common statistical tests. The model is able to find specializations and retrieve short-term forecasts of these industries, but because of some limitations, compromises regarding the selection of countries have to be made.

Contents

CHAPTER 1

Introduction

1.1 Introduction

The term *economy* is often equated to the whole economy of a country and seldom described as a composition of different branches and specializations. When talking about the economy of a country we are usually more interested in how the industries have grown in the past and which sectors are the significant and profitable ones for the whole economy now. Despite that topic, it is relevant to look at the future development of those sectors and simulate how others will become more important.

Different branches and the fact that industries have evolved specializations, have more varying impacts. Apart from influencing the Gross domestic product (GDP), they affect in global job opportunities and the overall labor market situation.

The research in empiric data of the countries' industries won't fully fit into the theoretically proposed macroeconomic models. Nevertheless it is still interesting to investigate the economy of a country with consideration of this limitation mentioned before. In this master's thesis the idea is to take a closer look at the different sectors of an economy and find the different specializations of several countries and their relevance to their economy.

1.2 Problem statement

In Germany, for example, the most profitable industrial branch is the automotive industry which is the leading specialization of the Germans [fEAE16]. Furthermore it would be beneficial to be able to forecast future developments and therefore develop a model that fits the sectoral division and specializations of a country.

In this paper a model will be proposed which will allow the analysis of the specialization of the top five countries of the EU, which are as following:

- France (FRA)
- Germany (GER)
- Italy (ITA)
- Spain (ESP)
- and the United Kingdom (UK) (GBR)

This model will additionally analyze the flow of final and intermediate goods which are the total imports and exports between those countries, as shown below: 1.1

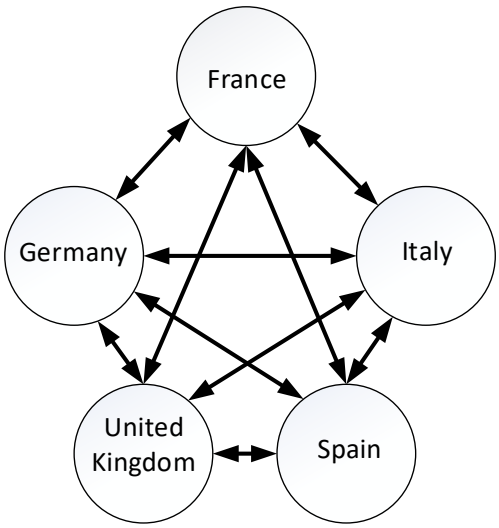

Figure 1.1: Representation of the flow of goods between the countries

This figure is related to the competitiveness of a country and its precious industrial sectors on international markets. While this can be measured through the GVC income which expresses the value added of industries which contributes to the production of final goods, it is important to take different actors into the simulation which are more interested in different facts and goals. For example, the country as a whole economy is more likely to reduce the unemployment rate or rise the real income, resulting in a complex structure which has to be regarded during modeling. The model is the first step to an agent based simulation where agents are industrial sectors as well as national economies than only using simple statistical models that are based on past data and are sufficient for short-term forecasts. Due to a static approach the model is not able to consider external changes which are nowadays a relevant factor in world economies as a result of the globalization [FF09].

To establish a common knowledge base for this master thesis it is important to first describe the development of the previously mentioned countries in the last twenty years. Economic foundations and historical development will be outlined in Chapter 2. For this, WIOT data obtained by the World Input-Output Database (WIOD) were analyzed. The I/O table provides harmonized national data which describe the flow of sale and purchase relationships within an economy of final and intermediate goods and services of 43 countries which are classified into 56 sectors [EC16b].

These problems and considerations result in the two research questions:

1. Which specializations are emerging within the top five European countries?
2. Is it possible to determine those specializations with a customizable model and predict future development?

1.3 Methodological Approach

The second chapter gives an account how the countries have been developed in the last twenty years. Therefore it was necessary to research economic surveys published by the Organization for Economic Co-operation and Development (OECD). Those surveys, which have been issued since 1961 in a time interval of 18 months for every member and non-member country, are viewed to determine the economic situation of each country and how economic indicators evolved in certain time spans (e.g. GDP, Gross fixed capital formation (GFCF), unemployment rate, etc.). Indicators will be defined, explained and visualized beforehand. Another aspect considered in this chapter will be the significance of recession and external events. Regarding Germany for example the impact of the fall of the "Berlin Wall" in 1989 [Woy16] and the reunion of Western and Eastern Germany afterwards will be discussed. Events that influenced all economies around the world are included in the historic overview. An example is the bursting of the housing bubble in 2007-2008 [Hol09] that ended in a global turn-down and shock in shares till the first half of 2010 when a world-wide recovery started. One additional event was the European debt crisis (2012-2013) in which almost every European country started struggling. This had big impacts on private and public consumption which then affected the whole economy, especially the budget deficit of each country [Fra15].

The third chapter covers basics and fundamental elements of the I/O analysis. At the beginning of the chapter the idea from Wassily Leontief will be presented, his intention was to describe the whole economy of the United States of America (USA) as a linkage system between its different industries [Leo36]. Afterwards one exemplary application will be calculated to illustrate and explain the most important mathematical definitions (matrices, vectors and coefficients) within the used I/O analysis method.

The subjects of the following chapter are the large amount of data in the I/O tables [EC16a] and why it is mandatory to utilize a method for statistical analysis. The chosen

approach is to use the Revealed comparative advantage (RCA) approach using the GVC income measurement to detect the important sectors which contribute strongest to an economy. To provide an answer to the requested questions and requirements, especially to create a model based on that data, it is necessary to analyze and evaluate these data. This mandatory step will be done with R-Project [1], creating functions to handle new input data, visualizing them and predicting the future and all further descriptive statistics too.

The results will be shown in Chapter 6, including diagrams, tables and graphs to show the development of the RCA of the country-sectors and the contribution of each sector to the labor market and even the exports of the country. The results of the validation using statistical hypothesis tests are part of this chapter. The methodological approach of this master's thesis is executed by following the steps below:

- Combining and reducing the amount of countries and sectors in a customizable way
- Preparing the already existing WIOT, available for the years 2000 - 2014
- Extracting data from different sources to calculate and predict further periods
- Determining and visualizing the industrial specializations of the five national economies
- Checking the model for the statistical consistency and reliability and adapting it accordingly.
- Making short-term forecasts with the model for the years 2015 - 2020.
- Summarizing and highlighting the results to conclude the thesis with an outlook for further work on this topic.

1.4 Thesis structure

The remaining chapters include the following topics:

- Chapter 2 describes important economic indicators and reviews the historical developments of the five countries.
- Chapter 3 explains the basic structure of I/O tables and what to consider when working with this kind of data.
- Chapter 4 demonstrates the working method and approaches measuring the GVC.

[1] R is a free software environment for statistical computing and graphics `https://www.r-project.org/`

- Chapter 5 introduces the model, the algorithms and the scripts used in each step to produce the results.
- In Chapter 6 the implemented model is going to be evaluated and validated using common statistical methods and results are presented.
- Chapter 7 shows up the limitations and restrictions of this model and an outlook on further work on this topic is outlined.
- Finally Chapter 8 summarizes the findings and results of this thesis.

CHAPTER 2

Economic fundamentals and historical developments

This chapter contains a summary of the historical development of each of the five previously mentioned countries. The collected information will be qualitatively analyzed to get a better understanding of how and why the biggest economies of the EU have emerged the way they did. Materials from the OECD from the last twenty years will be the base for this research. Fundamental economic data will be used to highlight and summarize the industrial status of those particular years.

2.1 Important economic indicators

2.1.1 GDP

The GDP can be defined as the sum of produced final goods and services in an economy adding the exports and excluding the imported goods. Intermediate goods are not represented in this calculation, as they would be counted twice, resulting in inaccurate figures [BR13].
This economic indicator can be described as the sum of value added goods during production less than the value of intermediate goods of the production in an economy. This type of calculation will be used in this thesis to determine the GDP of the countries. A further definition says that the GDP is the sum of labor and capital income in an economy.
There are two types of measurements for this economic indicator:

- Real - produced final goods times constant prices
- Nominal - produced final goods times current prices

In this thesis, the real GDP will always be used. This type of measure is a good starting point to get an overview of the historical growth of an economic growth [BR13].

The figure 2.1 visualizes how the GDP has grown in the last twenty years. As shown France, Germany and the UK have doubled their value in this period of time. Italy's economy however has grown by less than 70 percent and Spain has had the best performance with 136 percent of growth.

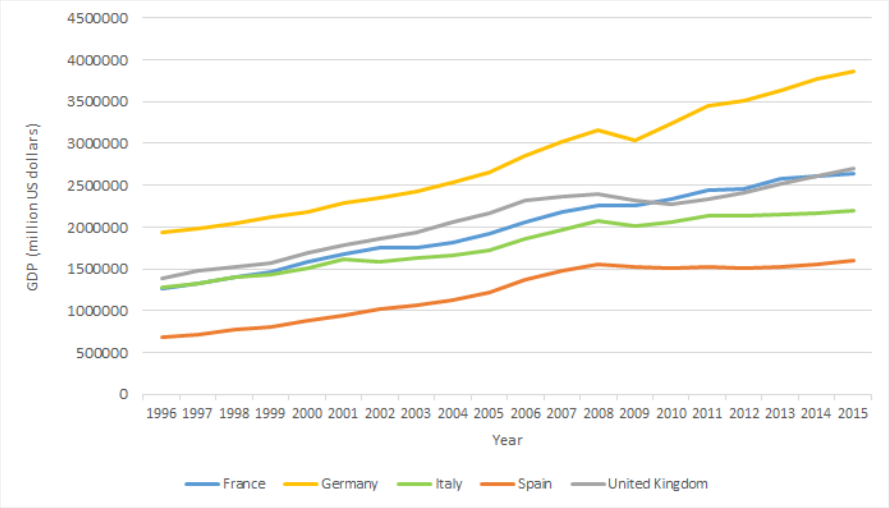

Figure 2.1: Representation of the GDP between 1996-2016 (Data source: [Stab])

The year 2008 should be highlighted in this context as the graph shows the time and influence of the housing bubble ending and leading to a debt and a deep recession. In the second half of 2009 the growth rate increased again. After the crisis, especially Germany's economy recovered faster compared to the other countries' and thus the GDP grew the strongest. However, it still can be seen that in the period of time between 2009 and 2013 not one of these countries could expand its economy continuously. This is due to the direct involvement in the European debt crisis which was mainly caused by the countries Cyprus, Greece, Ireland, Portugal and Spain. Greece's economy suffered the most with an average of -13 percent of change in GDPbetween 2008 and 2012. Nevertheless Germany's economy outperformed the expectations in this time span with an increase of more than 2 percent on an average [Fra15].

The figure 2.2 illustrates the influence of the housing bubble in more detail. First were the flourishing years before the burst of the housing bubble in 2008. Then there was a short recovery until 2011 and before the debt crisis between 2012 and 2013 in the EU. Afterwards is the recovery period and forecasts till 2018 are shown.

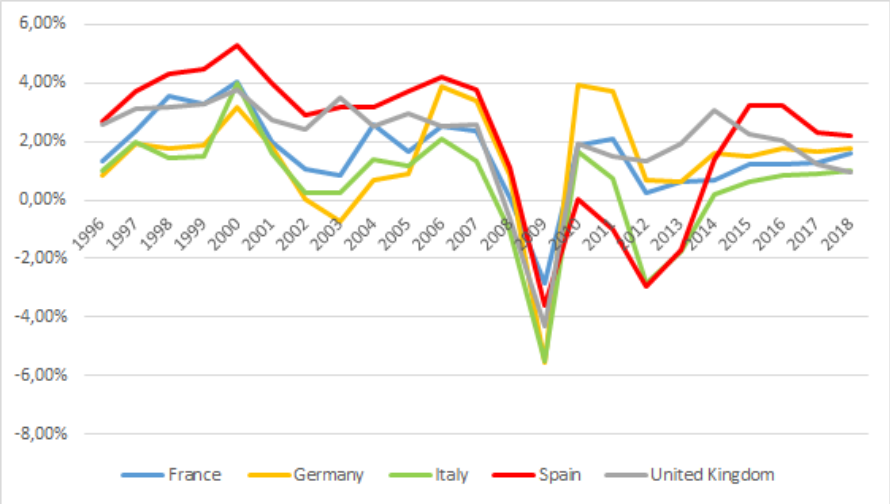

Figure 2.2: Representation of the GDP growth rate and forecast between 1996-2018 (Data source: [Stab])

2.1.2 GFCF

The GFCF covers residential producers investments (in particular new or second-hand machinery and equipment, vehicles, dwellings and other buildings) and manufacturing assets by producers for personal use excluding disposals producers fixed assets [Com16]. There are six different sub categories within this economic indicator:

- Cultivated assets
- Dwelling
- Information and communication technology (ICT)
- Intangible fixed assets
- Other buildings and structures
- Transport equipment

2.1.3 Current account (balance)

The actual current account balance represents the sum of all net payments to and from the rest of the world of a specific country [BR13].
The figure 2.3 shows the development of the current account balance of the GDP from 2000-2016. As can be seen, Germany has outperformed all the other countries with a high level growth. Spain troubled by the debt crisis in 2003 up to 2008 and is now having a surplus on the current account balance as well as Italy and France. Only the United Kingdom is having a lack of growth since 2011.

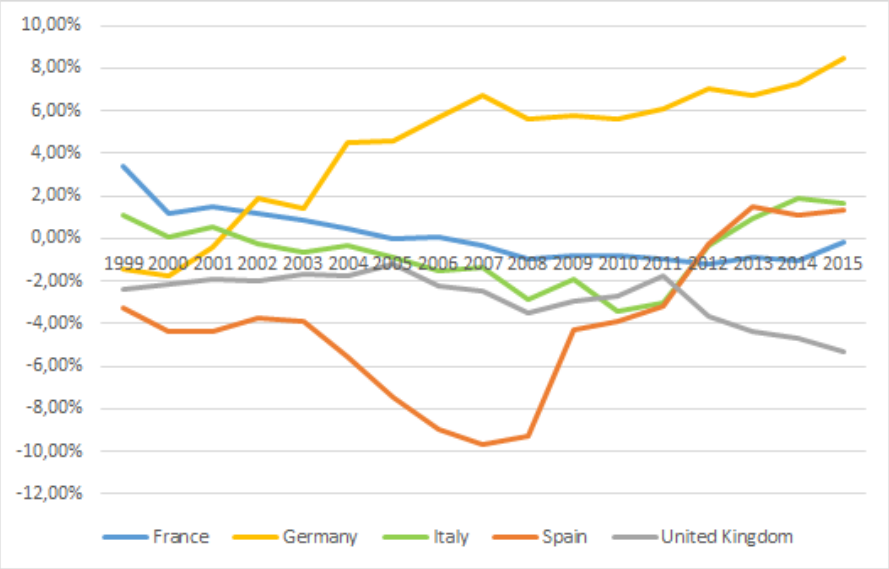

Figure 2.3: Representation of the current account balance from 1999-2015 measured by percentage of GDP (Data source: [Staa])

2.1.4 General government deficit

The general government deficit is the financial representation of the government budget balance which can be seen in the figure 2.4 below. It is measured by percentage of the GDP inheriting the government's spendings and revenues. A positive balance is a surplus and a negative balance is meant to be a deficit. Deficits happen more likely during recessions when the government has to stimulate the economy to avoid economic crises. This incidentally raises unemployment rates and causes other side effects [BR13].

2.1.5 Unemployment rate

The unemployment rate is a measure of the general situation on the labor market, specifically, it is the propagation of unemployment. The rate is calculated as a percentage of current unemployed workers [1] divided by the total labor force of a country. Unemployed, self- and otherwise employed make up the total labor force. Additional to this natural approach, there are several other categories of unemployment. One of them is the structural definition of unemployment. It reflects structural problems of the economy and of the labor market There is often an inefficiency between supply and demand of workers due to people requiring certain skills to fulfil certain jobs. In the figure 2.5 below there are the unemployment rates of the top five countries of the EU [BR13].

[1] Unemployment is defined as a person without work which has been actively searching for a job in the last four weeks, is still available for the work force and is willing to work again [OECz].

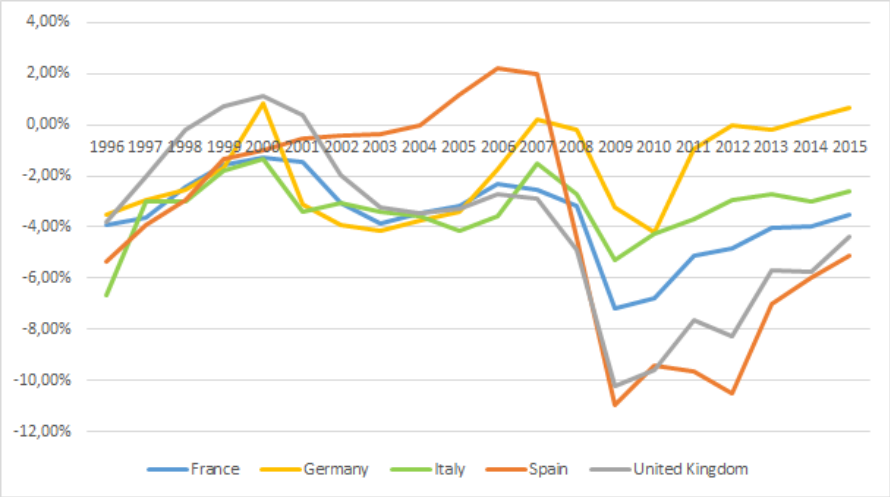

Figure 2.4: Representation of the general government deficit from 1996-2015 measured by percentage of GDP (Data source: [OECy])

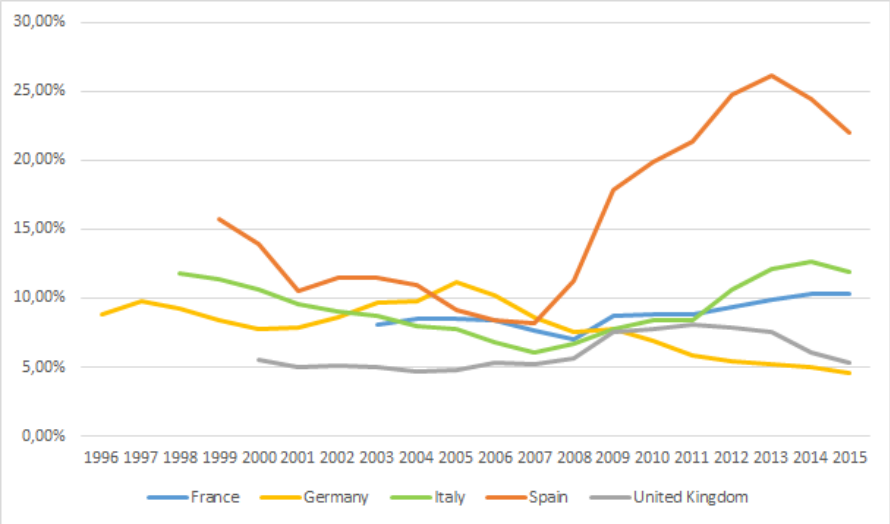

Figure 2.5: Representation of the unemployment rate from 1996-2015 measured by percentage of labor force (Data source: [OECz])

2.2 Other economic fundamentals

The following information is necessary to understand the theoretical basics of the I/O analysis and how they are constructed.
As described in the beginning, an economy consists of different branches of industries, therefore an economy can be categorized in multiple (n) industries. The number of sectors is i and x_i is the total output of a sector. The monetary values of the transactions

between pairs of each sectors (from i to j) are x_{ij}. This is the so called interindustry (intermediate) sale. Furthermore, y_i is the total final demand of sector i. To sum up these definitions, 2.1 can be populated. The equation represents the sectors i output through sales to other sectors or as final demand [RP09]:

$$x_i = \sum x_{ij} + y_i \tag{2.1}$$

This formula is applicable for each sector.
In the next sections all five countries' economies will be surveyed and highlighted by reviewing historical economic contexts of the last twenty years.

2.3 France

In 1995 France had economic issues as a result of the recession in 1993. France had to cut the expenses to reduce its deficit and had to set up political programs to reduce unemployment, introducing new employment programs for long-term unemployment and young people who were looking for jobs. Nevertheless, the unemployment rate stayed at a high level of around 12 percent. The government offered incentives to buy cars and build houses to accelerate the growth of the economy. This strategy turned into a 1 percent rise of GDP and the same percentage of inflation in 1996. In addition to that France suffered from the rescue of several banks in the late 80s and their chronic deficit problems which affected its economic situation. Short-term projections based on political decisions and a positive environment promised a recovery in 1998 (growth of 2.6 percent GDP and more than 6 percent in export and import) [OECc].
The biggest areas in export (Machinery and transport equipment, chemical products, other manufactured goods classified mainly by material) and import (Machinery and transport equipment, other manufactured goods classified mainly by materials and miscellaneous manufactured articles) were reflected by those enterprises mentioned above.[OECc].

After a fast recovery of the economy starting in 1995 the growth slowed down from 4.2 percent in 2000 (based on a robust domestic demand) to 1.2 percent in 2002. At the same time the deficit rose to 3.1 percent. This happened due to rising costs for pensions and the health care system. As in the years before, France struggled with relatively high unemployment rates (above 12 percent in 1997) but resolved other job market problems mainly with older workers. This resulted in a low of nearly 8.5 percent of unemployment in 2001 and a rise again to over 9 percent in 2003. Another reason for the declining growth rate of the economy was the breakdown of export and import immediately after 2000 (growth of 13.4 percent and 15.3 percent) to 1.2 percent and 0.7 percent in 2002 [OECd].

France struggled after the recession in 2008-2009 but not as much as other countries in the EU due to many stimulus actions installed by the government short after the first signs of the recession. Public investments (1.3 percent of GDP) were taken to fight against the downward trend of the economy. This affected the financial balance of the

government which was in 2007 0.3 percent below the Maastricht deficit criteria [2] but began to rise to a deficit of 6.7 percent in 2009.
In 2008 the GDP grew positive for the last time for 0.7 percent compared to 2009 where the recession shrank it to -3.3 percent. Export and import started to decline after 2008 (1.1 percent and 2 percent) for -11.4 percent and -7.6 percent in 2009. Despite earlier problems with ageing workers which were partly resolved with set up of various work incentives for older people, the unemployment rate rose again after 2008 from a low of 7.4 percent to 9.9 percent a year later [OECe].

In 2015 France experienced high productivity levels, a more respectable situation for living and a more sufficient labor force participation as a consequence of sustainable and diversified industrial structure. The country, however could not get out of enormous public spendings after the recession in 2008-2009. The spending had been 57.3 percent of GDP in 2014, which was the second highest among other OECD countries. Factors like public spendings partially reflected the growth of the economy which sped up from 0.4 percent in 2014 to 1.1 percent in 2015. Nevertheless, France faced recurring troubles on the labor market which resulted in a high unemployment rate of nearly static 10 percent. In addition to that the recovery of export and import performed better and rose from 1.2 percent and -1.2 percent in 2012 to 4 percent and 3 percent in 2015 [OECf].

