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Anton Paukner, BSc.
Matrikelnummer 0826471

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Betreuer: Ao.Univ.Prof. Mag.rer.soc.oec. Dr.rer.oec. Gerhard Hanappi
Mitwirkung: Univ.Ass. Mag.rer.soc.oec. Dr.rer.soc.oec. Bernhard Rengs

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MASTER THESIS

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Business Informatics

by

Anton Paukner, BSc.
Registration Number 0826471

to the faculty of Informatics
at the Vienna University of Technology

Advisor: Ao.Univ.Prof. Mag.rer.soc.oec. Dr.rer.oec. Gerhard Hanappi
Assistance: Univ.Ass. Mag.rer.soc.oec. Dr.rer.soc.oec. Bernhard Rengs

Vienna, 05.12.2013

(Signature of Author) (Signature of Advisor)

Erklärung zur Verfassung der Arbeit

Anton Paukner, BSc.
Gentzgasse 77/12
1180 Wien

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Abstract

Input-output analysis is one important technique to identify endogenous impacts on economic variables like industry output, shifts in sectoral structures or employment caused by exogenous changes of final demand or other stimuli. The main effort of this thesis consists in (re-)defining a new and more appropriate classification of the information sector, also in respect to the thesis' aims, creating a homogenous data basis of input-output tables in the first step, followed by conducting a time series analysis and as the final step measuring the economic impact of the information sector through Leontief-Inverse matrices and multiplier effects. Since the five largest EU economies are part of the investigation, a huge amount of data has to be processed, which clearly cannot be handled manually. Due to the context of the thesis, Austria and Portugal are being included too. Thus it is necessary to evaluate the steps to find out where automation is possible and effective. Scientific research methods are oriented towards empirical analysis techniques, analytical transformations and condensing conclusions for projecting complex economic coherences in a descriptive modality. The updated definition of the information sector and precise industry classification, represent an essential basis for further steps. An important requirement for conducting the time series and impact analysis is constituted by a homogeneous and compatible data basis of national input-output tables. The goal is to construct technical coefficient matrices, (socio-) economic multipliers and linkages, which facilitate the description of the information sector's economic impact. Later they are being translated into a set of decision variables to provide starting points for further analysis or enable researchers like economists for drawing conclusions about economic performance.

Keywords: information sector, input-output tables, industry classification, GRAS-algorithm, technology matrices, Leontief-Inverse matrices, multiplier effects, economic impact

Kurzfassung

Die Input-Output-Analyse ist eine der wichtigsten Verfahren, um endogene Auswirklungen auf wirtschaftliche Kerngrößen, wie beispielsweise industrielle Produktion, sektorale Änderungen oder den Wechsel von Arbeitskräfteverhältnissen durch exogene Wirtschaftsformen, wie Endnachfrage oder andere Stimuli, zu untersuchen. Die Kernaufgabe dieser wissenschaftlichen Arbeit besteht in einer Neu-Definition bzw. passenden Klassifizierung des Informationssektors, in Anbetracht der formulierten Forschungsziele.

Dies erfordert die Konstruktion einer homogenen Datenbasis, welche für die weiteren Schritte der Zeitreihen- sowie wirtschaftlichen Einflussanalyse unerlässlich ist. Der eben letzte Untersuchungsschritt, welcher auch bereits im Titel dieser Arbeit hervortritt, basiert vorwiegend auf den konstruierten Leontief-Inversen Matrizen und Multiplikator Effekten. Die Untersuchungen betreffen die fünf größten Wirtschaften der Europäischen Union sowie Österreich und Portugal. Hier wird augenscheinlich, dass eine große Menge an Daten zu verarbeiten ist, was im Hinblick auf Effizienz und Verringerung von Fehleranfälligkeiten nicht manuell durchgeführt werden sollte. Um dies sicherzustellen, ist es im Vorfeld notwendig, die einzelnen Schritte genauestens auf ihre Automatisierbarkeit hin zu evaluieren.

Die angewandten wissenschaftlichen Methoden basieren auf empirischen Analysetechniken, analytischen Transformationsprozessen und der Rekonstruktion einzelner Zusammenhänge. Die Forschungsergebnisse dieser Masterarbeit bilden eine bedeutende und fundierte Grundlage für weitere wissenschaftliche Studien, welche beispielsweise die Vorhersage der Entwicklung des Informationssektors thematisieren. Desweiteren ist es aufgrund der vorliegenden Forschungsergebnisse WissenschaftlerInnen, etwa ÖkonomInnen möglich, wirtschaftliche Rückschlüsse auf das Verhaltensmuster des Quartärsektors zu ziehen.