2.4 Germany

Five years after the fall of the "Berlin Wall" in 1989 [Woy16], Germany's economy grew exponentially in 1994 based on exports and machinery constructions, but the growth of GDP resulted in a slowdown from 2.9 percent in 1994 to 1.9 percent in 1995. The inflation rate declined from 2.5 percent in early 1995 to 0.75 percent and led to falling prices at the beginning of 1996. This happened because of the stagnating unemployment rates and reduced job development in former Eastern Germany and the not-moving wage levels.
Another factor for this slowdown was the gain of value of the exchange rates of the "Deutsche Mark" to other currencies of EU countries, Japan and the USA. This fact influenced the international competitiveness negatively and affected a rise of 60 percent of the unit labor costs in manufacturing against the relatively stable consumer price index and resulted in halving the growth of export.

The only positive factor which helped in growing was the export of capital goods which was proportionally about 57 percent of the total exports which consisted out of road vehicles (17 percent), mechanical engineering products (15 percent) and electrical engineering products (13 percent), followed by chemical products (14 percent) which are included in basic and producer goods (in total 24 percent), and consumer goods (11 percent). Capital goods held the biggest proportion of imports composed by electrical engineering products (12 percent), road vehicles (11 percent) and mechanical engineering goods (6

[2] general government fiscal balance should be kept under 3 percent deficit of GDP and gross debt of general government under 60 percent of GDP [BCR93]

percent), further consumer goods (16 percent), basic and consumer goods (in total 24 percent) and its subcategory chemical products (10 percent) [OECg].

Germany's economy grew by 3 percent in 2000, which was the highest growth since 1993, while the yearly inflation rate edged up to 1.3 percent in 2000. This recovery was driven mainly by main factors like exports which caused the gain of international market share of goods and the sinking unemployment rate from a high in 1997 by nearly 10 percent to 7.3 percent in 2000. Troubles emerged again with stronger rising unit labor costs compared to other countries level and a gap in production output between Western and former Eastern Germany [OECh].

It took Germany six years to prove its capabilities and strength in exports and international competitiveness. However, the country suffered a downward trend in domestic demand at the same time. Another economic benefit was an inflation lower than in other European countries and indicators of private consumption seemed to be positive again in the future. The GDP grew by 1.1 percent in 2005 and 1.75 percent in 2006 after the recession in 2003 (-0.2 percent) where the total employment went down by 1 percent. The unemployment rate began to rise to a high of 9.2 percent in 2004 but recovered again in 2005 to 9.1 percent and 8.5 percent in 2006. As written before, export was constantly rising from a low in the recession year of 2.3 percent to 8.3 percent in 2004 and 6.6 percent a year afterwards The import however, sank in 2002 by 1.3 percent but started to increase again in 2003 by 5 percent and nearly kept that level in 2005 (5.5 percent) [OECi].

As well as other countries Germany suffered from the recession which lasted from 2008 to 2009 and was then followed by a rapid recovery afterwards until 2011 of 3 percent compared to 2012, where the economy grew slower (0.6 percent) due to a weakness in international trade and its export dependent economy. This resulted in an increase of exports of 8.2 percent as well as of imports (7.2 percent) in 2011 and halved the growth rate in 2012 (3.4 percent and 4.1 percent). Germany endured the crisis significantly better than other European countries, because of a good condition on the labor market and the hardly increased unemployment rate which had a high in 2009 over 7 percent but dropped below 6 percent in 2011. This phenomena emerged from labor market reforms and structural enhancements in other governmental policies in the past. Another important factor was the relatively low governmental budget deficit around 4 percent compared to other European countries that had a lot more troubles after the recession and the debt crisis. Furthermore, Germany consolidated its position as a strong export nation of final and intermediate goods to other countries mainly based on close supply chains[OECj].

The recent development is shaped by low unemployment rates (2013 - 5.2 percent to 4.6 percent in 2016). On the one hand this leads to a strong labor market but on the other hand to a weakness of growing productivity as well. A drawback of the actual labor market situation is an ageing problem which can be seen in other European countries. Though the development of the GDP stayed nearly constant from 1.6 percent in 2014, 1.4 percent in 2015 and will be 1.3 percent in 2016. A different economic problem is the

low inflation rate of 1.6 percent in 2013 which went down to 0.1 percent in 2015 but should increase to 0.5 percent again in 2016. Another positive indicator is the enhancing of export from 1.8 percent in 2013 to 4.8 percent in 2015 but projected decrease to 1.6 in 2016. Import rates are rising more constantly from 3.2 percent in 2013 to estimated 5.4 percent in 2016. This gap between export and import results in a surplus in the current account balance and effects enlargement of governmental investments. Another positive factor for Germany's public investments and general safe economic situation is the financial balance of the government which did succeed the Maastricht deficit criteria (0.2 percent in 2016) and the governmental cross debt will be lowering down to the 60 percent level from 68.6 percent in 2016 [OECk].

2.5 Italy

The growth of the economy of Italy had its peak in 1995 at 3 percent but fell to 0.8 percent in 1996 due to a slowdown in exports (11.6 percent in 1995 to 0.6 percent in 1996) and imports (9.6 percent in 1995 to -2.1 percent in 1996). Other reasons for this decline were that the private consumption nearly stagnated in 1996, government consumption was reduced by -0.6 percent as well as the ongoing high unemployment rate of 12 percent in 1995. Additionally employment figures were declining in each of the three economic sectors. Furthermore the inflation rate of more than 4 percent since 1992 had a negative impact. Therefore productivity and unit labor costs were rising by 3.5 percent and 1.7 percent in 1995 and 0.8 percent as well as 4.4 percent in 1996 [OECl].

Italy was the only one of the three largest countries in the EU which successfully reached the three-percentage deficit limit (Maastricht deficit criteria) in 2002 (-2.5 percent after -2.7 percent a year before), even though, it had a slower growth of economy by 0.4 percent. While in 2000 it was 3.1 percent and a year after 1.8 percent. A possible reason for that deceleration was a drop of exports and imports which had been 11.7 percent as well as 8.9 percent in 2000 and were heading to -1 percent and 1.5 percent in 2002, resulting in a loss of market shares for Italian exporters. Another influencing factor has been the various productivity levels. Even though Italy had one of the lowest unemployment rates in total (10.7 percent in 2000 and 9.1 percent in 2002) the different un- and employment rates between the northern and southern parts of the country contributed to the decrease of economic growth. The declining of private consumptions of 2.7 percent in 2000 to 0.4 percent in 2002 and GFCF from 7.1 percent in 2000 and two years later to 0.4 percent led to this economic downturn [OECm].

As well as other countries Italy went into a deep recession because of the bursting of the housing bubble in 2008 [Hol09]. The tight link of external influences of the global financial crisis were leading to a decrease of external demand. Even before the global crisis, Italy was facing a reduction of productivity and a weak competitiveness on international markets. This already weakened state was a factor influencing the severity of the recession in this country.
While in 2007, a year before the start of the global financial crisis, the GDP grew by 1.5

percent but actually went down in 2008 by -1 percent. The UK had a decline of -0.5 percent in this year while France, Germany and Spain expanded at this point of time. In 2009 the recession hit Italy and the economy decreased by -5.3 percent. Exports and imports collapsed (4 percent and 3.3 percent in 2007) by -21.5 percent and -20.2 percent. Almost each economic indicator dropped in 2009, like the GFCF, which has been -16 percent and private consumption fell by -2.4 percent [OECn].

Italy was not able to defy the global financial crisis successfully and the European debt crisis affected the country. This fact led to a short recovery from 2010 until 2011 before Italy drifted into another recession. The labor market had trouble gaining momentum again. The unemployment rate nearly doubled since 2007 to 12.3 percent in 2015, but is prospected to lower to 11.3 percent in 2016. The economy recovered by a growth rate of 0.7 percent in 2011 before it began to decline in 2012 by -2.3 percent and 2014 by -0.4 percent. It started to rise again by 0.4 percent in 2015 and expected to be 1.3 percent in 2016. Exports showed only a short-time slowdown (6.1 percent in 2011 to a low of 0.9 percent in 2013 and projected 4.6 percent in 2016) but did not decrease in this time span. Due to the crisis the government made huge investments to boost the economy, nationalized banks and saved other banks from bankruptcy. This affected the general government cross debt (calculated by the Maastricht definition) from 116.4 percent in 2011 to be 133.5 percent in 2016.
Another research project of the OECD found that the widening of the regional gap between northern and southern Italy was caused by the recession in productivity level and employment rate. This has been a historically known weak spot of the Italian economy and is mentioned in every economic survey [OECo].

2.6 Spain

Before 2000 Spain had faced three years of growth and its general positive economic situation aided the entry into the EU. While the unemployment rate stayed as one of the highest (22 percent in 1996 to 15.8 percent in 1999) compared to other European countries, the country achieved high growth rates (4 percent in 1998 and 3.7 percent in 1999). One coefficient factor for this sustainable growth in the last couple of years was the rise of domestic demand (like an increase of housing investments driven by lower interest rates) by nearly 4.3 percent in 1999. The deficit in the current account balance (3.3 percent in 1999 and -4.4 percent in 2000) had still been a negative influence on the economy and the governmental debt. Growth of export and import remained on a high level in 1998 by 7.1 percent and 11.1 percent and in 2000 by 8 percent and 11.4 percent [OECp].

The international slowdown in 2002 did not really influence the Spanish economy, therefore the economy grew by 2.2 percent in 2002 and achieved 2.7 percent in 2004. Low interest rates and a partly strong labor market affected this growing in a positive manner. Nevertheless, there were some drawbacks like the productivity stagnated and the unemployment rate was still high (11 percent in 2004).

Spain's housing prices were mentioned to be inspected critically because they increased twice as high as the EU average and housing investments (nearly 8 percent change in 2003) were above all other countries. Another positive factor at this time was the strong growth of exports going up 1.2 percent in 2002 to 4.5 percent in 2004, whereas imports rose stronger in this period (3.1 percent in 2002 to 9 percent in 2004). A sign of growth was the increase of private consumption and GFCF (2.9 percent and 1.7 percent in 2002 to 3.5 percent and 4.6 percent in 2004) [OECq].

Compared to other countries of the EU Spain had more troubles after the deep recession in 2009 (GDP shrank by -3.7 percent after 0.9 percent in 2008). Due to the domestic demand boom before the crisis houses were build upon loans and unsustainable business investments were made which led to increases in unemployment rates after the crisis. Furthermore, the governmental policies during the recession led the government deficit from a surplus of 1.9 percent in 2007 to - 11.1 percent in 2009 with a goal to reach the 3 percent in 2013 based on reforms and other governmental savings. Due to this situation, the government gross debt (calculated by the Maastricht definition) rose dramatically from 39.8 percent to 53.2 percent in 2009. Another challenging situation was still the labor market where the unemployment rate grew up to 18 percent in 2009 after 11.3 percent in 2008 due to several impacts of the crisis. During 2009 exports and imports grew by -11.6 percent and -17.8 percent after -1.1 percent and -5.3 percent in 2008. Private consumptions fell from -0.6 percent in 2008 to -4.2 percent in 2009 which produced a gain in household savings ratio from 13.4 percent to 18 percent because of bad conditions on the labor market and tightened conditions of bank loans [OECr].

Years of strict reforms to close the gap of sovereign spreads, a decrement of government public debt and an increase of the international competitiveness led Spain to regain moderate growth. The tattered banking sector was strengthened by numerous regulations. Other reform steps were taken to reinforce the competitiveness on international markets and the national labor market which struggled a lot after the debt crisis. Some macroeconomic indicators intended to rise again like the growth rate of the GDP which was since 2010 (0.01 percent) positive again in 2014 (1.2 percent) with a recession in between the years 2011 (-1 percent), 2012 (-2.6 percent) and 2013 (-1.6 percent). Amongst other things, private consumption increased by 2.1 percent in 2014 after a steady drop since 2007 and it seemed to be more sustainable. Another indicator was the GFCF which increased in 2014 by 0.6 percent and rose up to 2.9 percent in 2015 after a deep decrease since 2007. Exports and imports were still rising by 3.7 percent and 4 percent in 2014 and went up to 5.9 percent and 5.2 percent in 2015. Although there were reforms implemented for improvement of the labor market, the unemployment rate was still one of the highest in the EU with 26.1 percent in 2013, but the rate got finally down to 23.6 percent in 2015.
Currently the general government gross debt (calculated by Maastricht definition) is still a problem because it increased from 70.5 percent in 2011 to 101.4 percent in 2015 affected by a remaining high deficit since the beginning of the crisis in 2007 [OECs].

2.7 The United Kingdom

The UK was able to sustain a recovery (3.4 percent in 1994 till 3.5 percent in 1997) for more than five years (after a recession from 1990-1992) which was due to the growth of domestic demand and an increase of exports. Finally after 1997 the recovery slowed down. Another motive power for the gain of the British economy was the sinking unemployment rate which dropped from almost 9.6 percent in 1993 down to 6.9 percent in 1997. The labor market conditions improved further and the private consumption restored from 0.1 percent in 1993 to a steady growth of 4.6 percent in 1997. Exports and imports were rising strongly in the same time span as well by an average of 7.9 percent and 6.8 percent. Another factor in this recovery were high business investments (capital investment, etc.) into the service sector than into the manufacturing sector [OECt].

In 2000 growth slowed down, but not as significantly as in other countries in the OECD, which suffered under the dot-com bubble and the decrease in international exports a lot more than the UK. Nevertheless, the slower growth still had a big impact on the economy, for example a lack of productivity. The GFCF had reached a peak in 1998 by 13.2 percent but severely declined and stayed at 2.4 percent in 2003. This deficiency was compensated by government public spending resulting in a raise of an average of 10.1 percent between 1999 and 2003. Private investments had a growth of 0.8 at the same time, which had an effect on the current account deficit of -2 percent. Apart from these factors the unemployment rate remained nearly constant at 5.5 percent at the end of 2003 compared to a low of 5.1 percent in 2001 [OECu].

In 2009 the British economy had troubles because of the housing-bubble like most of the other European economies. Like all the other countries, the UK struggled with a sharp downturn of house prices as well as problems with the financial system. Even though the government tried to stabilize the financial market system with appropriate countermeasures (especially the start of quantitative easing [BBN$^+$]) immediately after the beginning of the crisis, the UK still went into a deep recession. From 1992 on until the last couple of years before the crisis was leading up to 2007, the economy grew by an average of 2.8 percent. This made the UK a country with one of the highest growth rates in the EU, mainly due to the openness to globalization and the financial sector was focused on internationality and developed in this direction [oeca]. The whole economic situation of the UK was stable and well before the impacts of the crisis hit the economy. The large investments into the housing sector and a relatively unregulated financial sector have been driving factors for the severity of the recession [OECv].

After a period of recession and a European down-turned economy (housing-bubble and debt crisis afterwards) the UK had the best performance in 2014 by a growth rate of 2.6 percent as well as in 2015 and will be minimal below at 1.6 percent in 2016. This is contributed to the highly accommodative monetary policy and the support on the housing market by the government. The unemployment rate is estimated to lower back down to before crisis state (projected 5.4 percent in 2016) compared to 2011 with 8.1 percent. Other political reforms and public incentives were implemented after the crisis to

sustain recovery in re-powering the productivity of the country and increasing investments of GFCF. With a growth rate of 5.1 percent by an average since 2012 the main force of the British economy has been the business sector (average of 6.3 percent) before housing (about 6.1 percent). Although there were a lot of investments in the economy to gain strength again, the deficit will be near the Maastricht deficit criteria with 3.1 percent after a peak of 8.3 percent in 2012. The general government gross debt did not increase as much as in other European countries (80.1 percent in 2011 and will be 90.6 percent in 2016). A big current and upcoming problem is the growth of the domestic demand. Private consumption grows by an average of around 2 percent and government consumption is slightly increasing by an average of 0.6 percent since 2012 which most likely will lead to further issues in the future [OECw].

2.8 Political influences of 2016 and 2017

Several important political occurrences have happened in the year 2016 which will affect world economies in the next few years with a very high probability. These events will be described shortly and an outlook on possible impacts will be given:

- Presidential election in the USA
  On November 9th, 2016 the presidential election of the USA has taken place. The citizens of the USA had to choose primarily between the two main presidential candidates - Hillary Diane Rodham Clinton (born October 26th, 1947) who was the nominee of the Democratic party and Donald John Trump (born June 14th, 1946) running for the Republicans. Trump won the election and became the 45th president of the USA at the inauguration on January 20th, 2017. Regarding his economic agenda he is likely to terminate or renegotiate multilateral contracts regarding free trade zones (e.g. North American Free Trade Agreement (NAFTA)) and/or the discontinuation of lower import duties helping US companies to ship their (intermediate) products to other countries easier like the Trans-Pacific-Partnership (TPP) and other contracts to make trading easier and increase it. Some other intentions of his agenda might affect some of the European industries which are highly interlaced with the US industry.
  Even his campaign slogan *America first*, has discriminating implications in other economies as he plans to resettle outsourced industries from the Rest of the World (RoW) back to the USA to get the value creation inside the country. Other economic intentions consider tax cuts, but targeting lower and middle class workers then rich people, which would limit the boost of domestic demand of private households and would lead to an decrease of government earnings. This would increase the already large public deficit and his purpose to increase the military budget after a reduction made by the former president Barack Hussein Obama again would result in a higher deficit [Eco16].
- Withdrawal of the UK from the EU
  June 23rd, 2016 the British citizens voted against the remaining in the EU, which

led to the starting point of the *Brexit* negotiations one year later. The UK is likely to set up new trade agreements with the EU to establish and remain more than 51 % of their exports to this European association (as it was in 2014) which is the highest amount of exports since their joining in 1973. On the other hand, the spendings of 350 million pounds to the EU can be invested into the domestic industries and will raise educational levels of the country. One of the mainly driven arguments for leaving the Union was the high immigration rate on which the British economy strongly depends. Most of the immigrants are better educated and participate more in the labor market of the UK than immigrants in other countries of the EU.
In general the leaving conditions and their outcome is highly interconnected to the resignation negotiations which started in June 2017 and which cannot be foreseen at the moment [Eco17].

CHAPTER 3

Basics of I/O analysis

The last chapter was about the historical developments of the countries to be primarily investigated in this thesis. Before starting the research of the data sources which have to be provided for the model, it is necessary to get the basic knowledge of I/O tables and how the later applied I/O analysis is correctly executed. Concerns about working with this kind of data, anticipated problems and possible solutions are included in this chapter. Furthermore, it is important to get to clarify the different approaches which are possible to take when working with I/O tables based on the context of the research and which other methods have to be used for specific topics.

3.1 History and basics of I/O analysis

In 1758 Francois Quesnay (1694-1774) published the "Tableau Economique" in which for the first time in economic history he tried to represent the whole national economy in one single economic circle. This approach was based on an I/O schemata. Quesnay showed that only farmers had a value adding position and were paying most of the taxes. He concluded that if the farmers had a better life it would improve the whole economy. Higher tax income for landowners would lead to more employment and higher payment of craftsmen who then would buy more goods from the farmers and so on. This model was intended to be a too simplified version of a complex subject but it was still criticized for not adequately and exhaustively representing the whole economic system [HS94].

The first relevant article written about the I/O analysis came from Wassily Leontief (1905-1999) in 1936. He investigated the parts of an economy and tried to figure out what would happen to the total output of a country-sector if there were changes in the capital or labor input. His final goal was to illustrate and specify the linkage of industries to the economy of the USA. He won the Nobel Prize in Economic Science in 1973 for his work. Leontief's approach is based on the analysis of the flow of goods and services

between producers and consumers to represent and quantify the interdependence between a production sector and the final demand in a specific time period. Due to this approach the whole economy can be represented by one single matrix and is suitable to investigate in this thematic [RP09].

The I/O tables are the best way to determine the raw materials which are necessary for a good. A good does not have to be a final good, it can be reused as material for another good. This chain then results in a final good. Figure 3.1 visualizes this workflow. The producers (retailers, resellers, other consumers, etc.) take an amount of input (this is transitioned by delivery, purchase or other transactions) to produce a specific amount of output [Leo36].

Figure 3.1: Workflow of the production of goods with input and output

Based on this knowledge it is possible to research into economic theories and questions. A research question could be, for example, which effects the reduction of 10000 units of produced automobiles, caused by external economic events would have on other sectors. So the aim would be to find other sectors which are highly correlated to the automotive sector (iron, steel, tires, etc.) and take a look at industries which are affected by this change in production.

3.2 Sectioning by aggregation

Each row (input) or column(output) of an I/O table can be seen as an economic sector. As mentioned before a country can be divided into many industrial sectors, but this division is based on the context of research. An economy consists of a huge amount of companies which are producing goods in a specific industry branch. The difficulty here is to aggregate these companies into a sector which is meant to be homogeneous. However, sectors become more complex and heterogeneous the more companies are added to them [Leo86].

The sectors are an amount or value of single goods or an aggregated amount or values of an industry [Ber04]. There are three possible uses for produced goods in a sector which were already mentioned before:

- The product itself will be used to fulfill a requirement in the same sector
- The product will be used as an input for a production of another good in another sector

- Or the product goes straight to consumers or other investments for final consumption

For example the WIOT dataset is divided by 56 sectors. Additionally, they can be even further aggregated to the three economic sectors (first - raw materials, second - manufacturing and third - services). Figure 3.2 below demonstrates the flow of goods in a simple economy, including the above mentioned possible uses of goods [HS94].

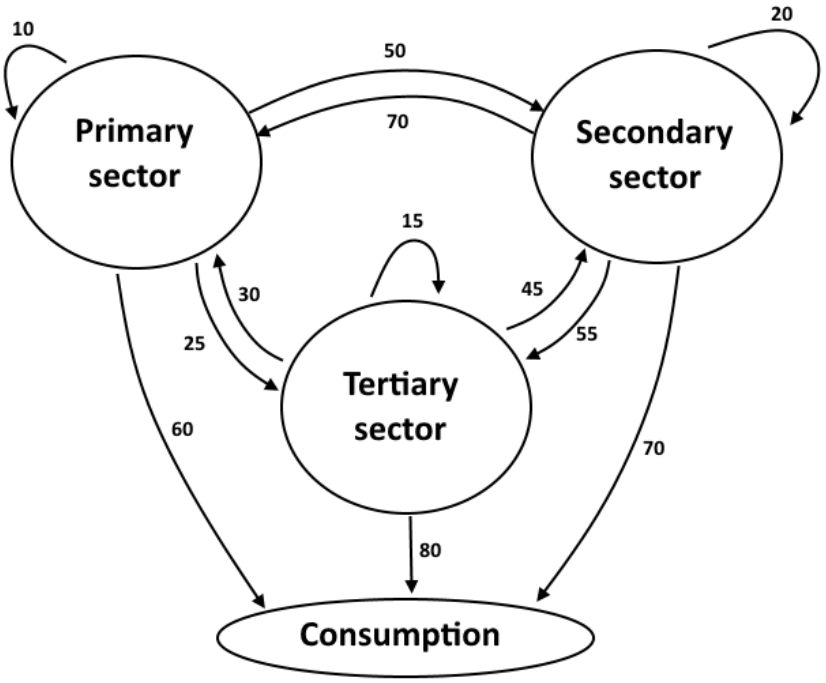

Figure 3.2: Flow of goods between the three economic sectors and consumption

Beside the spatial and time demarcation in I/O tables there is the size of the table, the capturing and the evaluation of the transactions within the rows and columns significant. One important aspect of building tables for a certain research question is the way in which sectors are built and merged. There are two possible and common approaches on how industries are shaped [HS94]:

- Institutional approach
  Statistical units (companies and other businesses) are classified by their main produced goods (market interweaving principle). This approach accepts more heterogeneity in transactions which are mapped.
- Functional approach
  Aggregation is done by products or homogeneous product groups (product interweaving principle). This approach tries to map the flow of all goods which are handled over to the market and within a company (which do not touch the market).