Schlüsselwörter: Informationssektor, Input-Output Tabellen, Industrieklassifizierung, GRAS-Algorithmus, Technologiematrizen, Leontief-Inverse Matrizen, Multiplikator Effekte, Wirtschaftlicher Einfluss

List of Contents

1. Introduction to the Project

1.1. Problem Definition

In the last two decades growth and impact of the information sector (also known as quaternary sector) has increased rapidly. There exist numerous definitions of the information sector which follow a theoretical approach. This thesis aims to derive a hybrid definition of the information sector – on the one hand existing theoretical definitions and fitting classifications for the used data set on the other hand. Lots of effort consists in differentiating and grouping the various industries e.g. where to make the distinction. In the thesis title appears the term 'ICT', which is the acronym for information communication technology. Due to generalization and distinction issues the term information sector will be used as a more comprehensive synonym for ICT.

The key difficulty is the methodology of converting the information of input-output tables into more concise and expressive structures. Many restrictions have to be considered guaranteeing the correctness in every step of the complex transformation process. This already begins at the information gathering task, where most of the data should be obtained from? Moreover there is a requirement for an automated approach due to the huge amount of data.

After solving these problems, there is the last hard task of identifying the crucial variables and coefficients, to be able to conduct an expressive impact analysis. For completing the impact analysis a type of representation has to be evaluated, which makes the inter-industrial correlations clearer and more understandable. To retrieve prominent results, the five largest EU economies (France, Germany, Italy, Spain and United Kingdom) as well as Austria and Portugal, due to continuance of the thesis at the IST in Lisbon, are being analysed.

1.2. Research Questions

The following research questions are being investigated:

- Due to the shift of economic structure in high-developed countries from primary and secondary activities towards tertiary and especially quaternary activities, a new definition and classification of the information sector is required. What are the characteristics of existing approaches and how do they have changed over time?
- There is a wide range of provided data for input-output statistics. Which data source is most appropriate for the impact analysis of the information sector?
- The amount of data exceeds manual treatment and also the reusability is of great importance nowadays. Therefore the automation of tasks has to be evaluated. Which tools are most feasible for e.g. conducting a time series or impact analysis and how exactly can these steps be automated?
- The development over time is an essential indicator for economic behaviour e.g. changes in output, final demand or labour. A time series analysis reveals this important information. What are the requirements and how can the found results be interpreted?
- Measuring the impact of the information sector requires lots of preparatory work. What are mathematical prerequisites for this step and through which measurements can economic impact be expressed?

- The inter-industrial linkage is a very important mechanism for determining the differences between industries e.g. when there is an exogenous change. Besides numerical evaluation is there a clearer approach e.g. visualization?

1.3. Process of Research

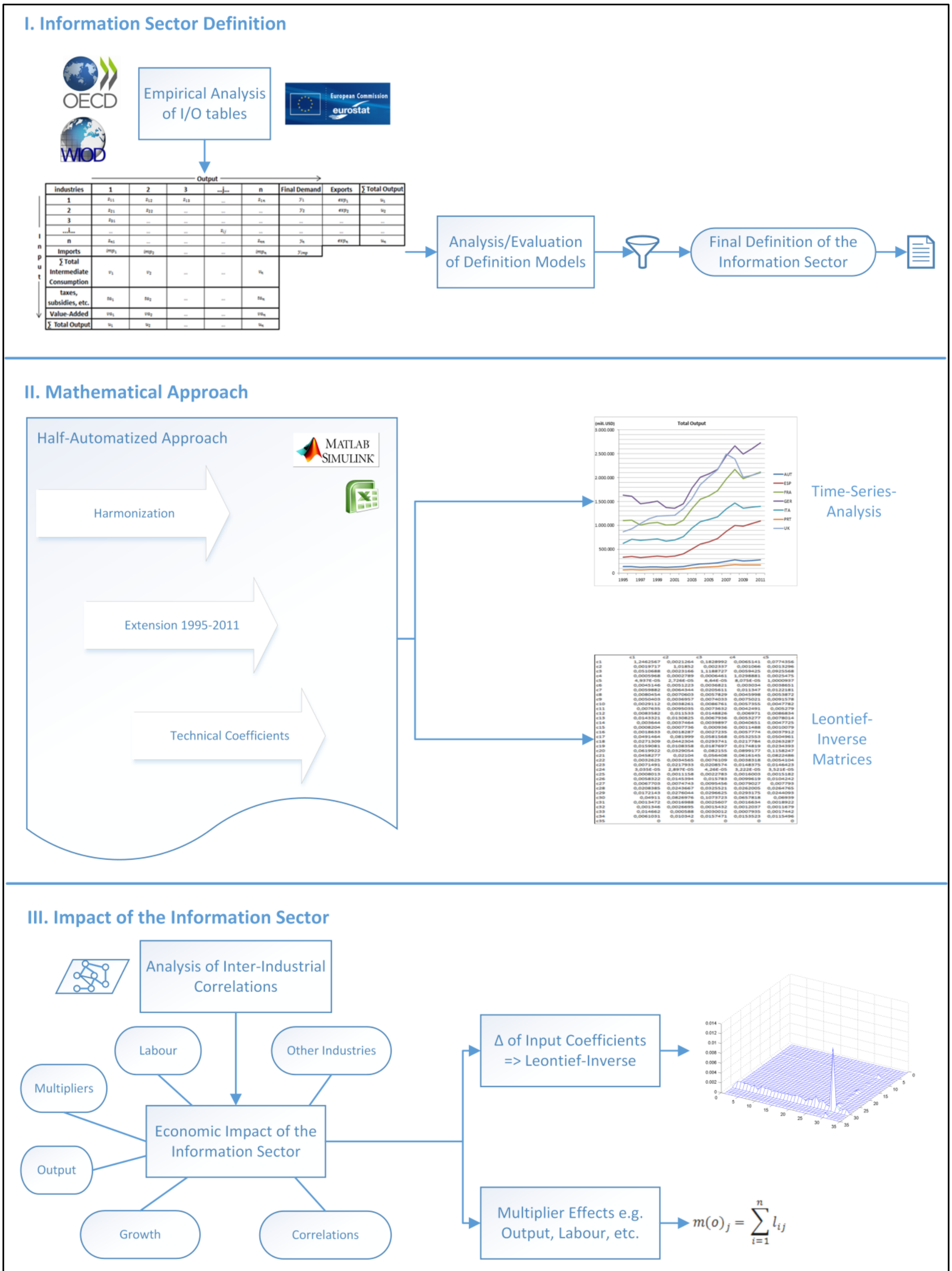
The main fields of research for this thesis can be divided into three bigger sub-projects. The first one covers the definition of the information sector, which is being derived from former theoretical attempts and empirical analysis of required data (input-output tables). These data will be obtained from statistical organizations like the OECD[1], WIOD[2] database or Eurostat[3]. An evaluation of the data sources is being conducted to find the most applicable one for the field of economic impact analysis. In addition several definition models of the information sector are being introduced and evaluated. These models should provide a fertile ground for being able to make a clear distinction of information sector industries later on.

The second sub-project covers the mathematic-focused approach. The main effort entails building a consistent and homogenous database of input-output tables, to be able to perform robust and sophisticated analysis as well as reach sufficient criteria for an automatized approach. Furthermore it can be necessary to extend the homogenized data for a certain number of years to retrieve a topical data pool – the (G)RAS-algorithm[4] (also known as IPF[5]) is therefore being introduced. The automation of steps is a quite time-consuming task and requires much pre-planning to implement an effective solution. To retrieve a comprehensive output, data from approx. seventeen years is used. The input-output tables themselves have to be transformed in a mathematical manner that a technical coefficient matrix can be computed to provide the basis for bottom-up impact measurements e.g. technical coefficients and multiplier effects or inter-industrial linkages.[6] Besides the impact analysis, the second sub-project contains a time series analysis, where the development of the information sector is being analysed, evaluated and visualized.

The third sub-project deals with inter-industrial relations and impacts of exogenous changes on endogenous variables e.g. impacts of changes in final demand, variation of single input coefficients or multiplier effects. The basis therefore are technical coefficient matrices, which have to be analysed in detail, to detect the most important coefficients and other measures, which officiate as crucial points. All previous efforts result in a detailed evaluation and interpretation of the impact analysis' final output. The last task is to find an appropriate type of representation for being able to establish a connection between changes of variables and its repercussions.

The following figure provides a visual overview of the research process:

[1] **OECD** <http://www.oecd.org/> (accessed June 2013).
[2] **WIOD** <http://www.wiod.org/> (accessed June 2013).
[3] **Eurostat** <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/> (accessed June 2013).
[4] **Oosterhaven** (2009), p. 329.
[5] **Norman** (1999), p. 1-2.
[6] see **Drmota** (2008) for basic matrix operations.