So typically multiple industries would be consolidated into sectors. It would be a crucial disadvantage to work with a highly concentrated table. Not to lose important informations a compromise has to be made.

3.3 Characteristics of I/O tables

Constructed sectors are represented in a transaction matrix which holds the values of inputs and outputs of various sectors. The table consists of three sub matrices which can be seen in figure 3.3 [HP95].

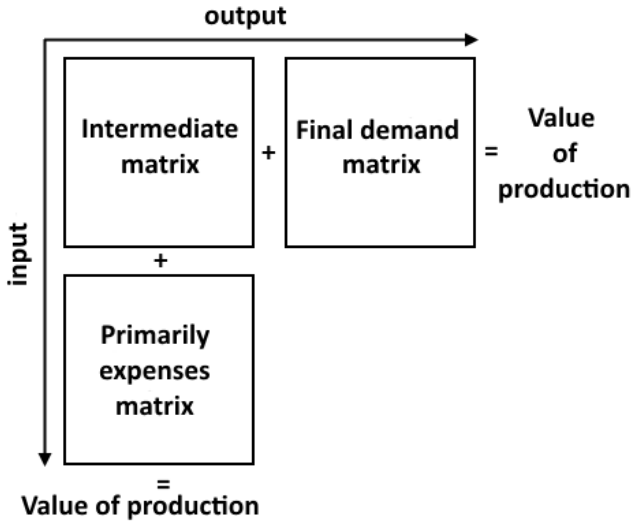

Figure 3.3: Structure of the whole transaction matrix

- (Raw) materials (intermediate input) matrix
  This matrix represents the flow of intermediate goods from one sector to other sectors and in between sectors - Intra-industry trade (IIT). Therefore the sum of a row equates to the total amount of all intermediate goods to other sectors whereas the sum of a column is representing the total amount of consumed intermediate goods of a sector. These values of the intermediate table are endogenous.

- Next to the first is the final demand matrix
  This matrix shows in detail column-wise transactions for each sector to the final demand organized by public/private consumption, GFCF, stocks and exports which are exogenous. The last column specifies the gross output which is the total output of the row (which might be, based on the type of the I/O table, the country-industry).

- Below the first matrix is the primarily expenses matrix
  This matrix represents row-wise the amount of profit, loans, depreciation, indirect taxes and imports which are exogenous, and the most important sector indicator, the Value added (VA).

A more precise explanation is given in the next chapter for the I/O tables hosted by the WIOT [RP09].

This table can be viewed with different types of data. It may reflect the amount of units or the amount of goods times prices (mostly done with the US-$) between sectors which is based upon the research context. Nevertheless it is an important fact that the sum of total input equals always the sum of total output [HS94]. Table 3.1 shows a simple I/O table which is based on the data illustrated in figure 3.2 where rows are the input and columns are the output. To sum up, an economy can be divided into $n + 1$ sectors, n industries and the $n + 1^{th}$ total output.

from/into	Primary x_1	Secondary x_2	Tertiary x_3	Consumption Y	Total output X
Primary x_1	10	50	25	60	145
Secondary x_2	70	20	55	70	215
Tertiary x_3	30	45	15	80	170
VA	VA1	VA2	VA3		

Table 3.1: Simple I/O table

To keep the calculations simple, the VA are not taken into account in the next sections.

3.4 I/O model

Before starting the analysis, the research question with the I/O model itself has to be defined. Furthermore, its limitations due to aggregation need and its requirements have to be clarified. It is nearly impossible to create an I/O model that fits every requirement, however the analysis after the construction of the table has to be considered (e.g. if the exports are not present in the dataset and the research question intends to determine the impact of increasing exports on the original labor market, the model will not fit those needs). On the basis of the availability and quality of the data which is used in the analysis, the I/O models can be separated into different types [HS94] [HUPW+93]:

- Open and closed
  In theory a whole economy is always seen as a closed circuit which is only effected by the system (endogenous). Furthermore, this means that if an economy is taken and is represented in a matrix the column sum equals the row sum. In practice however, external parts have to be considered too (exogenous), because a final demand can be influenced by external events. If this part should be considered as

endogenous it has to be treated separately and calculated manually. This would take more complex estimations into the model [HS94].

- Static and dynamic
  The difference here lies in the time reference. The data in the static variant always relies on the same point of time, whereby dynamic models take the time into account. It may occur that the production of goods and their uses (as an intermediate or final good) are not in the same time period but delayed (storing goods for the next period). Dynamic models are helpful in analyzing how industries developed in the last couple of years and which factors influenced the development [HUPW+93].

- Unit and prices
  On the one hand unit based models enable the analysis of how direct and indirect impacts change final demands of each industries. Exogenous variables are the inputs of the primary sector, as well as components of the gross values and imported preliminary goods. On the other hand, price based models are constructed to analyze changes in prices and how it affects preliminary work, prices of imported goods, amount of subsidies and changes in loan. In this kind of model exogenous variables are the private and public consumption, GFCF, changes in storage and exports.

3.4.1 Leontief model

Leontief's approach led to a model with the intention that the amount of flowing goods from sectors x_{ij} and the output from a supplied sector x_j are proportionally dependent. This assumption led to a basic I/O model. This was verified with many examples (four tires are need to produce one car and therefore the production of two cars require eight tires) and it's possible to generate the equation (3.1) [RP09]:

$$x_{ij} = a_{ij} \times x_j \tag{3.1}$$

Open static Leontief model

The commonly used model is the open static Leontief model which has the biggest importance and form of basis of assumptions [HUPW+93]:

- There exists a linear technology, that means in every industry the amount of factor inputs is proportional to each amount of output.
- Each output of a sector is homogeneous. If there is a heterogeneous production it will be declared as constant.
- Every sector has its own unique production mechanism.
- The final demand, which is only a part of the total output, will be seen as autonomous.

3.5 Other I/O characteristics

I/O tables have different kind of characteristics and indicators which help to resolve different kinds of scientific and mathematical questions in various research fields.

3.5.1 Technical coefficients

The equation (3.1) based on the Leontief model allows the deduction that the factor a_{ij} is the proportion to show the demand on intermediate goods of a sector x_i to produce one unit in sector x_j and are stated as the direct effects of change in final demand in a particular industry [HP95]. This factor is called the **technical coefficient** or **input coefficient** and is derived by the formula:

$$a_{ij} = \frac{x_{ij}}{x_j} \tag{3.2}$$

If a complete set of input coefficients is calculated, it reveals the *technical coefficient matrix* of that economy [HP95]. Taking the values from the dataset of the 3.1 and the definition for the input coefficients, the following matrix (3.3) can be built [RP09]:

$$A = \begin{vmatrix} 0.07 & 0.23 & 0.15 \\ 0.48 & 0.09 & 0.32 \\ 0.21 & 0.21 & 0.09 \end{vmatrix} \tag{3.3}$$

This example shows that one unit of production in the sector x_1 needs an input amount of 0.07 of x_1, 0.48 of x_2 and 0.21 units of sector x_3. The sum of a column in the coefficient matrix including the VA (in this example excluded) has to be always 1.0. [1]

3.5.2 I/O vectors

By means of the dataset in 3.1 two additional vectors can be constructed [RP09]:

- Production (total output) vector

$$\vec{x} = \begin{pmatrix} 145 \\ 215 \\ 170 \end{pmatrix} \tag{3.4}$$

- Consumption (final demand) vector

$$\vec{y} = \begin{pmatrix} 60 \\ 70 \\ 80 \end{pmatrix} \tag{3.5}$$

[1] All equations in this chapter are getting calculated exactly, but are shown with two decimal places in case of the reduced spaces.

3.5.3 Leontief inverse matrix

With the help of basic matrix operations on the structural matrix and the vectors which were previously defined, the *Leontief inverse* can be defined (where I is the identity matrix) [RP09]:

$$\begin{aligned} A \times \vec{x} + \vec{y} &= \vec{x} \\ \vec{y} &= \vec{x} - A \times \vec{x} \\ \vec{y} &= I \times \vec{x} - A \times \vec{x} \\ \vec{y} &= (I - A) \times \vec{x} \\ \Rightarrow \vec{x} &= (I - A)^{-1} \times \vec{y} \end{aligned} \tag{3.6}$$

These equations show that it is possible to compute the production vector or the consumption vector as long as the other vector exists and the structural matrix is given. These equations lead to the *Leontief inverse*:

$$(I - A)^{-1} \tag{3.7}$$

To take a better look at this model, the above data will be used to proceed the following mathematical steps:

$$\begin{aligned} (I - A) &= \begin{vmatrix} 0.93 & -0.23 & -0.15 \\ -0.48 & 0.91 & -0.32 \\ -0.21 & -0.21 & 0.91 \end{vmatrix} \\ (I - A)^{-1} &= \begin{vmatrix} 1.39 & 0.44 & 0.38 \\ 0.92 & 1.49 & 0.67 \\ 0.53 & 0.44 & 1.34 \end{vmatrix} \end{aligned} \tag{3.8}$$

This matrix can be interpreted as follows - an autonomous change of final demand of goods from the primary sector leads to an improved production in the primary sector by 1.39 units, the production of the secondary sector rises by 0.92 units and for the tertiary sector the production increases by 0.53 units.

An economy can fulfill every external market demand if $(I - A)$ is invertible and the inverse matrix has any negative coefficients [Leo86].

As relevant information about the data and the mathematical formulas have been described, it is now possible to derive the exact amount of goods which are needed to fulfill the required demand of the market:

$$(I - A)^{-}1 \times \vec{y} = \begin{vmatrix} 1.39 & 0.44 & 0.38 \\ 0.92 & 1.49 & 0.67 \\ 0.53 & 0.44 & 1.34 \end{vmatrix} \times \begin{matrix} 60 \\ 70 \\ 80 \end{matrix} = \begin{matrix} 145 \\ 215 \\ 170 \end{matrix} \tag{3.9}$$

This vector represents the total output of each sector again. The final demand in sector y_2 increases from 70 to 90, resulting in all three elements in vector x increasing too.

$$(I-A)^{-}1 \times \vec{y} = \begin{vmatrix} 1.39 & 0.44 & 0.38 \\ 0.92 & 1.49 & 0.67 \\ 0.53 & 0.44 & 1.34 \end{vmatrix} \times \begin{matrix} 60 \\ 90 \\ 80 \end{matrix} = \begin{matrix} 154 \\ 245 \\ 179 \end{matrix} \tag{3.10}$$

3.5.4 System of national accounts (SONA) model

For the first time in history the United Nations (UN) published the SONA in 1968. It is known as a framework or a set of recommendations on how to measure economic activities in a consistent and coherent way. This allows an international comparison following classifications and definitions [Nat08]. It was established to create standardized national economic calculations. Those got linked into the "Eurostat Manual of Supply, Use and Input-Output Tables" which was published in 2009 [Com08].

Since the I/O tables are sparsely refreshed - WIOT released its newest dataset in November 2016 containing data from 43 countries for the time period 2000-2014, whereby the previous version was released in 2013 covering data of 40 countries for the period 1995-2011 [EC16b] - national accounts are often used and adapted to be able to work with current data.

The fundamentals of the manual for the SONA are how to merge the national economic calculations and the I/O tables. This is done by using rectangular matrices (instead of quadratic matrices). The most important matrices used in this manual are [RP09]:

- Use matrix (input)
  Use of goods as preliminary work in each industry where rows represent the partition of goods as inputs for each industry and columns are responsible for the division of the input of an industry for each good (dimension: *industry* $\times$ *commodity*. This matrix is denoted with a U.
- Make matrix (output)
  This matrix shows how industries make commodities, therefore rows are showing the division of output of each industry for different goods and columns represent the split of produced goods for each industry (dimension: *industry* $\times$ *commodity* and is denoted with a V.

3.6 Forecasting technical coefficients

The widely-used bi-proportional matrix balancing technique RAS is used to estimate the technical coefficient matrix A in a new time period based on new data of the vectors x and y. This procedure updates the matrix A with R, a diagonal matrix containing factors to modify rows, and S which is a diagonal matrix with column modifiers in an iterative way to establish a "balanced" matrix due to the new vectors. The total output is:

$$\vec{X}' = (I - A') \times \vec{Y} \tag{3.11}$$

The adapted coefficient matrix can now be used to receive the new intermediate matrix of the I/O table. This procedure can be taken to calculate a market equilibrium where demand equals supply in the new time period.

3.7 Excerpt of the application of I/O analysis

In 2013 the I/O analysis was used to research the phenomena of maximum possible global oil production rate. It is the so called *peak oil* (not to be mistaken with the end of oil reserves) and its impacts on the economy of the USA and its feasible dangers were investigated. The paper's context was to analyze the relative importance of industries, how likely they get affected and the severity of the effect itself [KPFH13].

This goal was pursued by using the Leontief input-output price model (LPM) which demonstrated the potential price increase. For the practical part both approaches of linkage analysis were used. These methods are utilized to reveal the connection of an economic sector to other industries and it additionally measures the contribution (direct or indirect) of an industry to a whole economy (supply and demand) and is used as an indicator of relative importance. Linkages are additionally used to identify key sectors (input, output, employment, etc.) to demonstrate structural changes of sectors and to create an impact analysis [RP09]:

1. Forward linkage analysis (FLA) (supply-driven)
   A reduction of output in sector x which was used by sector y as an input leads the sector y to a declining output. This is the so called forward linkage and can be pursued for multiple sectors which are interconnected to each other. The easiest way to calculate the forward linkage is the summation of every element in the xth row. That's where its value represents the amount of inputs from other sectors y_i which are used for production in sector x. Another approach would be the use of the Leontief inverse where the row sums are the total forward linkage, which are better known as the **input multiplier** and are derived as follows:

   $$TFL_x = \sum_{y=1}^{n} l_{xy} \tag{3.12}$$

   l_{xy} is the element of the Leontief inverse at x, y. The sector with the highest linkage values grants the most **supply-push** effect on the national economy. If there is an increase of goods by a single unit in all sectors, it results in the highest increase of total production of this given sector.

2. Backward linkage analysis (BLA) (demand-driven)
   Let us consider the following example: if the sector y increases its production, there will be a raise in demand of other sectors x_i which are delivering their goods to sector y and are used as an input. The simplest method to derive the backward linkage can be done by using the same matrix A as above for summing up the elements of the yth column to measure the value of dependence of the sector y

inputs from other sectors. A similar approach can be found like in the FLA where the Leontief inverse is used, which is known as the **output multipliers**:

$$TBL_y = \sum_{x=1}^{n} l_{xy} \tag{3.13}$$

l_{xy} is an element of the Leontief inverse at x, y. The same interpretation of the highest value of linkage in the FLA applies to the backward linkage with the exception that the effect is called **demand-pull**.

A more detailed and technical explanation can be found at the citation above. The authors suggest using the Gosh inverse matrix to calculate the linkages [RP09].
The research concludes that there should be a shift to a more adaptive resource management. The authors assume that the peak oil has effects on the economy due to the dependency on oil and on sectors which are being structurally and monetarily important. In [KPFH13] it is recommended to shift to sectors/goods which are currently less essential A replacement of plastic packaging (which is an oil manufactured product) with paper or paperboards packagings or even glass containers would be beneficial. The shift to glass, for example, affects the demand on glass and would change other sector's amounts of input and output. As a conclusion [KPFH13] shows that peak oil is a dramatic occurrence in the future but it will not be an easy task to adapt economies to that.

CHAPTER 4

World Input-Output Database and the GVC

In the last chapter a basic knowledge of I/O tables was set up to be able to work with more complex datasets like the WIOT and how relevant coefficients are retrieved for specific statistical measures. This chapter covers the basics and construction of the WIOT database version released in 2016 (existing data from 2000 to 2014). Another subject included in this chapter is the approach to the massive amount of data. First, however, an overview is given of the classification of the data which is based on the ISIC.

The following section will deal with the I/O data which are provided by the WIOT and what circumstances have to be considered before any other calculations get started. This chapter will deal with the aggregation and integration of the 56 granular divided industries for each country in this dataset. All considerations and the foundation for the decisions will be explained. The last section in this chapter is about the different approaches of analyzing techniques in the I/O analysis. The RCA approach is used in this thesis because of the research question investigating the specializations of economies. There are several different implementations of this indicator which are going to be highlighted and especially the GVC income which was introduced by Timmer et al. in [TLSdV13] to proceed with the main goal of this research application.

The data source offers annual time series constructed by the system of national accounts merged with international trade statistics since 1995 [TDL+15].

Possible applications of I/O analysis using data from the WIOT found in the literature are mostly in the research area of analyzing the impact of global value chains (international trade as a consequence of globalization) [SRT13]. This becomes especially true in the case of Europe [dMPS13] and in analysis of the international fragmentation and clustering of production in industries, see [LTdV15] [TLSdV13]. Furthermore, the article [Joh14]

investigates value-added of gross exports. A case study is used as an example, and China was chosen as the specific country [KWW08].

Regarding those applications described above, further research areas are addressed when investigating different types of data from the WIOD - accordingly WIOT, National Input-Output Tables (NIOT), Socio Economic Accounts (SEA) and environmental accounts - [DLS+13]:

- Environmental analysis
  This dataset contains gross energy use, CO2 emissions, other emissions and land-, material- and water-use on the industry level of a country [EC12a].

- SEA
  This contains a country-industry level fundamental labor market data, like wages and employment based on skill-types and education and the number of worked hours and jobs. In addition to that, capital stocks and investments and aggregated value-added for each industry can be found for every country-industry [EC12b].

These datasets are yet only available and compatible to the WIOT released in 2013, containing environmental data to 2009, respectively to 2011 for the SEA. A new version will be published in the summer of 2017 for the newest version of the WIOT. If there is a need to use this account data with the actual version, data for the periods after 2011 have to be appended manually and the sector classification changes have to be considered (ISIC Rev. 3 to the usage of Rev. 4 in 2016) to map the industries correctly.

4.1 Description of the WIOT

This thesis uses the 2016 release (third release) of the WIOT which contains data of 43 countries (highlighted countries in bold are going to be investigated):

- All twenty-eight members of the EU (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, **France**, **Germany**, Greece, Hungary, Ireland, **Italy**, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, **Spain**, Sweden and **UK**)

- Fifteen other major countries (Australia, Brazil, Canada, China, Norway, India, Indonesia, Japan, Korea, Mexico, Russia, Switzerland, Taiwan, Turkey, United States)

- **RoW** which is only estimated

This dataset covers the years from 2000-2014 and represents the data in an industry-by-industry (other WIOTs could be product-by-product) matrix.

Other countries will be merged together into one region and will be seen as the RoW. In comparison to the older release of 2013, the new version, based on the ISIC Rev. 4, takes additional eighteen sectors into account. This helps to see the manufacturing and business services internationally more fragmented to cover the overall national economy.

It is important to understand the structure of the WIOT to utilize it in a correct and adequate manner. There are three necessary steps in order to create I/O tables: in the first step national accounts data are used for each country to determine annual time series of basic national Supply and use table (SUT). The second step deals with bilateral international trade statistics for disaggregating imports by country of origin and use category. The last step is done by integrating and merging all generated international SUT for all countries and the RoW together to one whole dataset. Therefore, the WIOT is good for analyzing and tracing development over time due to the time series structure and value-added for each industry and illustrating the flow of goods from the origin and its destination to trace the stream of commodities. Furthermore, the production stages can be investigated to track the added value of each country-industry to separate them by GVC for final goods [TLSdV16].

Another characteristic is found in the way the data is constructed within the tables. The use of the System of National Accounts (SNA) framework, allows better comparisons. However, the obvious disadvantage is the lower amount of nations which are considered (43 countries).
The structure of the table itself consists of three already known sub-matrices [DLS+13]:

- Intermediate
  This squared matrix shows the flow of intermediate goods between country-sectors having more than 5.7 million elements plus one row for the aggregation of each column meaning total intermediate consumption.

- Final demand
  The matrix for final demand for each country includes five columns, including the

  1. Final consumption expenditure by households
  2. Final consumption expenditure by non-profit organizations serving households
  3. Final consumption expenditure by government
  4. GFCF
  5. Changes in inventories and valuables

  one column for the summed up total output for each country-sector output and therefore having around half a million entries.

- Primarily expenses
  This sub-matrix populates the values for the following six rows:

  1. Taxes less subsidies on products

2. Cif/fob adjustments on exports
3. Direct purchases abroad by residents
4. Purchases on the domestic territory by non-residents
5. Value-added at basic prices
6. International transport margins

and an additional row for the aggregated output at basic prices for each column.

All values in the WIOT are represented in millions of US dollars and further expressed at basic prices (in comparison to purchase prices). This concept of this price valuation is taken because it considers cost structures of sectors and to ensure that any use of trade and transport margin is explicitly separated.

4.2 Classification - ISIC

In order to work with different kinds of national statistics institutes it is necessary to use a standardized guideline to compare those national data on a harmonized international basis. It is necessary to explain nomenclatures and use uniform scales for measuring. Therefore, the schemas are defined and the data is organized using alphabetical and numerical codes to organize the data.

In 1948 the UN published the first classification to capture all economic activities. Multiple revisions were released since then to react to changes in economic life cycles, impacts of industry behaviors and evolutions in technological progresses. The newest revision 4 is in use since August 2008. Inside there are 21 top level and 99 granular divided sectors, which can be seen here [1]

The number of sectors used in the WIOT are too many for a descriptive statistical model, so the sectors are combined and reduced from 56 to 18. The *manufacturing* sector is too granular divided with its 24 sub-divisions and has to be compressed into six categories (with their corresponding sector indices [2] in brackets and their new name convention afterwards). This allows to have a better look at the secondary sector of each national economy, which was already done in [TLSdV13] and can be seen as a guideline for creating manufacturing sub-sectors:

- Automotive/Transport (29, 30) - CA
- Chemicals (19, 20, 21, 22, 23) - CC

[1] The United Nations Statistics Division provides an overview for the actual revision of the classifications, `https://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27`, visited on 2017-06-06

[2] As the WIOT has its own structure of industries, it provides the description for each of it, whereby some sectors in the dataset are combined together, whereas others are separated into sub industries with an own index

- Electric machinery (26, 27) - CE
- Food products (10, 11, 12) - CF
- Non-electrical and metal (24, 25, 28, 32, 33) - CM
- Other non-durables (13, 14, 15, 16, 17, 18, 31) - CN

The table 1 provides a full overview and description of the new sectors used in this thesis's descriptive analysis part, where only the abbreviations for all the sectors are used. Those top-level sectors e.g. sector A - agriculture, forestry and mining are separated into 3 divisions in the WIOT but will be aggregated to one single sector A in this thesis.

4.3 Analyzing techniques

To find specializations of each country, it is necessary to take a look at different possible methods to investigate the first research question. In this thesis the decision has been made to use the RCA. With a worldwide increasing fragmentation of production, an increase of global competition has to be faced. One possible way to describe that is to track developments of shares in world export markets (approach following the RCA). However, this simple approach does not fit the globalized view of countries' specializations anymore due to the countries integration in GVC and international intransparent production processes. This is further explained in [GRH06]. Therefore, the measurement of specializations has to be revised to adjust to a more international and fragmented way. This may be done based on value-added, which is being calculated, for example, by taking the total output value at basic prices minus expenses for intermediate products and services at purchase prices.

4.3.1 RCA

Let us take a look at the concept of RCA from Balassa, which is known as the *Balassa-Index*. Generally, the index is calculated as follows:

$$RCA = \frac{E_{ij}/E_{it}}{E_{wj}/E_{wt}} \tag{4.1}$$

where E are the exports, i is the country index, w is the rest of the world, j is the commodity/industry/product and a more general sector index and t is the total amount of exports. This mathematical expression concludes that the dividend is the share of a sector i in total exports and the divisor remains for the share of the same sector in world exports. This index is due to the use of export factors and values more often used as an indicator of export potential of a country on a worldwide perspective, but it can help to compare potential trade of new goods on new markets. It is a good measurement for a country's industry trade potential and for finding out if it is in the process of extending.

Other driving factors to have a comparative advantage are technological progresses, wage costs and the quality of products out of the sector itself. A value below unity indicates a revealed comparative disadvantage. If the value exceeds unity it indicates a revealed comparative advantage in the respective sector [Bal65].

To take the example from the first chapter of the German automotive industry, let's assume that Germany exported \$5 billion in automotive sector and total exports are \$50 billion whereas the sectoral exports of the RoW are \$20 billion and are in total \$1000 billion, following the formula of the RCA we get the following:

$$\begin{aligned} RCA_{carG} &= \frac{5billion/50billion}{20billion/1000billion} \\ RCA_{carG} &= 5 \end{aligned} \tag{4.2}$$

The index exceeds 1 and we can see that inside Germany the automotive sector has a comparative advantage to other sectors. As we are supposed to compare them with other countries we take another country into account, in this example, France:

$$\begin{aligned} RCA_{carF} &= \frac{1,5billion/40billion}{20billion/1000billion} \\ RCA_{carF} &= 1,875 \end{aligned} \tag{4.3}$$

France has a national comparative advantage within the automotive sector, but compared to Germany, France has a comparative disadvantage which can be seen in the following equation:

$$\begin{aligned} RCA_{carFG} &= \frac{1,875}{5} \\ RCA_{carFG} &= 0,375 \end{aligned} \tag{4.4}$$

The next section considers a more accurate and advanced indicator, which takes the macroeconomic view to the next level. This knowledge is based on findings of Di Mauro and Forster [DMF08]. They revealed the weaknesses of the current approach of measuring the industrial specializations of countries on the base of the globalization and international fragmentation of assembling lines which is complex. Especially the case of intermediate crossing borders of countries multiple times leads to double counting of gross exports which Koopman et al. addresses in [KWW14] and its effect on the traditional RCA using gross exports for measuring this indicator (which includes the foreign demand, but misses the domestic market to take into account when computing the shares in international trade) instead of the value-added RCA approach which leads to the GVC income method (computing the shares in world markets and including the domestic market) [TLSdV13].

4.3.2 GVC income

Specializations are highly correlated to a country's competitiveness in different industries. This is a complex concept and it has been getting more important since the expansion of the globalization and since different production stages were relocated to different countries. This was done by outsourcing and offshoring activities and tasks (distribution and transport, marketing and advertisement, assembling and production, design and financial services, etc.) which are taking place in pre- and postproduction stages[SRT13]. This is the motivation for an alternative and more complex approach for a country RCA in particular sectors, where components of products are internationally dispersed, like several parts which are used for a car on an assembly line:

- engine block and gearbox
- interior decoration and vehicle body
- steering wheel and ...

This consideration above was used to create a new approach of measuring international trade and a country's competitiveness: *"the ability to perform activities that meet the test of international competition and generate increasing income and employment"*, proposed by Timmer et al. [TLSdV13]. This method tracks the valued-added in various stages across borders which are directly or indirectly involved in the production of a final product. The final products are then consumed by final users, although final products can be reused as intermediate supplies for other final goods. The payment for such a product gets dispersed to each labor and capital stage involved in the overall production process. This is the so-called GVC income which is related to a specific product measured on a domestic basis. It can be calculated with the help of I/O tables and will be achieved with the decomposition of the final product into multiple value-added parts and components running through other countries [TLSdV13].

Technical approach

This section is completely based on declarations and technical remarks of Timmer et al. [TLSdV13].

Due to the use of the WIOT, it is determined that there is an amount of F production factors and S industrial sectors in N countries which are taken into consideration for computing this indicator. This results in SN products, which are named country-sector, like for example the German mining and quarrying or the Spanish transport sector. Based on the *value-added tracking approach* of this method it is necessary to define multiple variables. Therefore i and s indicate the source industry and country, whereas j and t are used to define the destination country and sector. Let $x_{ij}(s)$ be the value of shipped goods from country i of sector s for intermediate use in country j in sector t, where the use of goods can take place inside the home country ($i = j$) or in a foreign country

$(i \neq j)$. Furthermore, $f_{ij}(s)$ defines the value of goods of country i of sector s for final use in country j, $y_i(s)$ indicates the value of the produced goods of country i of sector s. As a conclusion, the market clearing condition can be assumed because the quantity of a good produced by a country-sector is totally consumed domestically or abroad:

$$y_i(s) = \sum_j f_{ij}(s) + \sum_j \sum_t x_{ij}(s,t) \tag{4.5}$$

Based on this condition the country-sector goods can be merged into a compact I/O system. **y** can be a vector of production (SNx1) which is extracted by piling the output levels for each country-sector, **f** is a vector (SNx1) describing the stacked world final demand for capacity from each country-sector $f_i(s)$ which is the total demand of each country ($\sum_j f_{ij}(s)$). The next step defines **A** as the global intermediate input coefficients matrix (SNxSN). Each element denotes the production from sector s in country i which is used in sector t in country j as a share of output in the corresponding sector t in country j and those elements are defined as $a_{ij}(s,t) = x_{ij}(s,t)/y_j(t)$. This resulting matrix A characterizes how the goods of each country-sector are produced by using a combination of all sorts of intermediate inputs which can still be domestic or foreign.

Due to this transformation the equation 4.5 can be rewritten to $y = Ay + f$ which can be rearranged to the fundamental I/O identity:

$$y = (I - A)^{-1} \times f \tag{4.6}$$

I is the identity matrix (SNxSN) and $(I - A)^{-1}$ the well-known Leontief inverse which was described in the previous chapter. The obtained equation (4.6) is the I/O identity, which describes the linkage between the total production of an element (in row a and column b) which is required to produce a single unit of final output of the product b.

The next step is to calculate the value added for each unit of total output manufactured in a sector s and in country i $p_i(s)$ to derive the directly value-added coefficients country-industry vector (SNx1) **p** containing these elements. Therefore, $\hat{\mathbf{p}}$ is defined as a diagonal matrix (the hat - âbove determines a diagonal matrix) (SNxSN) which contains the elements of each **p**. As the GVC income is defined as the value added of direct and indirect contributions of producing goods for final demand. The indirect inputs have to be taken into account by creating the vector (SNx1) **v**, where the elements $v_i(s)$ are the value added produced by a country i in sector s. The vector **v** can be derived by:

$$v = \hat{p} \times (I - A)^{-1} \times f \tag{4.7}$$

The GVC income is only related to the capital input of the global production process, where the GVC worker takes the labor input into consideration which is calculated as follows:

$$v = \hat{l} \times (I - A)^{-1} \times f \tag{4.8}$$

$\hat{\mathbf{l}}$ is defined as a diagonal matrix (SNx1) and each element represents the value added for each employed worker in the country-sector.

The knowledge of this value-added approach for measuring the direct and indirect contributions of manufactures for final goods are now derived and can be adapted to the RCA, which will replace the standard formula with export values and defining a new equation to measure comparative advantage in industrial sectors to find specializations of a country.

$$RCA = \frac{G_{ij}/G_{it}}{G_{wj}/G_{wt}} \tag{4.9}$$

G represents the calculated GVC income and i is still the country index, w is the rest of the world, j is the commodity/industry/product and more general sector index and t is the total amount.

In this chapter we discussed the basics and structure of the WIOT, the amount of countries and included industries which are classified by the ISIC rev. 4, maintained by the OECD and adapted to this thesis. The RCA has been discussed to compare different country-industries and how this approach can be adapted to the GVC income which was technically described at the very last section.

CHAPTER 5

Economic model

In the previous chapter we discussed theoretical aspects regarding the base of the model proposed in this chapter, there was a technical introduction in the GVC income concept to identify industrial specialization based on this approach. The goal of this chapter is to describe the created economic model which was used to answer the thesis research questions. First we will look at the expected data output of the model considering a country and its 18 sectors.
Afterwards the data sources will be described and the process will be explained how to handle data that cannot be fetched automatically (e.g. employment data for the labor situation in the industries or data from inconsistent structures provided by the OECD). Scripts will be used for downloading data and the transformation afterwards.
Finally we will look at the implemented algorithm and which is used for calculations, based on various scenarios where e.g. the total output for a specific sector is raised for the next period by a certain percentage compared to the old period.

Due to the limitations of this work this model will be considered as a prototype implementation with partial dynamic input and parameters. It will not be a final version of a model and it does not completely include all different types of data and input variables. The model only computes the variant types of scenarios requested in the thesis question and not further eventualities. Although the model is able to handle partially dynamic data input and to calculate the market equilibrium using the matrix balancing procedure *RAS*, this model should not be considered as an agent based model, where agents may have further interactions and react on others' behaviour. A more detailed look at the limitations will be discussed in chapter 7 where an outlook and further work of this model and research topic are given.
An economic model is necessary to investigate if it is possibly based on input data from the WIOT and other sources from the OECD or the EU Klems database [Jä16], to find specializations of an economy. The data sources have to be defined and prepared before using them as an input for the model. Every calculation script or extraction of economic

key figures is written in R to provide a consistent language and to be able to use libraries for better visualization of the output. Figure 5.1 shows the structure and workflow of the model.

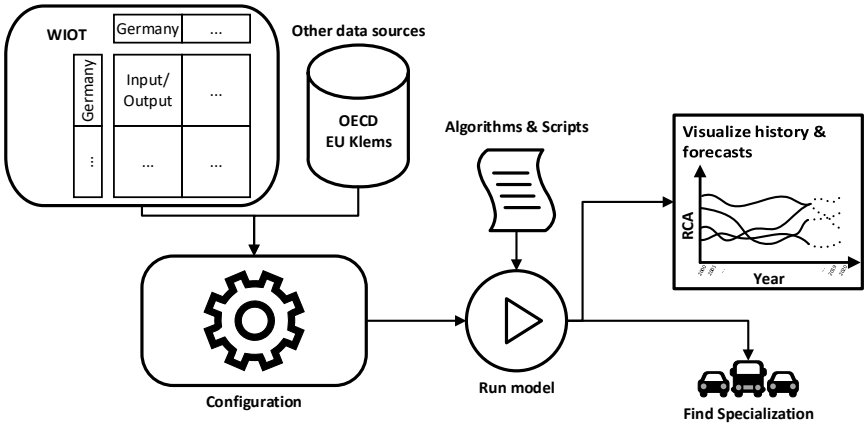

Figure 5.1: Structure and workflow of the proposed model

5.1 Expected data output

The following data output will be expected from the model for the period from 2000 to 2014 (already existing data sources). Additionally, individual methods will be used on external data to calculate the following periods from 2015 to 2020. Those results help to answer the question of how the sectors have emerged since 2000 and how they might develop based on forecasts. One economic indicator that has to be considered is the labor market, which is represented by the unemployment rate. A sector measures the activity of a specific industry. Multiple firms play a role on a national and international level to be in a competitive situation to contribute to an economy which is performed by using capital and labor input has to to be considered when extracting data output for a country-sector:

- Country
  Each economy of a country is able to produce these data and visualize their output, although tables and diagrams can vary based on the researcher field:
  - GDP growth
  - Unemployment
  - Import/Export ratio
  - International export shares

- Sector
  Top sectors will be computed from the data and will be used as an input for the following indicators:
  - % share of the GDP
  - % share of total exports
  - % share of total employment
  - % share of GVC income
  - % share of GVC workers
  - The RCA values

5.2 Acquiring input data

The basic source for this model will be the WIOT which was described in detail in the last chapter. By using the GVC income technique it is possible to figure out the top 5 specialized industrial sectors for each of the five biggest countries in the EU. This approach allows comparisons within and between the countries.The resulting sectors are the biggest contributors for each national economy. This overview gives a good insight into the development of newly *growing* sectors. For example, it is interesting to consider the progress of the sector because this might have an interaction with external factors in economies on a national or international level. It might affect internal factors and the biggest sectors as well. Additionally, growing sectors have impacts on regional growth and structural effects on infrastructure. New factories or labs might have to be built and new workers with different skill levels are attracted to surrounding areas. These are the reasons why the newly developing and growing sectors are regarded in this master thesis.

5.2.1 Existing WIOT

The already existing datasets [EC16a] from 2000 to 2014 had to be transformed and adapted according to the research topic. The written scripts have the advantage that the customizability enables researchers to compare any countries and sectors of interest. First each of the I/O tables were modified to include the data of 18 sectors and 6 countries and only two of the five columns of the original final demand matrix to analyze the data accordingly:

- Final consumption expenditure of households
- Final consumption expenditure by non-profit organizations serving households

were combined to act as one private final demand column.

For each of the already existing period of the WIOT the following calculations and steps are required, placeholder are used to label the customizability in this model:

1. Combine 56 original sectors to [sectors]
2. Combine 44 original countries to [countries]
3. Technical coefficient matrix A
4. Final demand vector f
5. Value added/total output vector $\hat{p}$
6. Value added/employment vector $\hat{l}$
7. Calculate the GVC income and workers vector
8. Calculate the RCA based on the GVC income results
9. Save the new country and sectoral combined WIOT according to its time period to a .csv file
10. Save the GVC income and workers vector and the RCA results into a .csv file

Based on this dataset the top 5 sectors were extracted to work with them to predict future periods. With the use of the formerly described method of identifying global value chains, the GVC income and the RCA will be measured as the country share in the overall value of the world's GVC income of an industry divided by the same ratio for all the sectors in the year 2014. After this calculation, other relevant economic indicators were taken from the WIOT to gain more information about the linkage of the countries and sectors used in the model afterwards.

5.2.2 OECD/EU Klems database

Due to the fact that the OECD only provides tables from 2000 to 2014, it was necessary to use similar data sources to be able to calculate and predict the periods from 2015 and onwards on a reliable basis. There were two data sources conducted for this lack of data. They are available for certain countries, but they have to be transformed. With the use of international trade statistics and NIOT they could have been properly generated for the time period after 2014, but this would have exceeded this thesis's capacity and intentions.:

- OECD
  This database provides data on nearly every economical, industrial and labor level. It is offered for free to any user, who wants to investigate any relating topic. The data is provided in different frequencies: annually, quarterly and monthly. The fact that not every required type of data is available within this frequency, the model and the forecast is restricted to the annually and quarterly (including a seasonal component for the Holt-Winters predictions) time series. The model works therefore only with annually and quarterly data frequencies. Two types of OECD provided papers and tables are used:

  - Annual National Accounts (ANA)
    The OECD publishes annual national account data every year for all member countries and other major economies. It consists of main economic indicators such as the GDP, GDP growth rate, total exports, total imports but detailed aggregated data on industry levels like value added, intermediate consumption and labor compensation. The latest issue published in February 2017 contains data from 2008 to 2015 for every country under investigation, the periods from 2000 had to be retrieved from previous tables accessing their database and with prior released dates [OECb]. The following values are extraced:

    * **P2A** Intermediate consumption with the transaction value
    * **D29_D39A** Other taxes subtracting subsidies on production

  - Quarterly National Accounts (QNA)
    In addition to the ANA, there exist accounts which are updated and released continuously every quarter. This dataset out of the time series from 1960 and onwards covers the GDP from the expenditure (private demand and government consumption) and from the production side (value added, taxes, etc.) amongst further other indicators. Furthermore, it offers data for the GFCF separated by type of product and the sector and labor market statistics like total employment, sectoral employment, wage levels, jobs, hours worked, etc. which are relevant for the division of labor in the context of this work [OECx].
    From this dataset the following factors are retrieved, first the subject value with the following description:

    * **P31S14_S15** - Private final consumption expenditure (Households and non-profit organizations)
    * **P3S13** - General government final consumption expenditure
    * **P51** - GFCF
    * **P52_P53** - Changes in inventories and acquisitions subtracting disposals of valuables
    * Gross value added in the following activities, starting with **B1GV**: A, B_E, C, F, G_I, J, K, L, M_N, O_Q, R_U

  - Real GDP forecast
    For some values, where no detailed data exist (without conducting NIOT, National supply and use table (NSUT) or even international trade statistics), like international transport margins or direct purchases abroad by residents and values for the RoW, which is already an estimated model, forecasts for the countries and the world are used to adapt those values accordingly.

  The OECD provides several ways to access the dataset via custom queries. This can be done by using their API (Application Programming Interface) to fetch SDMX-JSON formatted time series [1] to download the necessary data in this particular format to work with them for further calculations. Even though there is an official documentation of the data structure, a bug was found during the research which made customizing queries regarding the gross value added for each sector for a set of countries necessary. This will be further explained in chapter 7 regarding the limitations of this master's thesis.

- EU Klems
  The release in 2016 of this dataset covers ten European countries (Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain, Sweden and the UK) and contains basic information about country-sector output, input, and other productivity measures based on the ISIC classification Rev 4. There is extended information about the GFCF, value added, detailed employment data (men/women shares of employment), prices and capital stocks [Jä16].
  This comprehensive view on the industries allows a more in-depth investigation of their activities on one hand. On the other hand, however the acquired data set is only available in comma-separated .csv files. This format is hardly transformable in an automated way to fit the necessary input structure of the model. This disadvantage will be further discussed in chapter 7.
  Nevertheless, the described data will be used as the employment data for each sector, transcribed as the value **EMP**, which is the total of employees and self-employed people.

All the transformed .csv files have a time series structure. The countries or sectors are on the x-axis (row-wise) and the time span is found on the y-axis (column-wise). So with the help of the algorithms the averages and growths in percentages are easier determined and the forecast of the missing values requires data in time series format.

[1] JSON - Javascript Object Notation is a lightweight, text-based format to interchange data literally independent of the used language [Int13] combined with the structure of statistical to measure specific events which are represented as observations identified by a dimension and its attributes [fECoD16].

5.3 Calculating new periods

As the data of the intermediate consumption as well as the data from the OECD are not included in the model, the matrix balancing procedure *RAS* has to be performed before the next period calculations have been finished. All of the following steps are calculated with the help of R. The calculations starting with the year 2015 with the help of the data sources described above are made to get reliable data for as long as they are available. QNA data is currently available for 2016 in contrast to the ANA where data exist only until 2015. However, for some countries there are provisional values for 2016. For the latest present quarters provisional values of the QNA are available as well.
The following steps are executed to provide all periods after 2014. Due to the lack of data for the original RoW and the new combined RoW, all dependent values are adapted by taking the old period and estimating them with the growth rate of the RoW:

1. Copying the untouched intermediate matrix of the previous period
2. Adding new total intermediate consumptions
3. Adding taxes subtracted by subsidies on products for the intermediate goods
4. Adding all additional rows
   Due to the fact that there are no new data available from the OECD, values from the old period are taken and estimated with the GDP growth rate.
5. Adding value added for each country-sector
6. Adding final demand for each of the four final demand columns of each country
7. Adding taxes subtracted by subsidies on products for the final demand
8. The GDP growth rate calculated by the production side is checked against the forecast of the OECD. Value added for each country-industry is adapted to close the gap
9. Checking the total output
   If there is a manual interaction found to steer the total output based on certain percentage compared to the previous period, the total output gets modified before copying the total output for each column to each row.
10. Balancing the intermediate matrix with *RAS*
11. Saving the new period to a .csv file, for further processing
12. Extracting economic indicators for countries and top sectors

The base year for the price calculations of the OECD and the WIOT is different, so additional data from the OECD are not used directly and replaced with the old ones. Therefore, the old values are taken and adapted due to the growth rate between the previous and next period, otherwise taking the new values from the external data sources would not be reliable.

5.3.1 Prediction of missing time series

As previously assumed, there is no granular data available for the years 2017 and following. This information for those time periods has to be predicted. No detailed data (e.g. private final consumption expenditure, intermediate consumption on industry level) besides the GDP growth rate provided by the OECD are available. Those time-series have to be continued to make the model work properly. Similar to predicting the development of RoW as explained above, is the calculation of development of the GDP growth. All the other countries, where the required data exist until 2016 and even partially for the first quarter of 2017, Holt-Winters is used to predict the values needed for annual and quarterly datasets during the preparation of the calculation phase. In general, quarterly datasets can be seen as more accurate because of the included seasonal component, whereas annual time series have a deactivated seasonal component during the forecast.

5.3.2 Handling missing employment data

Data for the labor market is hard to find and nearly impossible to acquire automatically without any manual interference to transform granular divided sectors (which are mostly provided by the OECD and EU Klems database) to the necessary structure of the industries configured in this model. Employment data on industry level are almost completely available till 2014 for countries of the EU, while other countries do not provide this kind of granular datasets. The OECD supplies data for employment on top level classification (regarding the ISIC), where existing values can be adapted using the growth rate for the structure of industries used in the model.

Values for periods after 2016 are then calculated with the help of the elasticity concept related to the total output of a country-sector. The elasticity describes how much the employment of a sector will increase/decrease if the total output changes per unit. Regarding this model the arc elasticity is used to take time periods into consideration. The starting point to calculate the elasticity is the year 2010, which is the year when the recession after the housing bubble ceased and a world-wide recovery started. The second value corresponds to the latest available data which are data for the year 2016. This will be done for each of the 18 sectors to calculate the employment of years after 2016 to take a look at the development of the employment in the industries and especially at the unemployment rate to provide a general assessment of the overall economic position of a country.

5.4 Visualization

As part of the descriptive statistics, the data output has to be visualized accordingly. That means that graphs, diagrams and data tables have to be prepared. While the thesis only describes the division of labor, in this context the labor includes the labor and the capital division and contributions to the total economy of a sector.
A comparison from 2000 to 2020 will be created for the top sectors and their RCA values to take a look at how they developed and how comparative they will be in the future. This will be done in multiple time steps from 2000 to 2009, 2009 to 2016 and 2016 to 2020. The break in 2009 marks the bursting of the housing bubble and 2016 indicates the last period with full, reliable and real data of the OECD. There will be diagrams to point out the share percentages of the total exports, total employment and GDP for each sector.
Two graphs will illustrate the development of the GDP growth rate after and the unemployment rate till 2020. Further two diagrams will demonstrate the import/export ratio and the share of the export's destination of a country's total exports.