Sources of Pictures
-WIOD Logo: <http://www.wiod.org/img/wiodlogo.png> (accessed October 2013).
-Eurostat Logo: <http://torvergata.eurosblog.eu/IMG/jpg/eurostat_logo.jpg> (accessed October 2013).
-OECD Logo: <http://img.ibtimes.com/de/data/images/full/2011/09/27/7069-oecd-logo.jpg> (accessed October 2013)
-Matlab Logo: <http://upload.wikimedia.org/wikipedia/commons/2/21/Matlab_Logo.png> (accessed October 2013).
-Excel Logo: <http://www.teachme.at/includes/media/excello.png> (accessed October 2013).

Figure 1 Research Process

1.4. Expected Results

The main outcome of this thesis and answers to the postulated research questions can be summarized as follows:

- Updated definition of the information sector through the evaluation of several models and a detailed industry classification (ISIC Rev. 2)
- Homogeneous and topical data base of national input-output tables as required for the economic impact analysis and synthesising future works
- Comprehensive time series analysis of the information sector – interpretation and visualization of results
- Allocating implemented automations e.g. Matlab scripts and Excel macros
- Construction of Leontief-Inverse matrices through transformation processes of national input-output tables
- Investigation of exogenous changes and their endogenous impacts – evaluation of economic shifts and visualization of inter-industry relations e.g. effects on industry output, final demand variations, impacts on sectoral employment
- Cross-comparison and interpretation of results for the five largest EU economies, as well as Austria and Portugal

1.5. Structure of Work

As mentioned previously, the thesis is separated into three bigger sub-projects. To be able to provide a more granular structure, ease a comprehensive understanding and enable the reader to focus on certain topics, the thesis is separated into nine chapters.

The second chapter covers several terminologies e.g. data, information, knowledge, ICT, KBE, etc. These preliminary remarks should endow the reader already from the beginning with essential information which is necessary for a broad understanding and the used approaches, concepts and definitions. Furthermore this chapter contains information about the economic sector model and macro-economic effects of new information technologies too.

Chapter 3 deals with the evaluation of different data sources. As the OECD, Eurostat and WIOD provide national input-output tables, a detailed analysis and comparison is required, to be able to allocate the most appropriate data for the purposes of economic impact analysis.

Chapter 4 addresses existing definition approaches of the information sector e.g. OECD approach or Machlup approach. In addition an approach from the Vienna University of Technology and WIIW[7] will be introduced too. As an interim result the definition and industry classification of the information sector is provided.

In chapter 5 the prolongation of input-output tables is being introduced. This task is necessary as it results out of the data source decision. The methodological approach, covering also the self-written Matlab function 'eurostat_to_wiod', the usage of the information sector classification of the previous step and some auxiliary computations are being provided. An essential projection approach is represented by the GRAS-algorithm and the average growth rate (AGR). The methodology of extending the input-output table's time-span is explained in detail too. Interested readers may see chapter 5.2.4, where emerging barriers during the extension process

[7] **WIIW** <http://www.wiiw.ac.at/> (accessed July 2013).

are being discussed. Latter adaptions conclude the prolongation task and further the final version of the later used input-output tables is being provided.

Chapter 6 covers a subsequent task of the extension step, namely the time series analysis. This part of the thesis contains information about the basic concept of the methodology how to set up and conduct a proper time series analysis. The historical development is an important part of the thesis, followed by an appropriate type of visualization and an interpretation of the results. Attributes like industry output, economic share of the information sector, changes in final demand and also socio-economic developments like employment or high-skilled labour allocations are being investigated.

The construction of technical coefficient matrices (also known as Leontief-Inverse matrices) is one of the most complex and sensitive tasks of the whole thesis. The intrinsic mathematical concepts e.g. construction of Leontief-Inverse matrices or multipliers are presented in chapter 7. Furthermore it is again indispensable to automatize this transformation process, as the amount of data exceeds manual treatment and unnecessary error-proneness can be avoided through this too.

Now it comes to the task, which is said in the title of the thesis - to measure the impact of ICT (information sector). A theoretical introduction to the impact analysis is being provided, followed by the actual conduction. In general terms impacts of exogenous changes (e.g. shifts in final demand) on endogenous (socio-) economic variables are being analysed. Another interesting measurement is represented by multiplier effects and inter-industrial linkages. An appropriate visualization approach concludes the impact analysis' outcome of chapter 8. A national cross-comparison of the five largest EU economies as well as Austria and Portugal and their potential differences in economic behaviour represent the last assignment.

Chapter 9 summarizes the used approaches, problems and final outcome of this thesis. Moreover it bridges to the future work which can be set up on top of the thesis' results. Chapter 10 covers all bibliographic references, web resources and a key table for the used acronyms. The appendix provides additional information e.g. essential background information, Matlab scripts, Excel macros, comprehensive results/visualizations etc.

1.6. State of the Art

In the initial phase it got already obvious that the thesis will follow a more fundamental methodology. A major part of the gathered information and gained knowledge is being derived from empirical studies and analysis. It is indispensable to find suitable approaches for retrieving a homogeneous data basis, which enables the construction of technical coefficient matrices in the next step. Further on a time series analysis gives an overview about the historical development, which is followed by a comparison of several coefficients and measurement of the economic impact of the information sector. All these tasks and approaches require sophisticated knowledge in multiple fields e.g. mathematics, econometrics, micro- and macro-economics, programming, empirical research or system design. Regarding the mathematical and econometrical tasks, the literature will be often closely linked to formerly used books or papers from corresponding lectures at the Vienna University of Technology as well as importance is being ascribed to the topicality of these references. The empirical research and design part is based on multiple scientific publications of technical as well as economic universities and also prominent authors in the fields of information and knowledge-based economies. In addition the sources of Eurostat, the OECD and WIOD provide highly reputable and basic information concerning input-output tables and they also hold rough guidelines available, how to use their data with respect to different fields of applications. These three institutions allocate precious information regarding the linkage of issues to micro- and macro-economic perceptions too. As a consequence the decision for the used references and different sources of information illustrates a clear picture: On the one hand there is a focus on the wide scope of used references and on the other hand the attention is also directed on the specific specialization of researchers, institutions, authors etc.

1.7. Relevance to Business Informatics

The fields of Business Informatics[8] at the Vienna University of Technology address information and knowledge related issues as well as financial and social aspects on the micro- and macro-economic level. Hence it can be seen as an interface between society, organizations and technology. The focus of many subjects is on systems which are relevant for processing information and supporting different types of communication. Therefore it is necessary to acquire certain knowledge in the fields of analysing the environment, designing and modelling a system, conducting the implementation and evaluating the final outcome. Hence the linkage to the study can be evidenced in multiple areas. On the one hand there is a strong correlation to the learnt research methodologies regarding the writing of scientific papers, and on the other hand lots of technical as well as economical knowledge is necessary to conduct reputable results. Not only the theoretical and practical part of this thesis substantiates the strong reference but also the economic urgency for information sector agents of the topic. The essence of this scientific research yields not only to the perceptible impact of the information sector on large economies but moreover it provides a good indication for future developments, which can again be ascribed to the university sector and its focus of studies, especially the information technology domain.

[8] **Business Informatics** <http://www.tuwien.ac.at/en/teaching/master_programmes/business_informatics/> (accessed July 2013).

2. Preliminary Remarks

2.1. Terminologies

2.1.1. Data / Information / Knowledge / Wisdom

An essential issue is to differentiate terms like ‘data’, ‘information’ and ‘knowledge’ on abstract levels. Data can be treated as some kind of raw material and has no inner meaning. Thus it is represented on the lowest level of abstraction. Transforming or processing data attaches meaning to it and makes it thereby interpretable - it follows on the next level of abstraction.[9] Knowledge is represented on the pre-last level of abstraction and extends information with a cognitive dimension.[10] Thus it makes information reasonable and provides a fertile ground for interpreting it e.g. deriving decisions out of it, use it for further conclusions, etc. Knowledge can be differentiated into two types: tacit (implicit) and explicit. Tacit knowledge is hard to encode, communicate and formalize – it is context-specific and subjective.[11] Explicit knowledge instead is encodeable and transmittable. “It is explicit knowledge that most current knowledge management practices try to, and indeed are able to, *capture, acquire, create, leverage, retain, codify, store, transfer* and *share*.”[12] Wisdom is often mentioned that it relates to knowledge too. It represents the top layer or the last link in the chain and can be interpreted as structured and aggregated knowledge. The layering of the abstracted levels can be illustrated as a pyramid. Sometimes it is mentioned in several literatures as the ‘DIKW-Chain’[13], which is the abbreviation for ‘Data Information Knowledge Wisdom – Chain’. For interested readers the fabulous work in the domain of information, “The Information”[14] by James Gleick, should be mentioned, as it provided also some inputs for the thesis.