CHAPTER 6

Results

The last chapter described the proposed model to answer the research questions, the developed model calculates three different configurations. The first one will cover the top five countries of the EU to take a more precise look at the top country-sectors and their contributions to the national economy. The second research goal was to address the customizability of the model itself, which will be discussed afterwards. Finally, the validity of the model will be tested by verifying the data output based on a hypothesis test.

6.1 Top five European countries

The first part of this analysis will highlight the comparative advantage of the country-sectors and find the most specialized industries of each economy. Additionally, other sectors which might be of interest because of a high growth or reduction will be emphasized before taking a look at the employment in these sectors. Next, the contribution of those sectors will be presented before a discussion of the labor market in the national economy, as well as the export statistics. This analytical structure is consistent for each of the five countries described in the following sections.

6.1.1 Sectoral specializations and their economic contribution

The first step was identifying the five industries that have the highest value measuring the RCA (setting the base year for this calculation to 2014 - last existing WIOT) based on the GVC income approach and determining the additional sectors which gained the most since 2014 for each country.
First the five biggest sectors are named [1] with its number according to the customized

[1] The first part in the analysis will use the full classification names of the sectors, while in further parts, only the shorthand symbols will be provided.

classification using the ISIC rev. 4, which can be found here in table 1. Furthermore, the industries are sorted by ranking them in descending order with the development measured in percentage from 2014 to 2020 and stated in between the braces. Below the top sectors, there is a list of other sectors which have percentage changes in this timespan which might be interesting. The results are shown in table 6.1.

France	Germany	Italy	Spain	UK
MN (+6.04%)	**Ca** (-7.7%)	**L** (-1.34%)	**I** (+3.32%)	**MN** (+4.25%)
L (+2.08%)	**Cm** (-8.35%)	**I** (+5.57%)	**L** (-4.85%)	**J** (+17.33%)
OU (+1.16%)	**MN** (-1.83%)	**Cn** (+7.92%)	**DE** (+2.87%)	**K** (-4.71%)
I (-0.36%)	**Ce** (-8.88%)	**Cm** (+8.37%)	**Cf** (-6.82%)	**L** (-0.48%)
J (+14.26%)	**L** (-2.27%)	**H** (+5.78%)	**OU** (+0.86%)	**I** (+4.14%)
...	**B** (+45.83%)	**Ca** (+8.96%)	**MN** (+16.68%)	...
...	**DE** (+44,99%)	...	...	...
K (-9.76%)	**F** (+21,29%)	...	...	...
F (-13.47%)	**Cf** (-8.91%)	**K** (-10.08%)	...	**B** (-34.29%)
A (-16.28%)	**A** (-32.74%)	**J** (-12.57%)	**K** (-13.08%)	**DE** (-34.70%)

Table 6.1: Top five industries & top gainers of the top five European countries - RCA results

6.1.2 France

France's biggest specialization can be found in the sector *MN* - an aggregation of professional, scientific and technical activities and administrative and support service activities which will increase in further periods at about 6 percent. Following is *L* which includes real estate activities. The biggest rise can be seen in sector *J* - better known as ICT - by more than 14 percent till 2020, while the growth rates of other industries stay below 10 percent.
There is a loss of comparative advantage predicted in multiple sectors which is led by *A* - agriculture, forestry and fishing (ranked at the last place but one out of 18, where *B* - mining and quarrying is at the last place) by a reduction of -16 percent from 2014 and 2020, as well as *F* - construction by -13 percent and the *K* - financial and insurance activities by nearly -10 percent in this timespan. The chart 6.1 below shows the development from 2000 to 2020 of these relevant sectors:

Another interesting timespan starts in 2009 and ends in 2015, when the housing bubble triggered the European debt crisis. It can be seen that not every sector was affected as harsh as others by this crisis. Whereas sector *A* did not change at all, the country-sector *K* increased its RCA by more than 10 percent.

The top specialization *MN* contributes 12 percent to the overall economy of France refering to the graph 6.2, this is done with nearly the same proportion in the share of total jobs - to be 15.7 percent 2020. The greatest proportion of national employment - 35 percent - is found in sector *OU* which can be seen in the graph 6.3. employed

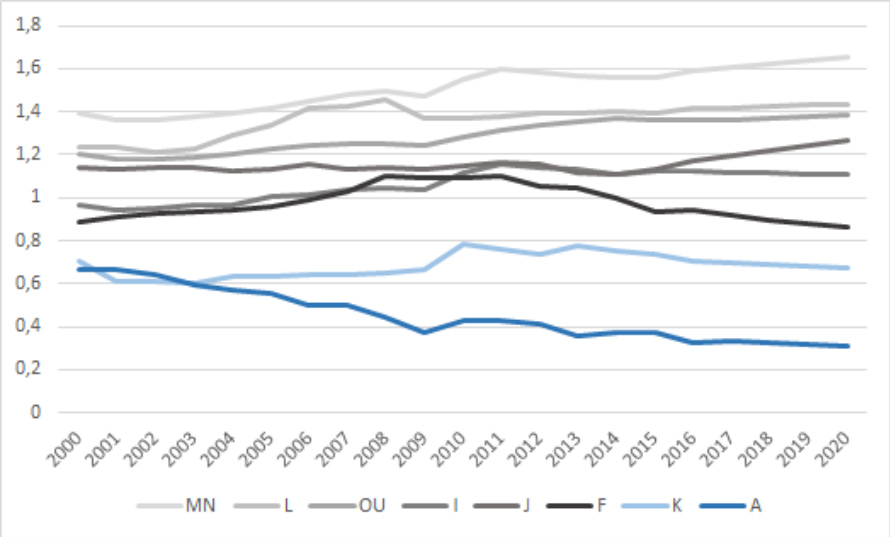

Figure 6.1: Development of the RCA of selected sectors of France from 2000 to 2020 (Data source: Authors calculations)

people will contribute 25 percent to the national economy of France at the end of the forecasting period. All top five sectors together hold not only a proportion of 59 percent of the employed individuals in the economy, nearly 58 percent of the GDP is achieved by this share of employment. The two sectors had an increase by more than 10 percent in employment, which is *MN* - +15 percent and *I*, the biggest reduction considering those five sectors can be found at *L* - -3.7 percent.

France has higher exports in non-competitive sectors on a globalization level, which are *Ca* and *Ce*. They each contribute 15 percent to the total exports, although only 2.2 percent of the employees work in these two sectors and have an even smaller share to the GDP - 1.8 percent. In contrast to the development of the RCA values, the chart showing the contribution to the GDP and employment of the economy in France, shows hardly any gaps or peaks in the history, except the unemployment rate. This rate has had an all-time low for the analyzed time period in 2008 at 7.4 percent. The bursting of the housing bubble and the national debt crisis in the EU contributed to the higher unemployment rate afterwards, when in 2015 the peak was reached at 10.4 percent, as it should at 7.6 percent regarding the forecast of the model.

The fact that Germany is the most important exporting destination for French goods can be seen in the chart 6.4 below. As in the results of Germany stated, this is true for exports coming from Germany to France. Almost 13 percent of the produced goods are going to the European neighbour at the Eastern border, which has not changed since 2000. The exports of France strongly depend on the EU, 40 percent of the exports were going into the other four investigated countries in 2000. This value had two break-ins,

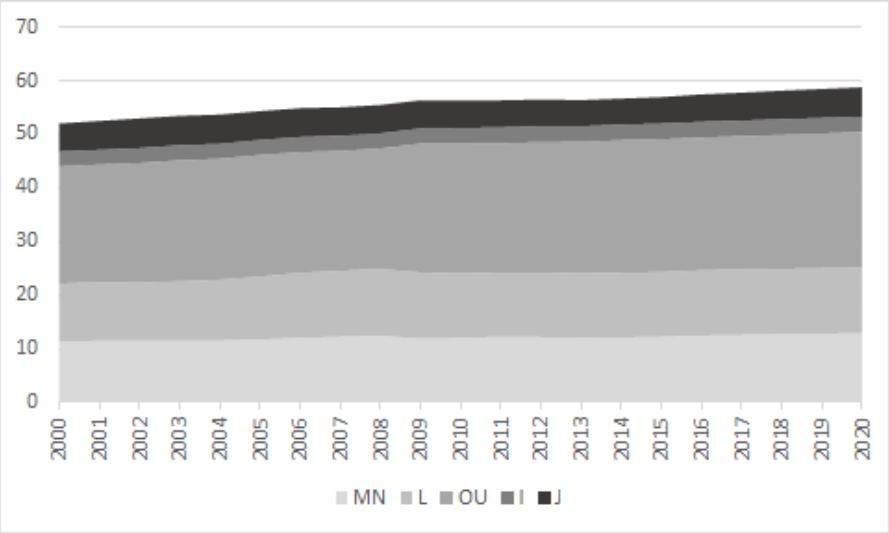

Figure 6.2: Development of the contribution of selected sectors to the GDP of France from 2000 to 2020 (Data source: Authors calculations)

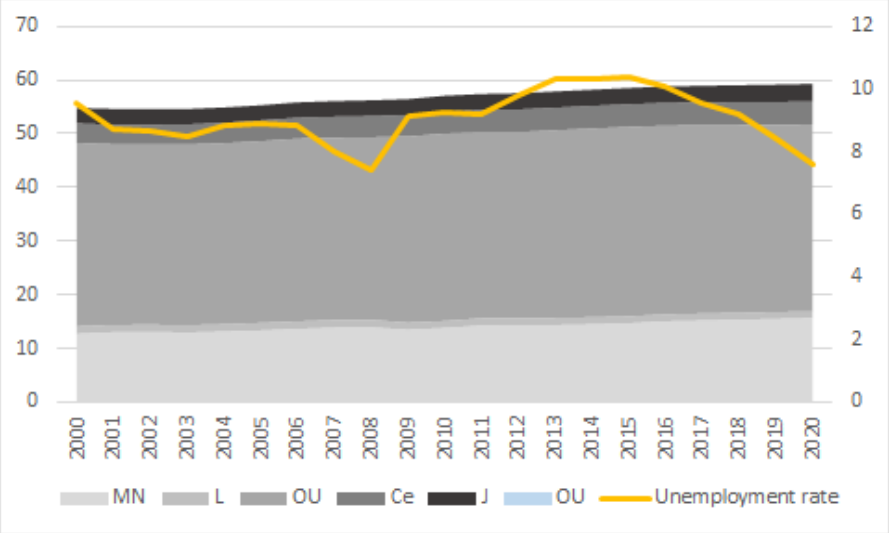

Figure 6.3: Development of selected sectors contribution to France's employment and the unemployment rate from 2000 to 2020 (Data source: Authors calculations)

one in 2009 and one in 2012, marking both crisis which affected worldwide economies and a slowdown demand of goods from other countries. The years after are marking steady export rates of about 33 percent.

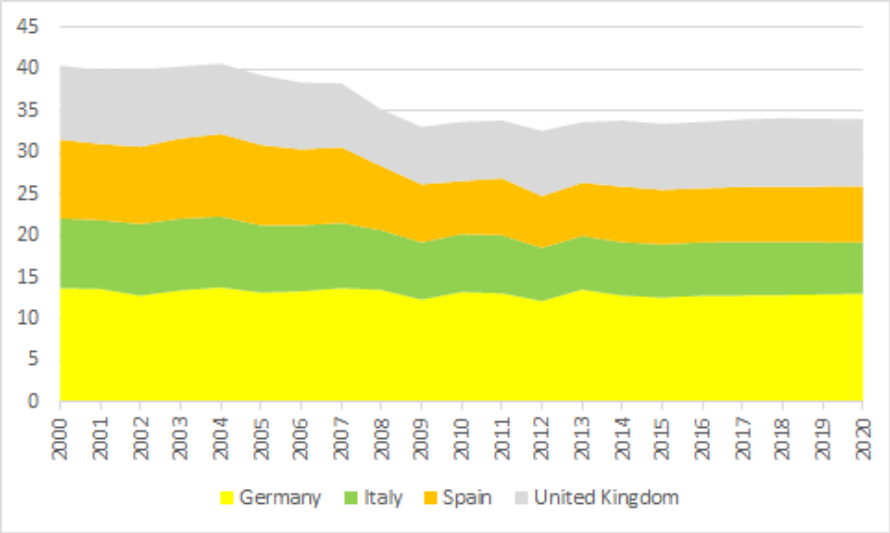

Figure 6.4: Development of flow of exports of France from 2000 to 2020 (Data source: Authors calculations)

6.1.3 Germany

Ca - the automotive and transport manufacturing sector - is, as in the introduction already stated, the specialization of Germany with the highest RCA. This supports other articles in this research area. However, this sector had bigger troubles, compared to the others shown in figure 6.5. During the recession and after the bursting of the housing bubble in 2009 this sector suffered a lot, but the decrease already started in 2007. The recovery started after 2009 again till its peak in 2012 (+26 percent). Since then the comparative advantage based on the GVC steadily decreased. The second most important sector is the *Cm* - machinery & metal manufacturing. Three (missing the *Ce* - electrical machinery manufacturings) out of the top five sectors belong to the manufacturing part of Germany's economy which points to international importance of the secondary sector.

Considering the same time period from 2014 to 2020 as in France, *B* - mining and quarrying are still remaining at the last position of relevance on the international market. The other outperforming sector will be *DE* - an aggregation of the sectors electricity, gas, steam and air conditioning supply and water supply and waste management. Both sectors will nearly double their competitiveness. Additionally, *DE* was able to circumnavigate the crisis by one year, but had a decline afterwards, this is mainly due to a delay of the decrease in production of the manufacturing sector, which affected their supplier mostly in the period afterwards. In 2020 the country-sector *DE* will be the third most important sector. This may happen because of the German energy revolution due to the anti-nuclear commitment in 2011 [uIdB17]. This spending might move investments into more renewable energy. On the other hand *A* - agriculture, forestry and fishing - might take the second to last place in the ranking but it's predicted in a decrease of a third in

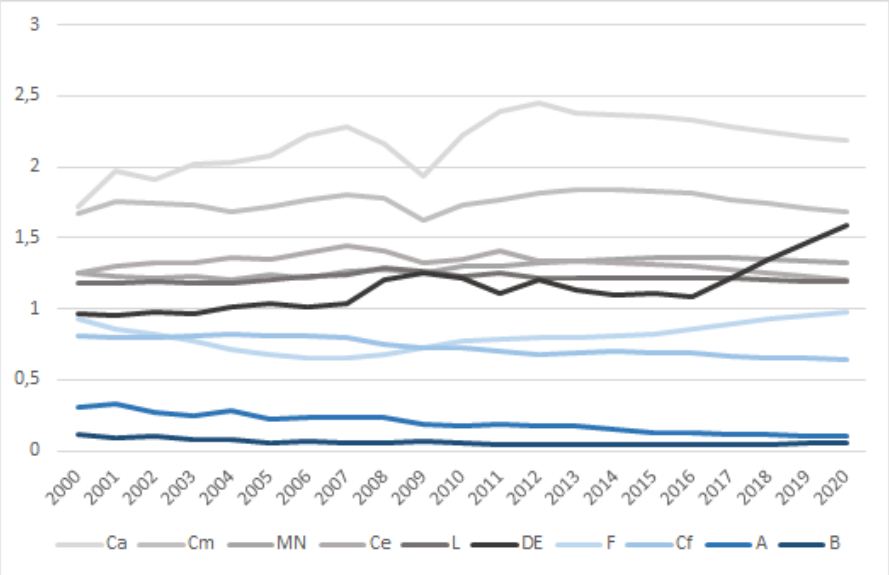

Figure 6.5: Development of the RCA of selected sectors of Germany from 2000 to 2020 (Data source: Authors calculations)

its competitiveness.
Figure 6.6 shows the contribution of the top five sectors to the total GDP, which is about 33 percent. Although *Ca* is the most specialized sector considering international competitiveness, it contributes only 4 percent to the overall economy. The country-sector *Ce* contributes the lowest to the economy with almost 3 percent. On the other hand *L* and *MN* each has a share of about 10 percent to the GDP and as shown *OU* has by far the most shares to the national economy with 22 percent. All six sectors together add up to 55 percent. There was a little gap in 2009, but the six sectors are staying constant on the same level.

While the automotive manufacturing sector does not contribute that much to the GDP, the picture changes when looking at the export shares of the industries in the visualization 6.7. *Ca* has a share of 21 percent with the smallest drop in 2009 compared to the other sectors. In total the top five contribute almost 55 percent to the total exports of Germany, where *L* is more or less reprehensible. Together with *Cc* - chemical manufacturing - adding nearly 18 percent, the export share of those six sectors adds up to almost 73 percent in 2020. This amount is not changing at all since the recovery after the crisis in 2009, which is true for the contribution to the GDP. Another interesting fact is that the charts of the exports and the GDP are looking very similar, only the value levels differ, but the column curves are looking nearly the same.

Furthermore, the data retrieved from the model contains information about the flow of goods into other countries refering to the graph 6.8. In 2000 the export share into the

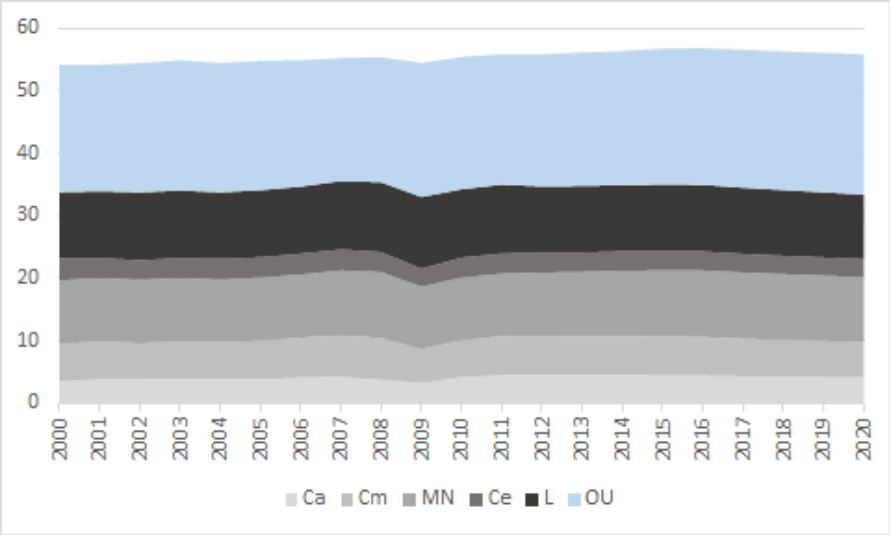

Figure 6.6: Development of the contribution of selected sectors to the GDP of Germany from 2000 to 2020 (Data source: Authors calculations)

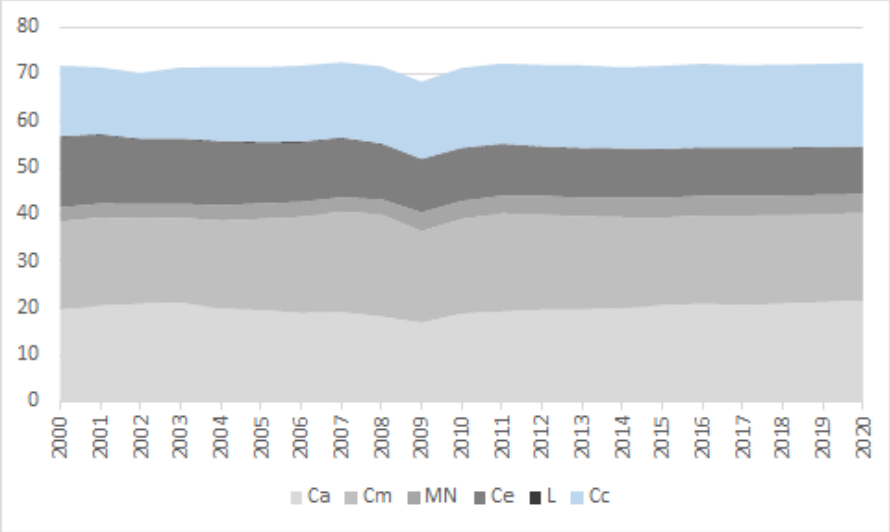

Figure 6.7: Development of selected sectors contribution to Germany's exports from 2000 to 2020 (Data source: Authors calculations)

other four European countries was in total 28 percent. As the globalization became more important in the last two decades, the share shifted towards the rest of the world and is predicted to be 22 percent in 2020. The biggest buyer of exported goods will be France with 8.1 percent, coming down from a peak of 9.9 percent in 2000, followed by UK with 6.2 percent in 2020 with the highest amount of 7.1 percent in 2001.

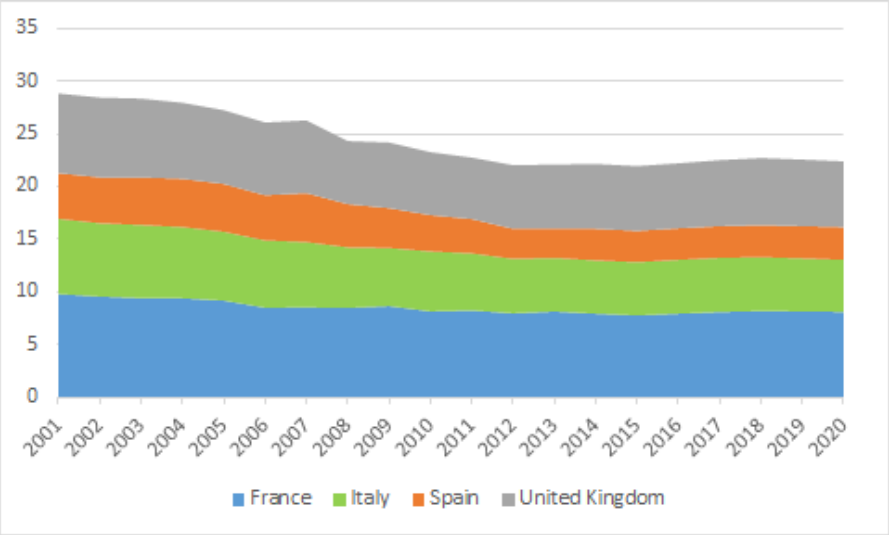

Figure 6.8: Development of flow of exports of Germany from 2000 to 2020 (Data source: Authors calculations)

While the share to Germany's export is about 22 percent and a low contribution to the GDP - 4 percent, only 2.3 percent are employed in *Ca*, appearing in the chart 6.9. Only *Ce* - 1.9 percent - and *L* - 1 percent - employ less, but a steady development is predicted till 2020. In contrast to *MN* where more than 9.5 were employed at the beginning of the investigating time period in 2000 and in 2020 there are almost 14 percent predicted which would nearly double the amount. The sector with the most employment share is *OU* - 31 percent, which is a highly concentrated industry that covers multiple service activities and several public administrations. In total, those six country-sectors employ more than half of the total employment in Germany.
Additionally, the figure with employment data represents the unemployment rate on the secondary axes, which had its peak in 2005 at approximately 11.3 percent. A recovery started afterwards with a little break in 2009 during the crisis when it slightly went up before hitting the 5 percent threshold in 2014. In 2016 the unemployment rate reached its lowest at 4.1 percent. Now it is likely to rise again to 4.8 percent based on the forecast of the model.

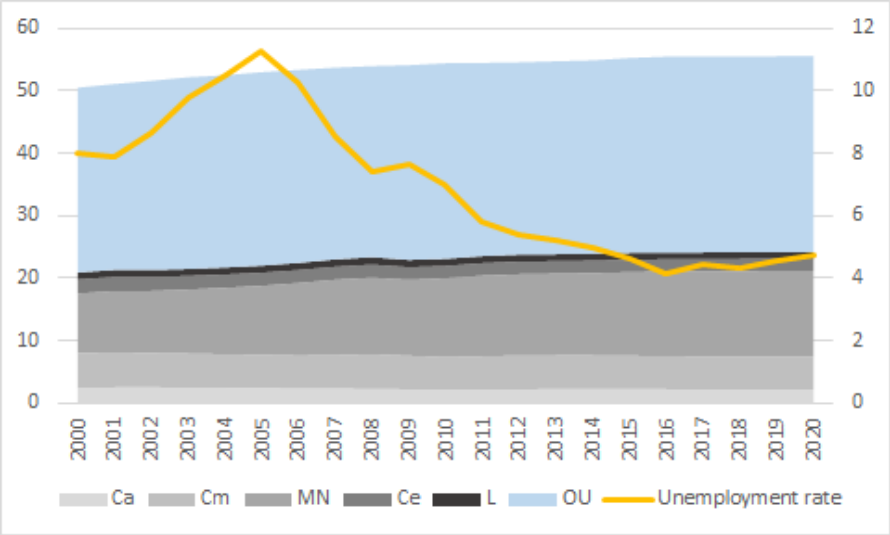

Figure 6.9: Development of selected sectors contribution to Germany's employment and the unemployment rate from 2000 to 2020 (Data source: Authors calculations)

6.1.4 Italy

Italy's economy has the sector *L* - real estate activities - as its internationally most comparative sector which recovered nearly constantly after the crisis in 2009 with only a short gap between 2011 and 2012. This fact can be seen in figure 6.10. Sector *L* is predicted to be almost taken over in the nearby future from the sectors *I* - accommodation and food services activities - which RCA increased by 5.5 percent and *Cn* - other non-durable manufacturing - which will raise its competitive value by nearly 8 percent to 2020.

The biggest gainer of international competitiveness is predicted to be *Ca* - the automotive and transport sector - with almost 9 percent. In contrast the other sector *K* - covering all financial and insurance activities - will loose at least -10 percent. The industry *J* containing all ICT services is predicted to have the biggest reduction by -12.5 percent of its international relevance and is constantly decreasing since the European debt crisis which happened between 2011 and 2012.

The analysis of the RCA based on the GVC reveals the least comparative sectors in economies. The industries *A* - agriculture, forestry and fishing - and *B* - mining and quarrying - and in almost every country except Germany the sector *Ce* - electrical machinery manufacturing - share the last three places in the ranking. Another common change can be seen when taking a look at the development of these three sectors. While in France, Italy, Spain and the UK the competitiveness is more likely to decrease, those sectors in Germany gain more advantage.

When taking a look at the employment share, it can be seen that only 20 percent are

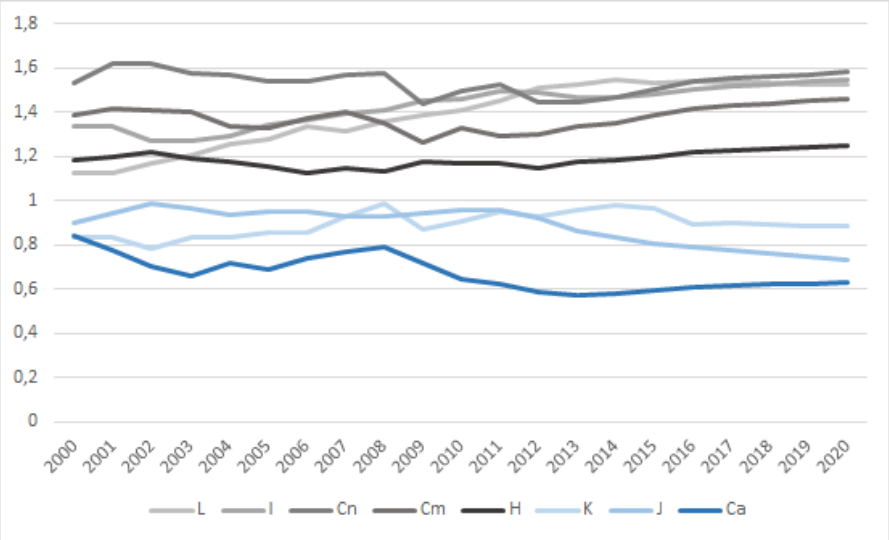

Figure 6.10: Development of the RCA of selected sectors of Italy from 2000 to 2020 (Data source: Authors calculations)

employed in those five sectors. Only *L* and *I* were able to grow its employment share since 2009 by 19 and respectively almost 20 percent. The other sectors were losing its proportion to the total employment in Italy, most of all *Cn* by -18 percent.
In 2007 the unemployment rate has had its all-time low at almost 6 percent, but even before the housing crisis affected the economies, the rate grew again with a high in 2014 marking the peak. The labor market was tremendously effected by the European debt crisis, which led to an unemployment rate of around 12.6 percent in Italy. The rate sank in the following years back to 11.6 percent in 2016. Now it is predicted to fall abruptly to 7.5 percent in the next few years.

In contrast to the low employment share of the five sectors, *L* already contributes 13 percent to the overall economy which is valid from 2013 and afterwards. This is an increment of almost 35 percent since the starting year of the analyzed time period, seen in the chart 6.12 below. Additionally, there is hardly any reduction of share for all the industries in the particular years of 2009 and 2012. This is where most of the gaps were seen and a decline can not be identified until 2010. The sector *Cm* has a reduction of one quarter of proportion to the GDP from 2000 to 2020, which is the most in comparison to all other sectors. Those five sectors will contribute almost one third to the national economy of Italy prospected in the year 2020, an increase by more than 10 percent since 2000.

Nevertheless there is hardly any contribution to Italy's exports from the first two important sectors *L* and *I*, adding up to 0.4 percent. In total, the five sectors make up 46 percent in 2020. The highest contribution is coming from *Cm* - predicted to be 26 percent in 2020 followed by *Cn* 16 percent. That means that almost 16 percent of the total employment

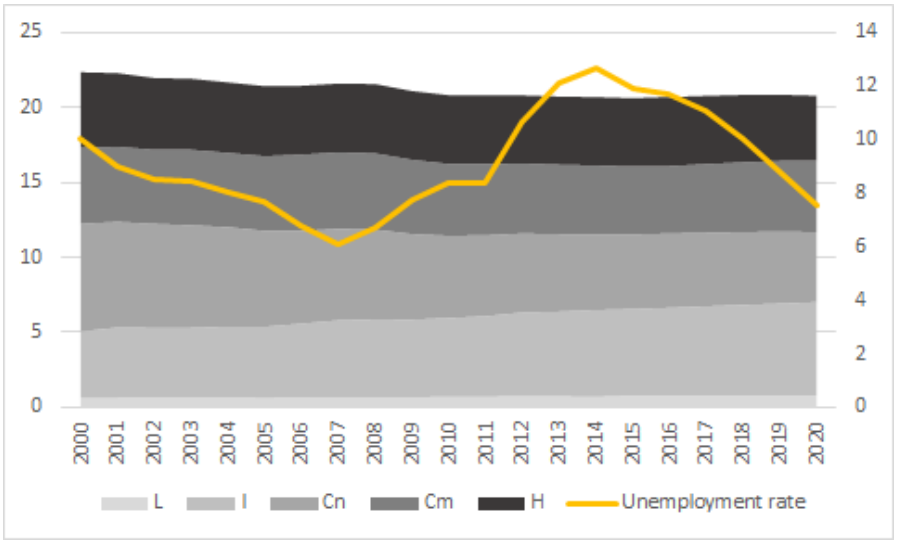

Figure 6.11: Development of selected sectors contribution to Italy's employment and the unemployment rate from 2000 to 2020 (Data source: Authors calculations)

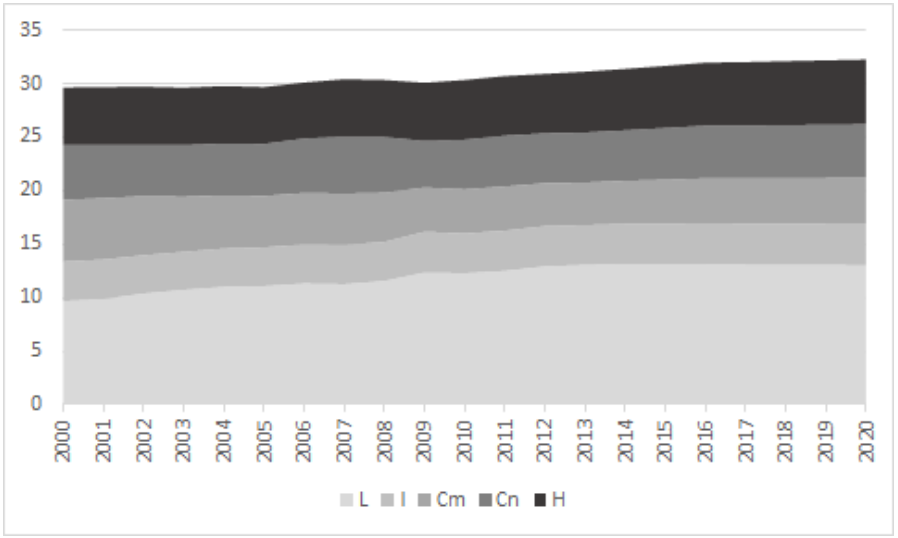

Figure 6.12: Development of the contribution of selected sectors to the GDP of Italy from 2000 to 2020 (Data source: Authors calculations)

generates 9.2 percent of the GDP and is responsible for 43 percent of the exports. While in 2000 the share of exports to France, Germany, Spain and the UK was about 38 percent, 20 years later it will remain at 33 percent, which is not a big reduction. Taking a look at each of the specific countries individually a different picture shows up when looking at the graph 6.13. Exports to France decreased by 11 percent in the whole time period. Spain and the UK, both had a reduction of imports from the Italian economy

of almost -30 percent. In the period from 2011 and afterwards the export rates were stagnating for all of the other countries. This fact demonstrates that a shift is happening towards more scattered exports into the RoW than only concentrated into a small amount of countries.

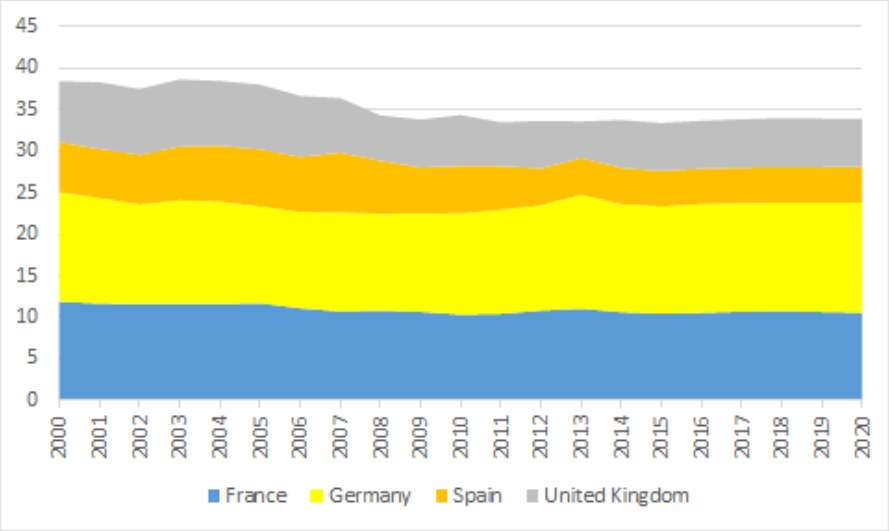

Figure 6.13: Development of flow of exports of Italy from 2000 to 2020 (Data source: Authors calculations)

6.1.5 Spain

The Spanish economy has its industrial specialization grounded in the sector *I* - accommodation and food service activities - which is in general known as tourism. This sector is predicted to have a slight increment of 4.25 percent from 2014 till 2020 but had a increase from 2009 to 2016 by more than 10 percent as seen in the chart 6.14 below. The Spanish tourism industry is widely-known to be the most important sector, the question is, why it is the biggest specialization considering the GVC. Nevertheless, the economy strongly depends on the sector *I* which can be seen when taking a look at the contribution to the labor market and its economic value [Org16]. The second most important sector is *L* - which covers the real estate activities - which caused the big troubles of the economy during the European debt crisis and is still responsible for the issues on the Spanish housing market.
However, this sector increased it's relevance by nearly 30 percent after the housing bubble in 2009 till 2016, but there is a reduction predicted from 2014 to the end of the investigated time period in 2020. While the base year of the ranking is 2014, even though in 2015 the sector *DE* - energy and water supply - overtook the sector *J* due to a steady increase of comparative advantage and a reduction of relevance in real estate activities. This shift of sectors is probably due to higher investments into renewable energy productions like in Germany.

The analysis of the biggest gainer of international importance reveals the sector *MN* -

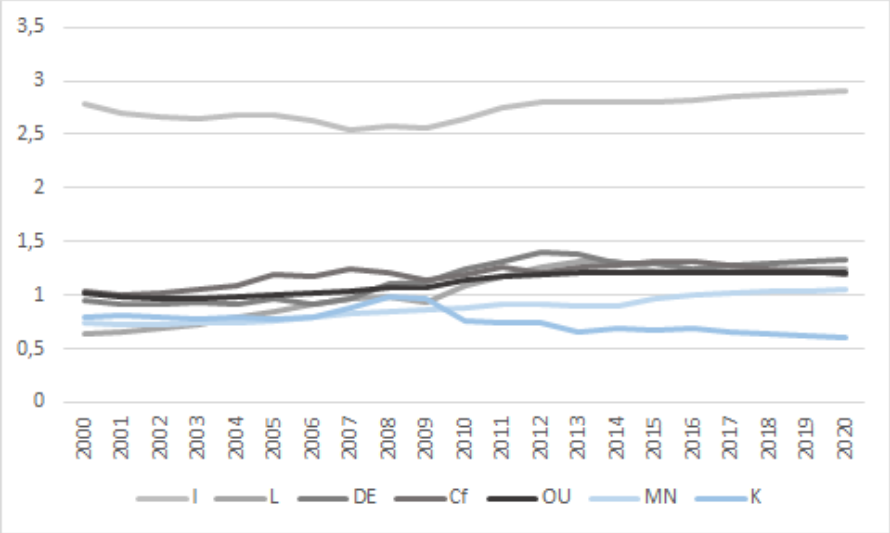

Figure 6.14: Development of the RCA of selected sectors of Spain from 2000 to 2020 (Data source: Authors calculations)

professional, scientific and administrative support services - with an increment by nearly 17 percent from 2014 to 2020 and an already strong growth of 29 percent from 2009 to 2016. On the other hand, the sector *K* - financial and insurance activities - has the biggest loss by -16 percent in the same time period, while in the period after the collapse of the banking system in the USA in 2009 it even had a reduction of around 30 percent.

Sector *I* is prospected to take up 8.2 percent of Spain's employment in 2020, starting at 5.6 percent in 2000, which is an increase by almost 16 percent in the last two decades. The people working in this country-sector establish 7 percent of the national economic performance and represents a low proportion of exports with only 1 percent. In 2020 a high amount of people - 30 percent - is expected to work in sector *OU*. Since 2012 already 30 percent are working in this sector and it is predicted to stay on such a constantly high level. It contributes 22 percent to the GDP and has an export share of 65 percent. Almost 43 percent of the individuals employed in the Spanish economy will contribute 47 percent to the overall economy as seen in the graph 6.15, but only 12 percent to exports. This depends on the top five industries of Spain, where tourism and other sectors are already consumed more on a domestic level, especially *L* and *DE*. Another well-known fact is the dominant position of its domestic territory, the Spanish food production (fruits and vegetables) - *Cf* - where only 2.2 percent of the total employment is exporting 8.3 percent of the total goods to foreign countries and contributing a bit more to the GDP - 2.8 percent.

Analyzing the overall labor market leads to the assumption that Spain is the country with the highest unemployment rate in the EU. During the whole investigated time period

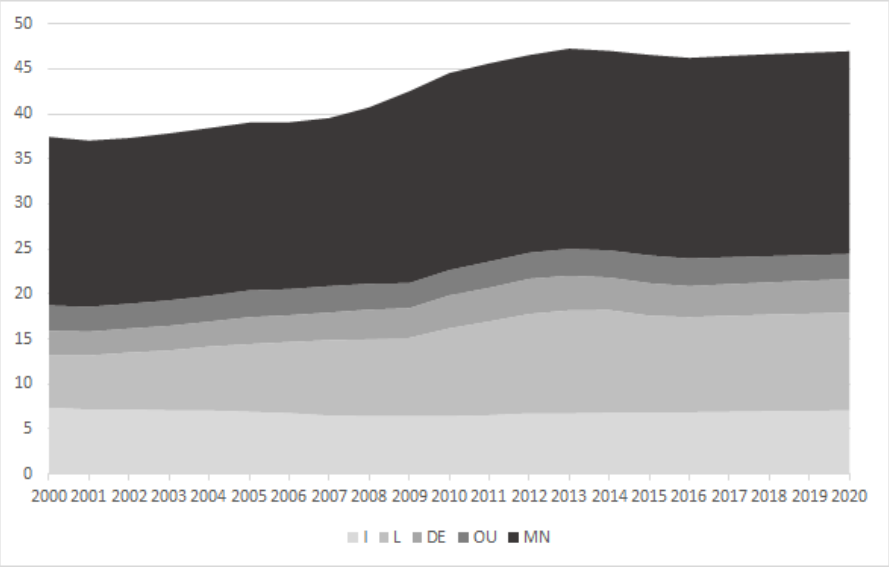

Figure 6.15: Development of the contribution of selected sectors to the GDP of Spain from 2000 to 2020 (Data source: Authors calculations)

it only went down to 8.2 percent in 2007, which is a big improvement in contrast to the starting point with almost 12 percent. The unemployment rate raised dramatically within two years to 17.9 percent, reaching its peak in 2013 at about 26 percent. The labor market has recovered continuously since then and is predicted to reach 15 percent of unemployment in 2020.

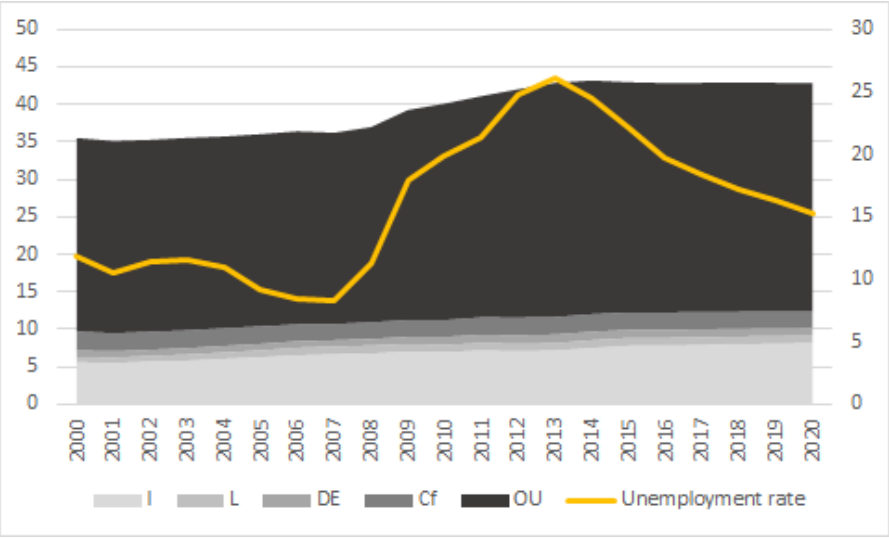

Figure 6.16: Development of selected sectors contribution to Spain's employment and the unemployment rate from 2000 to 2020 (Data source: Authors calculations)

Finally, foreign countries export shares highlight that as in the other already discussed countries, from the beginning of the time period of the model the export rates to the other economies have been going down till 2014 (as in France, Germany and Italy 2012) to stay then at a constant level. This seems to support the findings from the other countries having the same experience of the gap between the years 2008 and 2009. The dominating export destination of goods from Spain is Germany so far and predicted to grow to 14 percent. It has been already 17 percent in 2000 but then started to decline steadily and had only a small growth in 2009. The second biggest customer of Spain's manufactures is predicted to be France, buying 9.4 percent in 2020. The reduction starting from 2000 was nearly the same as to Germany. The biggest loss of exports is predicted to be the UK with -41 percent, while transports of goods in the RoW is supposed to increase by almost 20 percent.

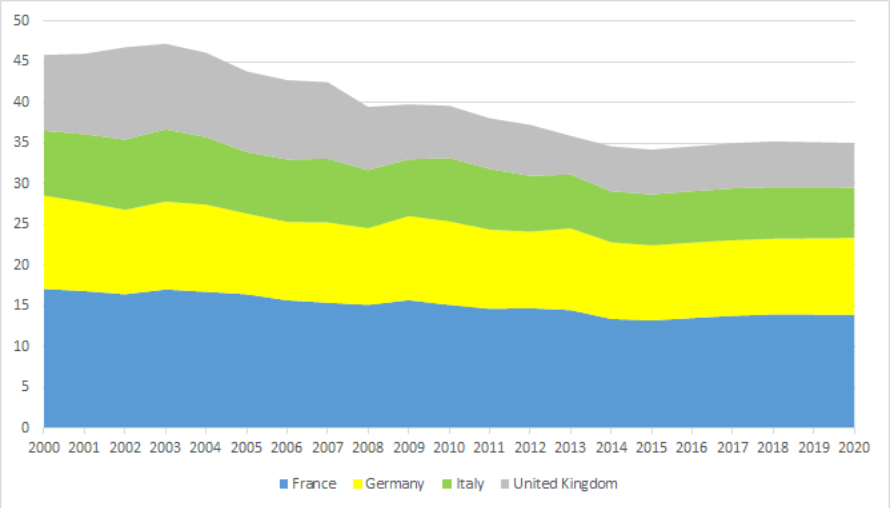

Figure 6.17: Development of flow of exports of Spain from 2000 to 2020 (Data source: Authors calculations)

6.1.6 UK

The most sectoral specialization of the UK can be found in sector *MN* - the sector which contains the professional, science and administrative support services. This sector was stagnating in 2015 and afterwards. *J* - covering all activities in ICT - will take the spot of the most sectoral specialization in 2017 with an increase by more than 21 percent since 2009. This sector is the biggest gainer in the prediction period.
Another interesting fact can be seen in 6.18, when taking a look at sector *K* - financial and insurance activities. This sector had its peak in 2009, when it became the most specialized sector of the economy before it began to decline.