2.1.2. Information Communication Technology

The terminus ‘Information Communication Technology’ (ICT) is often used in association with the information sector, as it is considered as a part of it. As already mentioned in a previous chapter the term ICT is treated as a more comprehensive synonym for the information sector. Detailed information regarding the distinction/classification of the information sector and the precise structure is provided in chapter 4. ICT has gained increasingly impact on economic activities in the last two decades. It is treating the unified communication approach of today’s computer and telecommunication networks. Governments should provide high-quality infrastructure e.g. broadband networks to ensure that there is an on-going growth and sustainable development of ICT. Of course it is linked with pretty high investment costs, but the returns, which can be made out of it, are much higher. “It has been a catalyst of change in business, improving work organisation for instance, helping firms to reduce routine transaction costs and rationalise their supply chains. It has spurred innovation in services and made manufacturing and design more efficient. Inventories and overheads have become more

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[9] **Katzenberger** (2010), p. 33.
[10] **Amaral** (2013), p. 9.
[11] **Nonaka** (1995), p. 7.
[12] **Brown** (2001), p. 198-213.
[13] **Hey** (2004), p. 3.
[14] **Gleick** (2012).

manageable."[15] ICT is also a technological backbone for innovations hence it provides the required technology for creating a fertile environment for innovativeness. Furthermore ICT has endowed producers and consumers with a more efficient connection via so called 'value-generating networks' to let them benefit in long-term effects and continuous future development.[16]

2.1.3. Knowledge-Based Economy

Over the last decades, especially in the nowadays information society, knowledge got very important in terms of an economic growth and performance indicator. Knowledge production, distribution and utilization got one of the key drivers for powerful and growing national economies e.g. OECD member states' economies nowadays mostly depend on this economic factor.

The term 'knowledge-based economy' relates to the wider view of the role of knowledge and technology in a national economy. Knowledge is mostly contained in humans, hence it can be seen as some type of 'human capital' and moreover it is deeply embedded into the fields of technology. These two representations are very essential for economic growth and development. Producing, distributing and using knowledge implicates to have a high-skilled labour force too. This sector of giving people sophisticated education is called 'learning economy'. To be able to distribute knowledge and make it thereby accessible for usage a performant network is required. The transmission and procession of information and also knowledge via computer and communication networks has been dramatically increasing for years. The innovation potential of these networks is very important to keep the knowledge flow and consumption as efficient and up-to-date as possible.[17]

Knowledge can be also seen as an important production factor. Before the emergence of knowledge there were just two productions factors: labour and capital. The old production function was *S(L, C)*, where *S* equals the classical production function and *L* respectively *C* stand for labour and capital. Economic growth was solely dependent on physical factors which are subjected to decreasing marginal gains and hence limits the growth rate. In the 20th century the technological evolution caused a major change to these two factors. Nowadays economic growth and also the way of creating wealth are mainly influenced by technology and knowledge. As a consequence, the old production function gets extended with one parameter, namely knowledge. The new production function has the following structure: *S(L, C, K)*. As knowledge and its influence on the growth of the economy is not subjected to decreasing marginal gains, it is rather determined by increasing marginal gains, which can be treated as an endogenous growth variable.[18]

Innovation is a key driver for the intrinsic growth. It should make an organization "[…] capable of increasing the depth and diversity levels of its knowledge base."[19] Innovation also keeps up the competence of an organization, due to its continuous search for new processes and products. Furthermore it has a more strategic focus because when trying to preserve a high level of innovativeness, an organization will never stop at a certain threshold. It will rather try to

[15] **OECD** (2001), p. 27.
[16] ibid., p. 28.
[17] **OECD** (1996), p. 3-9.
[18] **Amaral** (2013), p. 6-8.
[19] ibid., p. 10.

generate more of its innovative knowledge, to make it also tougher for competitors, to just let them reach the same level, just by copying the resulting products.

2.1.4. Knowledge Index & Knowledge Economy Index

The World Bank Group[20] invented the framework of knowledge assessment methodology (KAM) to provide a world-wide measurement for benchmarking a country's position in the knowledge economy. Two indices are being combined to form a technical and normalized coefficient. The first one is called 'Knowledge Index' (KI) and is based on 3 pillars: education, innovation and ICT. Three sub-indices are being formulated to provide a basement for the aggregated indices. The key function of the KI is to indicate the overall potential of knowledge development in a certain country. The second index, called Knowledge Economy Index (KEI), extends the KI with one further variable: It considers also the environment for knowledge if it is used effectively for economic development. The KEI provides an aggregated measurement and takes also into account the overall development of a country combined with the economic incentives and institutional regime (EIR) within a knowledge economy. Figure 2 provides a visual presentation of the KI and KEI.[21] Table 1 contains statistical information about the top countries sorted by KEI.

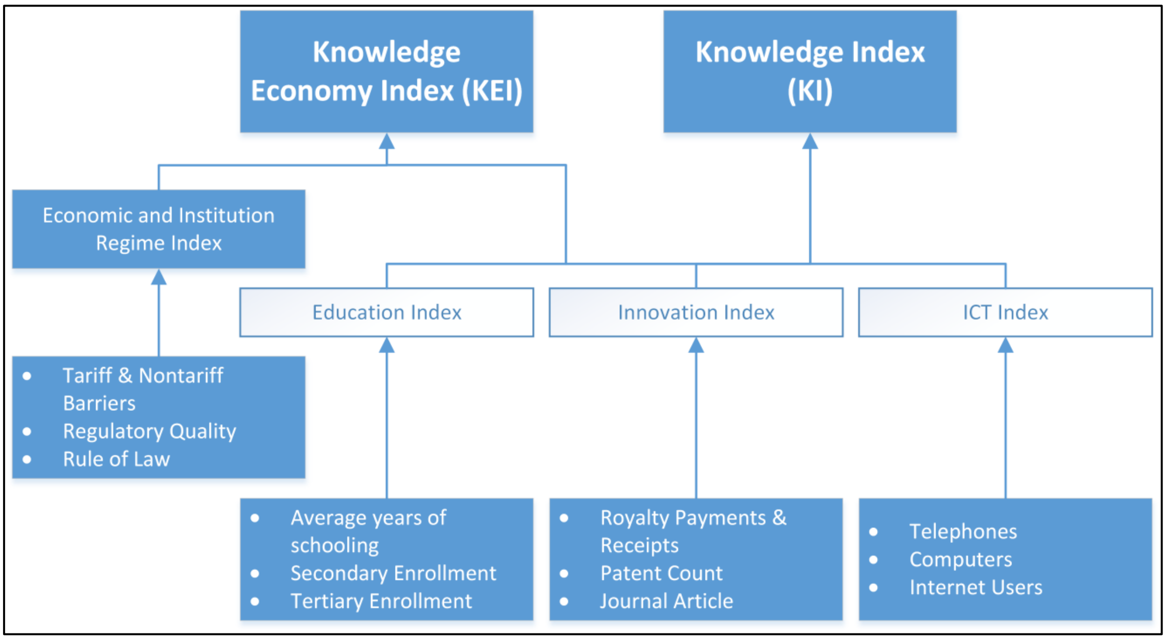

Figure 2 Knowledge Indexes

[20] **World Bank Group** <http://www.worldbank.org/> (accessed May 2013).
[21] **KEI** <http://go.worldbank.org/SDDP3I1T40> (accessed May 2013).

Rank	Change since 2000	Country	**KEI (0-10)**	KI (0-10)	EIR (0-10)	Innovation	Education	ICT
1	+-0	Sweden	9.43	9.38	9.58	9.74	8.92	9.49
2	+6	Finland	9.33	9.22	9.65	9.66	8.77	9.22
3	+-0	Denmark	9.16	9.00	9.63	9.49	8.63	8.88
4	-2	Netherlands	9.11	9.22	8.79	9.46	8.75	9.45
5	+2	Norway	9.11	8.99	9.47	9.01	9.43	8.53
6	+3	New Zealand	8.97	8.93	9.09	8.66	9.81	8.30
7	+3	Canada	8.92	8.72	9.52	9.32	8.61	8.23
8	*+7*	***Germany***	*8.90*	*8.83*	*9.10*	*9.11*	*8.20*	*9.17*
9	-3	Australia	8.88	8.98	8.56	8.92	9.71	8.32
10	-5	Switzerland	8.87	8.65	9.54	9.86	6.90	9.20
14	*-2*	***U.K.***	*8.76*	*8.61*	*9.20*	*9.12*	*7.27*	*9.45*
17	-4	**Austria**	8.61	8.39	9.26	8.87	7.33	8.97
21	*+2*	***Spain***	*8.35*	*8.26*	*8.63*	*8.23*	*8.82*	*7.73*
24	*-3*	***France***	*8.21*	*8.36*	*7.76*	*8.66*	*8.26*	*8.16*
30	*-3*	***Italy***	*7.89*	*7.94*	*7.76*	*8.01*	*7.58*	*8.21*
34	-4	**Portugal**	7.61	7.34	8.42	7.62	6.99	7.41

Table 1 Extract of KAM 2012[22]