Starting in 2000 *B* - mining and quarrying - was an adequate specialized sector ranked on the third place. Since then this industry lost more than half of its RCA and even more

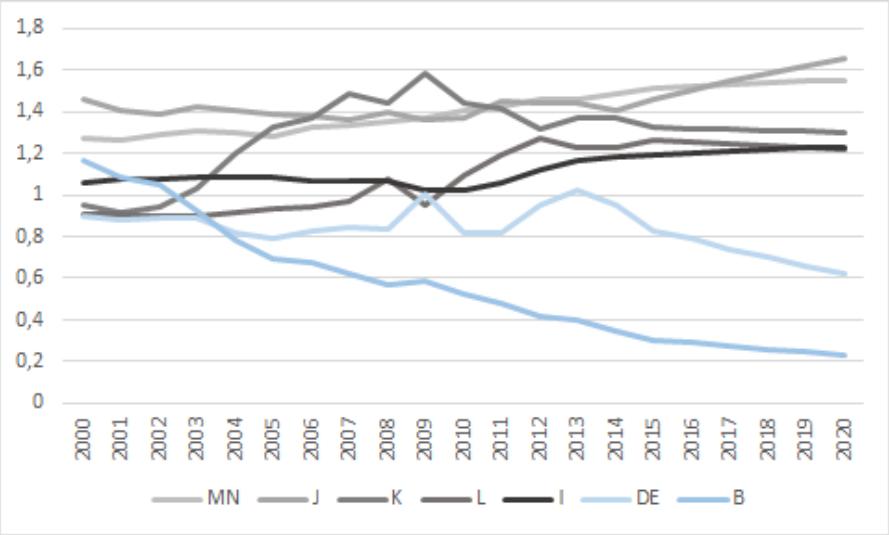

Figure 6.18: Development of the RCA of top five and two additional sectors of UK from 2000 to 2020 (Data source: Authors calculations)

with 34 percent predicted for the time period 2014 to 2020. It is forecasted that this sector does not play any important role in the economy of UK anymore. Furthermore, the sector *DE* - energy and water supply - has a loss of -34 percent of competitiveness in the GVC, although it had the same peak value in 2009 like *J* and a reduction afterwards.

One third of the total employment (compared to 27 percent in 2000) in the UK will generate almost 41 percent (in comparison to 2000 with 34 percent) of the economic output. The most specialized country-sector *MN* holds a share of 12 percent and *L* with 10.5 percent of the GDP. This proportion is achieved by an aggregated value of 19 percent of workers employed in those two sectors. Both sectors enlarged their employment share since 2000 (18.8 percent and 7.6 percent). Sector *K* is predicted to have the largest reduction of share of the total employment by -16 percent. It is forecasted to only have 3.2 percent in 2020 as shown in the figure 6.19.

The financial and insurance industry contributes almost 8 percent to the overall economy of the UK and takes up more than 15 percent of the total exports, which is the most compared to the other top sectors. This is captured in the chart 6.20. As seen in the figure 6.20 the real estate sectors hold only a share of 0.1 percent of goods shipped into other countries, while *MN* is the second largest contributor to the exports with 14 percent. All together, the top five sectors have a share of almost 37 percent, whereas it has been only 25 percent in 2000. In the years 2007 and 2009 there occurred two hikes, interrupted by the financial crisis and the troubles with the public debts in the EU. After 2011 exports started to increase constantly and will stay on a high level. These findings reflect and support the results found here [Rho16].

When analyzing exports into other countries, it can be seen in 6.21 that the UK never

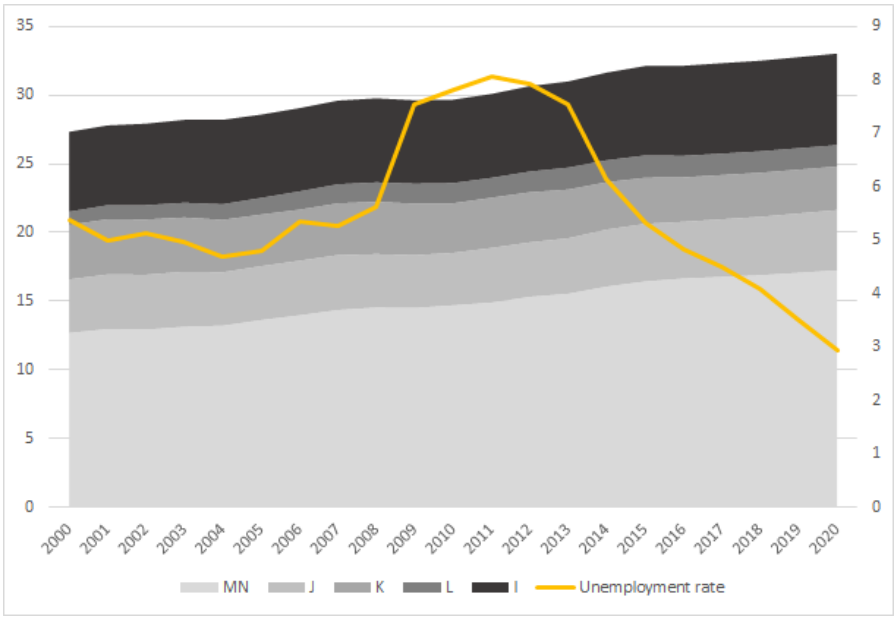

Figure 6.19: Development of top five sectors contribution to the employment of the UK and the unemployment rate from 2000 to 2020 (Data source: Authors calculations)

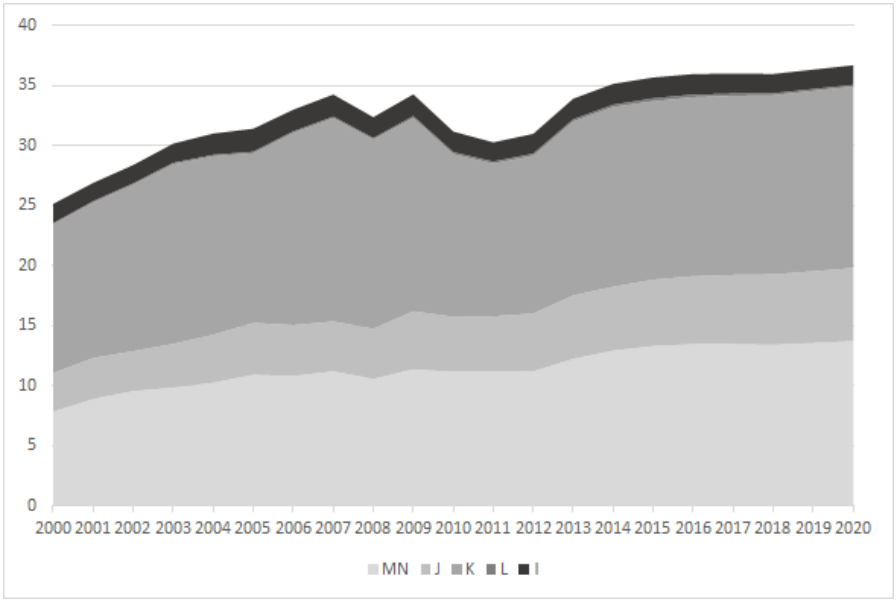

Figure 6.20: Development of top five sectors contribution to the exports of the UK from 2000 to 2020 (Data source: Authors calculations)

really shipped more than 25 percent to the other investigated countries. The UK had a small peak in 2001 and then the exports reduced continuously till 2013 where a drop

from 20 percent to 15 percent occurred. After 2013 a short but sharp recovery started but it is predicted to stay on the same level until the end of the prediction period in 2020. Germany and France are the UK's biggest export objectives within those five countries, taking up almost 14 percent, where 81 percent of the exports are going to the RoW.

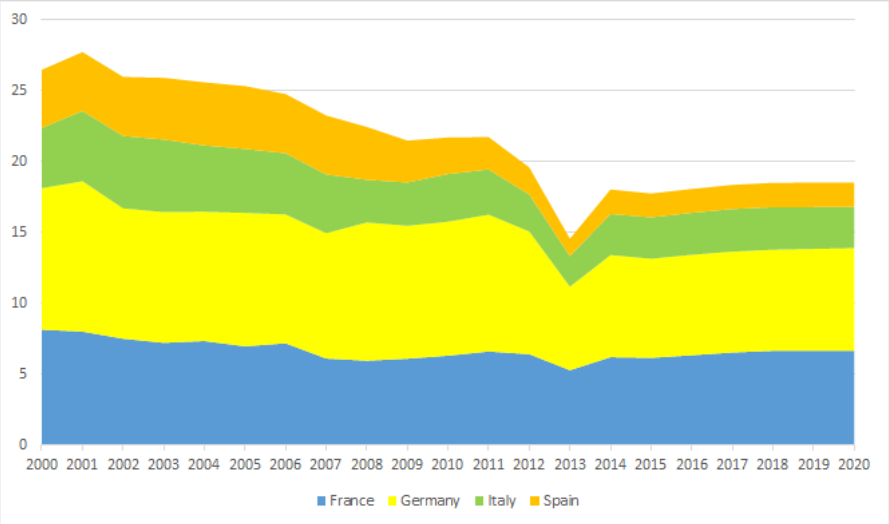

Figure 6.21: Development of flow of exports of the UK from 2000 to 2020 (Data source: Authors calculations)

6.2 Reconfiguration of the model

As in the introduction chapter already mentioned, this model should be able to investigate any of the 44 countries which are available in the WIOT as stated in the second research question/goal. This goal was reached by making the algorithms as flexible and generic as possible, that only slight changes are necessary. While trying to run this model with the new configuration again, a hurdle showed up - lack of information for certain countries under investigation. This downside could not be solved (this will be discussed in chapter 7), so the data output was limited - all labor market dependent calculations were deactivated during this run and no predictions were made because some of the required data (e.g. value-added for sectors) are not available, too.
In addition to the already investigated countries, the following economies were added:

- Austria
- China
- Japan
- USA

The discussion will be about the top five sectors presented in the table 6.2 and their contribution to the economy (export share and flow of exports to other countries). The labor market and the analysis for the years 2015 to 2020 are skipped, as there were no predictions made because of the lack of input data. Additionally, the already presented countries will be left out.

Austria	China	Japan	USA
I	**A**	**L**	**J**
Cm	**Ce**	**Ca**	**MN**
Cn	**Cm**	**Cf**	**L**
H	**Cn**	**Ce**	**OU**
MN	**Cc**	**I**	**K**

Table 6.2: Top five industries - RCA results in the extended model

6.2.1 Austria

Austria has it's specialization in sector *I* - accommodation and food service activities, although the sector contributes only 1.5 percent to the total exports in 2014. The share in GDP is much higher - 7.8 percent, nevertheless, the fact that *I* is the most specialized sector in Austria seems reasonable, because tourism is identified as very important for the national economy, as well as it's contribution to the labor market [BfW15]. On the other hand *Cm* contributes almost 21 percent to the overall exports ranked as the second specialized industry. In total these five top sectors represent 43 percent of the total

exports refering to the visualization 6.23. The chart shows a gap for every top sector in 2009 with a slight recovery and a stagnating or even weak development after 2011 - seen as the beginning of the European debt crisis, while I remains on a constant level. This picture reflects the contribution to the GDP of Austria.

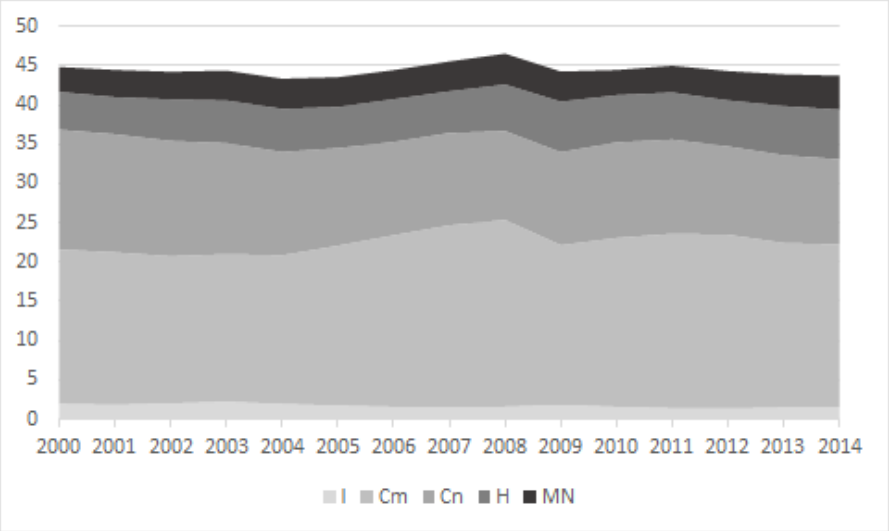

Figure 6.22: Development of selected sectors contribute to the total exports of Austria from 2000 to 2014 (Data source: Authors calculations)

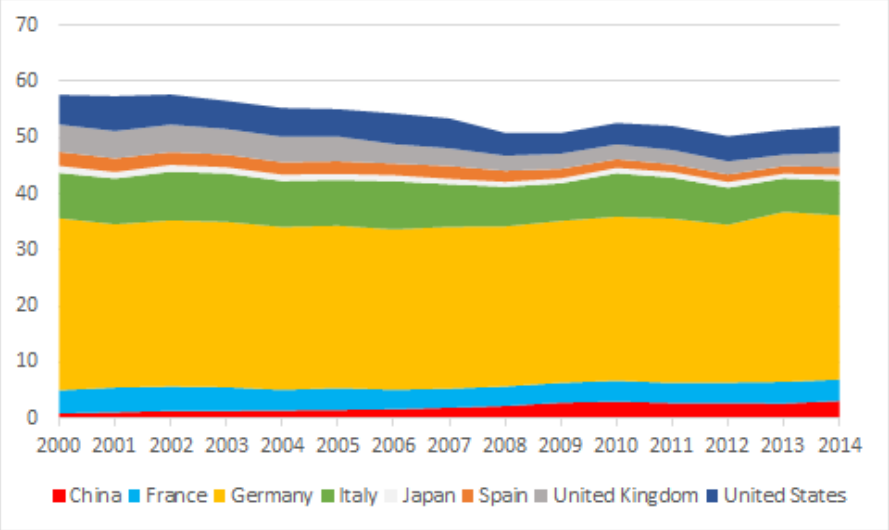

Figure 6.23: Development of flow of exports of Austria from 2000 to 2014 (Data source: Authors calculations)

If taking a look at the flow of exports to other countries, Germany as the destination has a share of almost 30 percent of all exports. The biggest increase is within the the

exporting goods to China, while in 2000 it has been below 1 percent, in 2014 it is almost 3.1 percent. The housing crisis did not lead to a certain decrease of exports, although the European debt crisis which had its biggest impact in 2012 before starting into a recovery phase again.

6.2.2 China

Even more interesting is the top sector in China - *A* - agriculture, forestry and fishing, which nearly bisected from 2000 to 2014 of its RCA and has only an export share of 0.6 percent, interpreting, that the output of this sectors is almost completely consumed domestically. The next specialization *Ce* takes 32 percent of the overall exports. The top five sectors which are settled in the manufacturing sector - *Ce*, *Cm*, *Cn* and *Cc*, except *A* are responsible for three quarters of China's exports in 2014 which can be seen in the graph 6.24. The highest value of export share can be seen in 2006 with almost 80 percent before hitting a low in 2012 of 73.4 percent before starting a recovery afterwards.

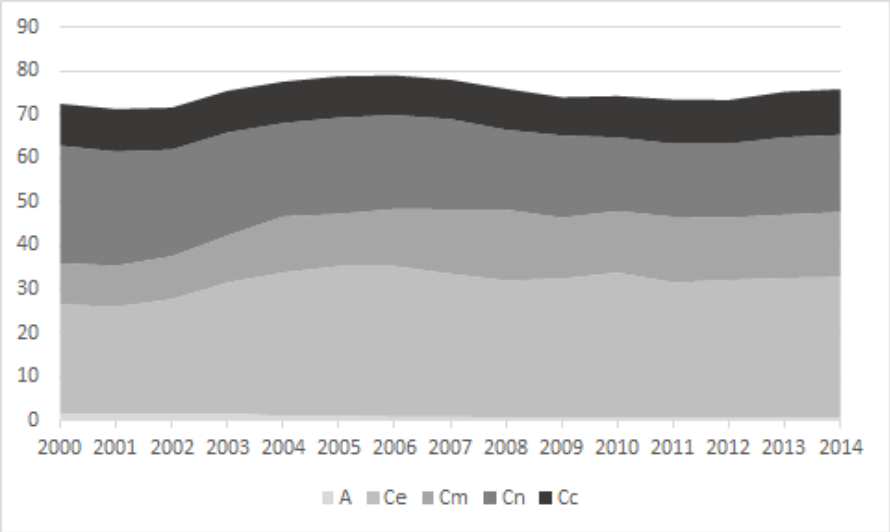

Figure 6.24: Development of selected sectors contribute to the total exports of China from 2000 to 2014 (Data source: Authors calculations)

The visualization 6.25 of the flow of exports of China shows clearly that there is globalization in progress, while those selected countries took up more than 45 percent of all the exports in 2000, this value reduced to almost 31 percent in 2014. While Austria (0.2 percent) and Spain (0.9 percent) do not play any important role, the USA holds the biggest share with 14 percent, which reduced by - 27 percent starting from 2000. Additionally, Japan imports from China halved since 2000 and export shares remained at 7.1 percent in 2014.

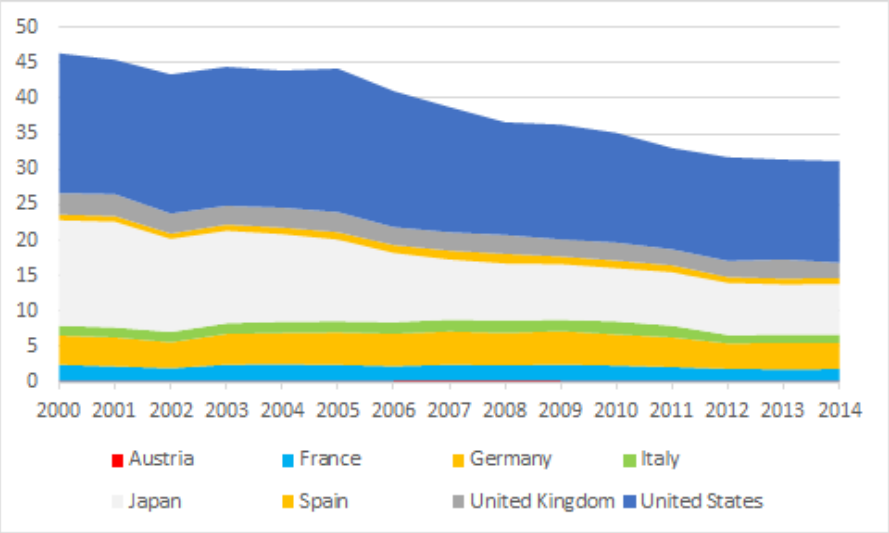

Figure 6.25: Development of flow of exports of China from 2000 to 2014 (Data source: Authors calculations)

6.2.3 Japan

Japan's industrial specialization is based on *L* - real estate activities, although all the top five sectors are close side by side in the RCA. Furthermore, the following three sectors are stated in the field of manufacturing - *Ca*, *Cf*, *Ce*. Although *L* is the most specialized sector, the Japanese automotive industry is known as one of the most competitive worldwide in this area of manufacturing [SVBG08]. Relevant export shares of those five sectors are only found for *Ca* - 22 percent and *Ce* - 21 percent. The output of the other three sectors are consumed on domestic territory, therefore it is not relevant at all considering the exports of Japan - only aggregated 1.1 percent.
The export share to foreign countries is headed by China, nearly 16 percent, which is an increase of 180 percent since 2000, and further increasing since 2011 again refering to the graph 6.26. The second biggest export destination is the USA, the destination already fell below 15 percent in 2014, which has been 25 percent in 2000. Spain, as an export target lost half of the share of Japan exports in this time period, the same finding is valid for France.

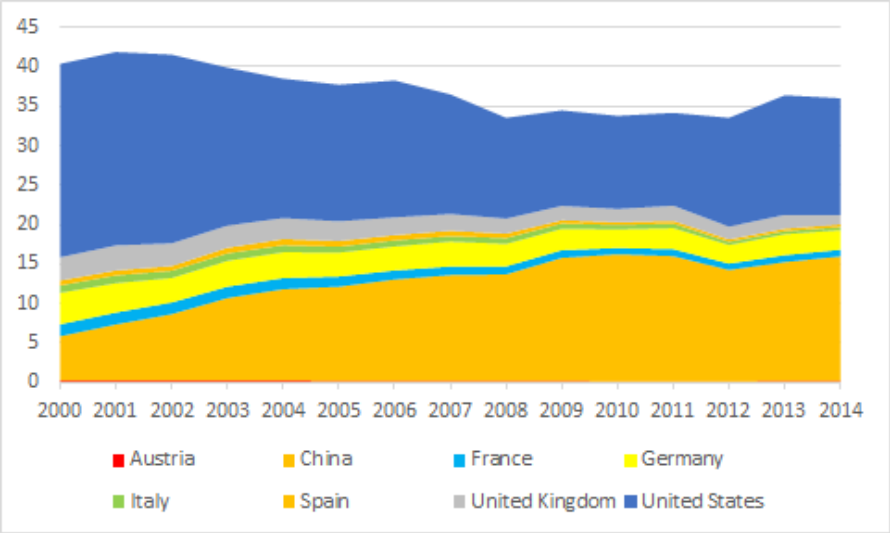

Figure 6.26: Development of flow of exports of Japan from 2000 to 2014 (Data source: Authors calculations)

6.2.4 USA

The most important industrial specialization in the USA is J - the overall ICT sector, which seems to be valid, because private and public investments increased dramatically since 1995 in this country to make this sector competitive, which has its peak in 2009. These investments were a driver for innovation, yield at the beginning of the raise of the economic competitiveness of J two decades ago [CKS13]. J exports information services by 5.8 percent to foreign countries, while the next ranked sector MN contributes 8.6 percent to the total exports. The results of the USA conclude that the specializations are finside the service sector of the economy.
One of the biggest gainer of export shares of the American economy is China, which took only 1.3 percent in 2000, while in 2014 it was already at 5.8 percent, an ascent by 322 percent. On the other hand Italy and Japan halved their imports from the USA in the time period from 2000 to 2014, exports to France and the RoW remained almost constant as this can be seen in the graph 6.27.

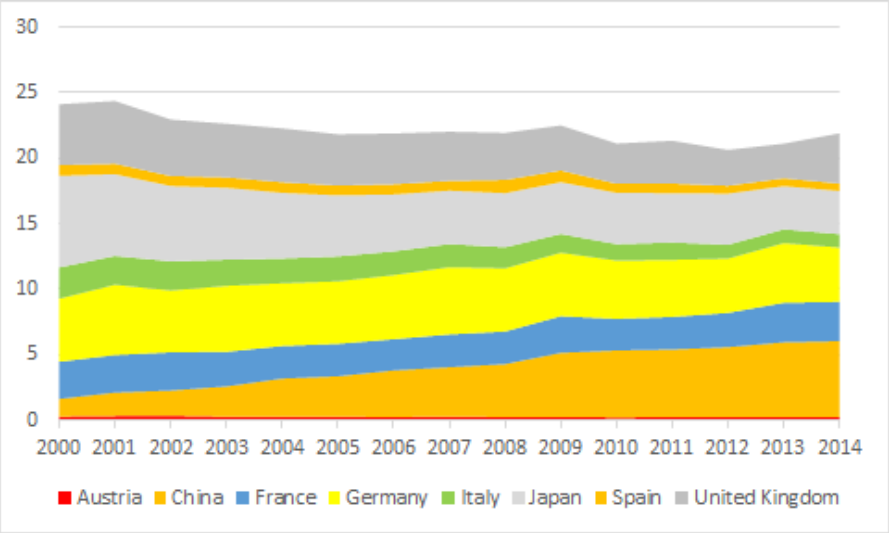

Figure 6.27: Development of flow of exports of the USA from 2000 to 2014 (Data source: Authors calculations)

6.3 Validation of the model

Models which are not validated carefully, are hardly reliable considering their data output and are not qualified within the field of statistical researches. This risk has to be minimized to ensure and verify the model in a standardized statistical way. While prediction models can be validated with e.g. using R^2 regression tests, it is possible to test a model with cross-validation or even the F-Test. In the case that the model cannot be validated against any real data for the time-period from 2016 to 2020, another approach is taken to ensure that the model is accurate. This procedure is done by using the *t-test distribution* [2] to check whether the data output of the model which takes all periods from the WIOT compared to the model which leaves one out is significantly different:

1. First round - calculate periods from 2000-2014 and then to 2018
2. Second round - calculate periods from 2000-2013 and then to 2018
3. Check the variances of the resulting RCA values for each comparing sector

[2]The t-test checks the mean of two independent samples on equality and therefore looking for significant differences in the expectation value. This test is done in R via the command *t.test(x1, x2)*, the resulting test statistic is evaluated against the value based on the degree of freedom and the confidence interval. The null hypothesis is accepted if the test statistic is smaller or equals than the actual value from the t distribution, otherwise the alternative hypothesis is accepted. While the t-test requires same variances, the Welch two sample t-test does not, therefore the command *t.test* will be run with the parameter *var.equal=FALSE*. The variances are first tested with the command *var.test(x1, x2)*, these results are not provided at all. [SH16]

4. Make a Welch two sample t-test to ensure there is no significant difference between the results (reject alternative hypothesis)

For a better readability and simplicity not every country will be targeted through the validation in this chapter, while every country is calculated, only the results for Germany (a shift of two sectors were noticed, 5 and 17 change their *top* positions during the calculation of the first and the second round) will be presented in the following table 6.3 which shows the RCA values of the sector for each calculation round (**f** - first, **s** - second with four decimal points) for the relevant time period after 2013. The t-test results include the test statistics, the degree of freedom and the p-value for each of the five top sectors for these two samples.

Sector-Round	**RCA values**					T-test results			
	2014	2015	2016	2017	2018	t-Value	df	p-Value	t-distribution value
3f	2,3697	2,3537	2,3367	2,2817	2,2472	-0.2067	35	0.8374	$t_{35;0.95} = 2.0301$
3s	2,4220	2,4061	2,3894	2,3332	2,2984				
7f	1,8422	1,8293	1,8141	1,7686	1,7394	-0.3954	35	0.6949	$t_{35;0.95} = 2.0301$
7s	1,8738	1,8600	1,8447	1,7987	1,7690				
17f	1,3511	1,3596	1,3643	1,3571	1,3467	-0.0578	35	0.9543	$t_{35;0.95} = 2.0301$
17s	1,3550	1,3635	1,3683	1,3613	1,3509				
5f	1,3279	1,3185	1,3071	1,2725	1,2499	-0.4738	35	0.6386	$t_{35;0.95} = 2.0301$
5s	1,3567	1,3470	1,3355	1,3003	1,2774				
16f	1,2163	1,2193	1,2190	1,2141	1,2056	1.0508	35	0.3007	$t_{35;0.95} = 2.0301$
16s	1,1754	1,1784	1,1781	1,1733	1,1649				

Table 6.3: Two sample t-test results for top five sectors of Germany

The results for those listed sectors show that the alternative hypothesis can be rejected and the null hypothesis be accepted for each test run, which is valid for all the other top sectors of the other four countries. Furthermore, there is no significant difference between the values retrieved during the validation of the model, which is true for every country-sector. These results are essential for the reliability of the data output of the model and proves the functionality of the written algorithm to a predicted period where only external data are used as input.

In addition to the validation of the model, the results were verified by using an automatic outlier detection procedure to highlight any breaking structural changes in the RCA values after 2014 [3]. Although each of the countries top five sectors were analyzed, no outliers were found during this verification. The only significant changes that were detected, were in the years 2009 and 2012, marking the beginning of the housing crisis and European debt crisis, which do not affect the verified model at all and will not be presented.

[3]The R library *tsoutliers* `https://cran.r-project.org/web/packages/tsoutliers/index.html`) was used to determine any unnatural structural changes in the time series of the RCA of the five sectors for each country.

CHAPTER 7

Limitations & Future outlook

The model sufficiently fulfills most of the requirements regarding this thesis. The identification of the industrial specializations of the investigated economies and their contributions to the overall economy was achieved. In addition to that, several other economic indicators were retrieved using the WIOT as a foundation of the model. Furthermore, the prediction part was accomplished with the model. It was possible to make forecasts and to look at prospective developments considering all country-sectors and especially those which contribute the most to the economy and the countries theirselves. However, there are some limitations to work with this I/O model araised during the investigation and extraction of of relevant data afterwards. Some restrictions could be solved partially performing some steps manually in the model with a certain amount of additional time.

There are some already considered features which have not been implemented into the model yet. However, this goes along with the overall option that the interaction with the user should be taken into account. So it is possible that the user is able to correct or control the data input regarding to their research topic. For example, a future research question could be:
What happens to the automotive sector in Germany, when the government reduces its total consumption by 5 percent to consolidate its deficit?
To answer this and further research questions, the model has to be extended in a way that every input data is customizable to handle these settings. At the moment it is only possible to change the total output of a country-sector manually. There are other extensions which could go into the model. Especially the visualization which might lead into a network graph to show the participation in flow of goods between the countries and additionally the scope of the results which might go more into the context of the GVC of products.

7.1 Semi-automatic handling of external data sources

As one of the requirements of this research goal, the model should facilitate the prediction of the development of the specified indicators. It is only to determine which data has to be provided as a precondition and then let the model run through iterations until the end of the time span. It is especially simple when investigating countries of the EU, because the European Commission provides harmonized detailed datasets, aggregated on a standardized industrial level (ISIC rev. 4) for better comparison inside the EU. The third calculation of the model included Austria, China, Japan and USA to prove the possibility that the model is customizable and that the amount of countries is variable. However, some of the datasets regarding the different countries did not exist on this granular sector-level and often only most three common economic sectors are provided as data sources.

This problem in particular occurs to most of the countries which are not inside the EU. For those countries only datasets from the OECD are available or other national institutions are responsible for documenting these values for the different types of indicators (e.g. employment, working hours, % share of men/women in a sector, etc.).

7.2 Manual visualization of the data output

Most of the visualizations in this thesis are made by the scripts which were responsible for the aggregation and calculations of the periods using the WIOT beforehand. Nevertheless, some of the visualizations had to be refined afterwards to consider the research goal and to answer the first question accordingly. This problem was faced due to some data transformations done before creating the graphs or tables. In addition to that, as the context of the research topic and the expected data output changed, the scripts had to be modified to handle the data in a different way. This might lead to further improvements and is especially important when more complex GVC or export oriented research is targeted.

Despite the issues mentioned above, the more countries are taken into account, the more data output will be available to analyze. This might produce overloaded graphs where important information cannot be interpreted anymore. The scripts then just publish the results in a primitive way without coloring or special marking of the data. Therefore, simplicity is hard to establish in such graphs and manual interactions are required to fetch only the data which are of interest.

Mapping the sector names to the numbers after extracting the data to create diagrams and graphs is not a trivial issue, which can be handled with a non-complex solution. Additionally, presenting 18 sectors in one table limits the readability and understanding of the reader, so it is beneficial to print only the important and relevant sectors. Like in chapter 5, where the results are discussed, the RCA values for the top five countries are printed with additional sectors which provide further information. Specific thresholds have to be defined, where sectors of interest will be printed while others will be dismissed.

The correct mapping has to be chosen and further diagrams which show, for example, the contribution of those sectors to the GDP of a country, have to be created. Sectors and countries need to have consistent coloring in the diagrams and graphs to make reading them easier and faster.

7.3 Limited availability of input data

The calculations at the beginning of the model using mostly the I/O tables and external data sources do not have to be addressed in this chapter. The second step of forecasting calculations however, depends on further data input for the years from 2014 to 2016 and in particular cases already for the first quarter of 2017. A disadvantage of the OECD provided data is the availability of a structure of the data. For example, the intermediate consumption as an annual time series, does not contain any seasonal component that can be used for a more precise Holt-Winters prediction for the year 2017 and afterwards. Another limitation regarding the annual and quarterly data coming from external resources is that there is only a reliable forecast of the GDP. Further information on this data would increase the reliability because the forecasts should consider more factors than the prediction method used in this model.

The customizability of the model was demonstrated by adding several countries to the analysis, but the research was limited by the availability of employment data. This especially is due to the model focusing mainly on the labor part of an economy and not only on the capital indicators. It is possible to claim data from the EU Klems database which provides labor and capital data for further work on this topic with multiple other countries, but only those which are listed in chapter 5. Nevertheless, most of the economic indicators for a country-sector and national economies are not affected by this lack of data (contribution of a country-sector to the overall economy, etc.), only those which require employment data are left out during the calculations.

Another disadvantage might be the lack of data of the OECD for the other 27 member countries of the EU. This is especially true when the research is extended to the BRIC [1] countries. There is hardly any data available without any necessary modifications and a lot of quarters and years in the time series are incomplete or even missing. This results in a decrease of possible countries to investigate with this model. This issue is responsible for the limited time period (2000 - 2014), which was analyzed after reconfiguration to run the model with extended countries. This applies in particular for China, Japan and USA, where data from the OECD were available for Austria but not for the others.

[1] Brazil, Russia, India and China

7.4 Value added and GVC

This thesis touches only the amount of applications of the WIOT. There are more indicators which can be introduced and taken into account. For example, it is possible in the context of GVC to slice up the chains. This was already done with existing WIOT data [TEL+14], but would be interesting to calculate on periods afterwards based on the forecasts of this thesis.
There are a couple of papers investigating the value added in trade which might become a possible extension to the produced results of this master's thesis [KWW08].
Regarding the customizability and the possibility to change the countries in the model, an interesting research topic would be to conduct calculations for all the countries EU to highlight their specializations, or take a look at their prospective developments using short-term forecasts. Another relevant idea to investigate would be to combine all EU countries to one big country and see if there are any changes in trade with China, Japan, India and USA during the last decade where globalization became more important. This concludes the importance of the thematic and highlights the relevance of research in this economic field of international trade networks.

7.5 Agent based simulations

The first step done towards an agent based simulation was the development of this model [2]. In an agent based simulation each country and each sector is an agent with a reactive behavior, having instruments and tools to reach certain goals within a time span. To illustrate such a simulation, an example based on a possible guideline is given:

7.5.1 Sector

An industry has the goal to enlarge its economic value and gain further comparative advantage:

- Enlarge its economic value
- Gain further comparative advantage

It wants to increase the total output but has certain restrictions which are primarily national origins (taxes, available skilled workers, etc.) and secondly international boundaries due to the globalization where transportation margins might rise due to radical political reasons and further shift of work to other countries. Their properties will be:

[2] This simulation type is arranged in bottom-up modeling techniques and is based on interaction (direct or indirectly) over time between multiple heterogeneous (states and types) individuals having their own behaviors, functions, (natural) processes and properties and is known as agent based computational modeling [Gil08]

- Growth
  Due to a higher demand in the previous period the sectors will claim their new goal to reach the new higher output level to satisfy the market. This can be done by a higher investments in their production lines and facilities or in technological progress or additional employment of new staff.

- Shrink
  If the sector is forced to shrink due to lower demand on the market, the following instruments can be applied: reducing their investments or even dismantling their production facilities, keeping or lowering the prices for their goods, reducing the working time for employees or even dismissing them. Dismissal will not have an impact on the actual period but on the next one because of work protection and unions.

7.5.2 National economy

Furthermore the national economy has to be defined as an agent because industries are only part of the economy of a country and depend on the countries policies which highly influences growth and output of each sectors. The industries and the economy interact based on multiple considerations because they have direct impacts on the output and basically every economic indicator especially in the largest industries. For example, the value chains influence not only the GDP, but they affect the labor market at lower order levels, maybe leading to dismissals of employees which is then going to influence the unemployed rate and possible social state support.

7.6 Adjusting data sources

The data sources have to be kept up-to-date to be able to validate the forecasts after every year. It is then possible to see if the calculated data is reliable in comparison to the real data. This means that data sources might change, when for example new values and indicators are used in further updates of the WIOT to keep the model valid.

Another interesting subject which is not part of this thesis, is gathering and analyzing further information about the overall labor market in the countries. Additional employment data could be added to extend the research in this field, which would for example be information about the amount of jobs in each sector or total hours worked. This could be broken down to the industry-level of an economy. Since there is additional data available regarding the share of women and men working in the sectors this could be a topic to investigate. Most of the data would have to be acquired manually because no automatic fetching and transformations can be done with simple algorithms without covering all hidden edge cases.

7.7 Quarterly developments

For some external data sources used during the calculations of the model there are quarterly time series available. That information could be used to study the development of country-sectors and overall economies in a more granular time-based model. This might result in questions like, is there a significant shift of competitive advantage on the industry level during a year and how can this be measured considering the employment in these sectors. This might move the model into the context of a more detailed examination of the situation of labor and capital input for each quarter in a particular sector.

CHAPTER 8

Conclusion & Summary

Economic models are rarely providing a wide range of indicators. They often only include more general data like GDP or unemployment rate on a total economy level. A typical economy consists of many different companies which contribute to the gross value added, employ a serious amount of workers and add up to the total imports and exports of a country. Those companies form several industries, which are as homogeneous as possible to divide the three sectors of an economy as good as possible, but are more likely to act independently from other industries and represent specializations which may be typically found in a country. In addition to that, the GVC is another important issue which got relevant in the last decades on the international market of trading goods and services. Since there is a shift of companies to outsource specific parts of assembling or production, the location of goods and the ways through other countries to the consumer are more difficult to trace.

These factors are the foundation of this thesis and necessary to investigate the specializations of European economies, especially for the five biggest countries - France, Germany, Italy, Spain and the UK - and their contribution to the international GVC. The important industries of each country usually contribute the most. First, however, the indicators have to be defined to start the research and analysis accordingly - the sector's share of the total GDP, exports, employment, GVC income and the degree of comparative advantage in contrast to other countries' industries. Furthermore, it is important to find and extract additional important information about the country itself - growth of GDP, unemployment rate, import/export ratio and the share of exports on an international level. The research goal was achieved by creating a model which is able to prepare the necessary data from various sources and find, extract, predict and visualize all the data needed to retrieve relevant results.

The research was done with the help of the WIOT, an I/O table constructed out of 43 countries and an estimation of the RoW covering 56 industries. The dataset is hosted and maintained by the OECD offering time periods from 2000 to 2014. The OECD

provides data for forecasts of future periods with an additional data source, the EU Klems database, which covers socio economic data of countries in the EU.

Scripts of mathematical operations on matrices and vectors are responsible to transform the I/O tables in the first place to prepare the correct amount of countries and sectors. In the next step, scripts fetch updated data for different kind of indicators from the two additional data sources to adapt the I/O tables for future periods, namely from 2015 to the present year 2017. Furthermore, algorithms provide the balancing of a market equilibrium, combining and extracting important and questioned data, to output and visualize them to retrieve answers for the research questions. Additionally, calculations are made to predict data from the year 2017 and onwards to 2020 to offer short-term forecasts.

Modeling these kind of I/O structures as it was done for the economic model in this thesis is a complex task. One has to deal with different data sources which do not provide all the necessary values to calculate further periods including the computation of future employment with the help of elasticities based on the total output. Additionally it is needed to find the market equilibrium and to take the model to a generic and dynamic level to add other countries which are included in the WIOT and set the level of granularity regarding the amount of sectors to answer any kind of question in this economic area.

The first research question - considering the specialization of the top five European countries, is answered accordingly by analyzing and describing the top five sectors for each country and highlighting other economic key figures. For example, Germany's economy is specialized in the automotive and transport industry, followed by the machinery & metal manufacturing sector and scientific and service activities. Together those three parts of the overall industry contribute to almost 21 percent of the national GDP which is achieved by more than 21 percent of the total employment. National indicators identify the big role of Germany in the world, having one of the lowest unemployment rates - which will be about 4.7 percent in 2020 and a confirmed export surplus, which will reduce in the future.

A model is only as good as it's input data of suitable quality and covers all the limits which are required for calculations. Because there is hardly any data available apart from the GDP forecast after 2017, all the other values have to be forecasted by Holt-Winters to build the I/O tables till 2020, especially the estimation of the RoW is handled in a very simple way - adapting all the values to the growth rate of the GDP instead of having detailed values, which is a disadvantage of such models to guarantee accurate and reliable results.

The reconfigurability and customizability of the presented model has been proven by adding more countries, for example, for example, Austria, China, Japan and the USA to the calculations of this model. The model did not deliver results after 2014, because there is hardly any data available for non-European countries and if so, these data are only estimated or incomplete in its time series or key figures, which is not sufficient for

the model computations. If these data become available it is easy to extend the research to other countries outside of the EU or even to access data sources of domestic regions because at the initialization phase all of the required data are loaded and transformed before importing them into the model and using them in later calculation steps.
These limitations show the enormous lack of information and available data. Although there are national and international institutions, which are responsible for collecting, gathering and providing these datasets, and external sources, but are not able to provide up-to-date data or even have any data available for certain countries, which make investigations into them not even possible. If the model is configured to take only countries of the EU, the results are complete to start researching in this area with the ability to add other key figures to the output, which might conduct more details of the flow and structure of today, which is not fully targeted in this thesis.

As a conclusion we introduced a model which has successfully identified industrial specializations of countries and forecast the development of them in a short-term outlook. Industrial specializations are discovered with the help of the RCA based on the GVC income computing WIOT hosted by the OECD. Results of single sectors or adding up those, which contribute the most or least to the overall economy and additional data to the national economy, are available and can be analyzed in figures. Some Limitations are responsible for the restricted results regarding the second research question, because the results depend on the data gathering method and sources concerning the selection of the countries. This given model still supports already existing models and results. The possibility to easily customize it by changing the configuration script and to calculate an outlook for future periods and the market equilibrium for each period to retrieve reliable and consistent data within the model, opens new research fields. These forecasts can only be done if external data sources provide time series for those countries after the last period of the WIOT - 2014.

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Glossary

Cultivated assets *Cultivated assets are livestock for breeding (including fish and poultry), dairy, draught, etc and vineyards, orchards and other plantations of trees yielding repeat products that are under the direct control, responsibility and management of institutional units.* [fECoD01a]. 9

Dwelling *A dwelling is a room or suite of rooms and its accessories in a permanent building or structurally separated part thereof which by the way it has been built, rebuilt, converted, etc., is intended for private habitation.* [fECoD01b]. 9

Intangible fixed assets *Intangible fixed assets are non-financial produced fixed assets that mainly consist of mineral exploration, computer software, entertainment, literary or artistic originals intended to be used for more than one year.* [fECoD01c] plural. 9

Other buildings and structures *The other buildings and structures category of non-financial, produced, tangible fixed assets consists of non-residential buildings and other structures, such as civil engineering works.* [fECoD01d] plural. 9

Transport equipment *Transport equipment (assets) consists of equipment for moving people and objects, other than any such equipment acquired by households for final consumption.* [fECoD01e]. 9

Acronyms

ANA Annual National Accounts. 47, 49

BLA Backward linkage analysis. 30

EU European Union. ix, 1, 7, 8, 10, 12, 13, 15–20, 34, 45, 50, 53, 55, 65, 68, 80–82, 86, 87

FLA Forward linkage analysis. 30, 31

GDP Gross domestic product. 1, 3, 7–15, 17, 47–51, 55, 56, 58–60, 62, 63, 65, 66, 68, 71, 72, 81, 83, 85, 86, 89, 90

GFCF Gross fixed capital formation. 3, 9, 15–19, 24, 26, 35, 47, 48

GVC Global value chain. ix, xi, xii, 2, 4, 33–41, 43, 45, 46, 53, 57, 61, 64, 68, 79, 80, 82, 85, 87

GWK Globale Wertschöpfungskette. vii

I/O Input-Output-Tabllen. vii

I/O Input-Output. ix, xi, 3, 4, 11, 21–31, 33, 35, 39, 40, 45, 79, 81, 85, 86, 91

ICT Information and communication technology. 9, 54, 61, 67, 75

IIT Intra-industry trade. 24

ISIC International standard industrial classification of all economic activities. xii, 33–36, 41, 48, 50, 54, 80, 91, 103

LPM Leontief input-output price model. 30

NAFTA North American Free Trade Agreement. 19

NIOT National Input-Output Tables. 34, 46, 48

NSUT National supply and use table. 48

OECD Organization for Economic Co-operation and Development. 3, 7, 13, 16, 18, 41, 43, 46–51, 80, 81, 85, 87

QNA Quarterly National Accounts. 47, 49

RCA Revealed comparative advantage. 4, 33, 37–39, 41, 45, 46, 51, 53–55, 57, 58, 61, 62, 65, 67, 68, 71, 73, 74, 76, 77, 80, 87, 89–91

RoW Rest of the World. 19, 34, 35, 38, 48–50, 64, 67, 70, 75, 85, 86

SEA Socio Economic Accounts. 34

SNA System of National Accounts. 35

SONA System of national accounts. 29

SUT Supply and use table. 35

TPP Trans-Pacific-Partnership. 19

UK United Kingdom. 2, 8, 16, 18–20, 34, 48, 54, 59, 61, 63, 67–70, 85, 90

UN United Nations. 29, 36

USA United States of America. 3, 13, 19, 21, 30, 65, 71, 73–76, 80–82, 86, 90

VA Value added. 25, 27

WIOD World Input-Output Database. 3, 34

WIOT Welt-Input-Output-Tablle. vii

WIOT World Input-Output Table. ix, xi, 3, 4, 23, 25, 29, 33–37, 39, 41, 43, 45, 46, 50, 53, 71, 76, 79, 80, 82, 83, 85–87

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Appendix

Custom/Top level sector(Number)	Definition	Number of WIOT groups
A (1)	Agriculture, forestry and fishing	3
B (2)	Mining and quarrying	1
Ca (3)	Automotive & transport manufacturing	2
Cc (4)	Chemical manufacturing	5
Ce (5)	Electrical machinery manufacturing	2
Cf (6)	Food manufacturing	1
Cm (7)	Machinery & metal manufacturing	3
Cn (8)	Other non-durable manufacturing	6
DE (9)	Electricity, gas, steam, water, air conditioning supply	3
F (10)	Construction	1
G (11)	Wholesale and retail trade; repair of motor vehicles and motorcycles	3
H (12)	Transportation and storage	5
I (13)	Accommodation and food services activities	1
J (14)	Information and communication	4
K (15)	Financial and insurance activities	3
L (16)	Real estate activities	1
MN (17)	Professional, scientific, technical, administrative and support service activities	6
OU (18)	Public administration and defence; compulsory social security, Education, Human health and social work activities, Arts, entertainment and recreation, Other services activities, Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use, Activities of extraterritorial organizations and bodies	6

Table 1: ISIC Rev. 4 - August 2008 - customized sectors