2.1.5. Lisbon Strategy & Europe 2020

The EU already defined a strategy in the former decade to empower the European economy, especially the knowledge-based economy (KBE). In the year 2000 an agenda was initiated to formulate goals for the next ten years: “to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion”[23]. The agenda was named ‘Lisbon Strategy’ because it was set out by the European Council in Lisbon. As the European economy was confronted with huge changes in their economic system, also due to the increasing globalization and a shift to KBE, strategies had to be defined to carry out an effective reaction plan to the changed environment. The way forward and new strategic goal was concentrating on 3 main pillars:[24]

- Preparing the EU’s economic system for the shift towards KBE
- Establish and strengthen the so called ‘learning economy’ e.g. satisfy the rising demand for high-skilled labour via reforming the European social model to open up the educational system for everybody
- Macro-economic policy mix should sustain the well-growing economy and economic forecast

Evaluating the degree of achieved objects during the realization of these strategies and in the year 2010 showed a clear picture, that the EU did not achieve many of its defined goals. Many

[22] **KAM** <http://info.worldbank.org/etools/kam2/KAM_page5.asp#c32> (accessed May 2013).

[23] **Lisbon Strategy – Presidency Conclusions** <http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/00100-r1.en0.htm> (accessed May 2013).

[24] **Lisbon Strategy – A general overview** <http://www.eapn.eu/en/what-we-do/issues-we-focus-on/the-lisbon-strategy-a-general-overview> (accessed May 2013).

experts and also heads of EU member states announced that the commitment for achieving these goals was too low, which may is also due to the non-obligatory mechanism. Therefore the EU tried to learn out of its mistakes and make it better at the follow-up project for the decade 2010-2020.

Europe 2020[25] was launched as a ten-year growth strategy. It incorporates five key targets which can be mainly summarized as follows:[26]

- 75 % of the European population aged 20 to 64 should be employed
- 3 % of the EU's GDP should be invested in R&D
- The '20/20/20' climate/energy targets should be met (including an increase to 30% of emissions reduction if the conditions are right).
- The share of early school leavers should be under 10% and at least 40% of the younger generation should have a tertiary education.
- 20 million less people should be at risk of poverty.

The maxim is to create a "smart, sustainable and inclusive growth"[27]. The EU Commission proposed that the goals should be tailored to every country's specific situation by translating it into national laws. The intention behind is still that there is no legal punishment for non-compliance. It should be understood as an opportunity by each member state to carry out structural reforms, not just following Europe 2020 and its growth strategies, but also using the goal's interdependencies and synergy effects on many other economic sectors. Annual reports should record the progress and development of the realization by each member state.

2.2. Input/Output Tables

2.2.1. Introduction

Input-output tables contain information about national production and final demand compositions as well as imports and exports.[28] These tables are "[…] primarily used for macro-economic analyses such as the compilation of GDP, value added, consumption, investments, imports and exports as well as impact analysis."[29] The table symmetry is an essential mathematical characteristic (same number of rows and columns). They are pretty light-weight, compact and thus easy to use for several purposes e.g. they represent a basis for input-output researchers, which are enabled to set models on top of input-output tables or carry out structural analysis.

Input-output tables are mainly assembled out of three sub-parts, namely National Account Data, 'Supply and Use Tables' (SUT) and data concerning international trade. As there are many different ways of how a country does its national accounting, the 'System of National Accounts' (SNA) or 'European System of Accounts' (ESA) are well-known frameworks which provide many standards to accommodate such heterogeneities.[30] To harmonize SUTs as well as international trade data, these standards are of great importance too.

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[25] **Europe 2020** <http://ec.europa.eu/europe2020/index_en.htm> (accessed June 2013).
[26] **European Commission** (2010), p. 5-6.
[27] ibid., p. 2.
[28] **Timmer** (2012), p. 41.
[29] **Karlics** (2010), p. 76.
[30] **Eurostat** (2008), p. 17.

2.2.2. Transformation Process from SUTs to Input-Output Tables

One main source of data for symmetric input-output tables are the so called SUTs. Supply tables contain information about the output of goods distributed over industries.[31] The prices for these goods are rated at basic prices[32]. Moreover the supply table includes the imports of products separated by industries. A simplified supply table can be seen in Table 2.

	Industries	**Imports**	**Σ**
Products	Output of products distributed over industries	Import of products	
Σ			

Table 2 Simplified Supply Table

On the contrary use tables provide information about the use of goods and services distributed over products. In addition the type of use is also indicated e.g. intermediate consumption or final usage. Intermediate consumption is the consumption of products by other industries, which transform them to higher-class products. Final usage is separated onto households, non-profit organizations and expenditures by government. Prices within use tables are valued at purchaser prices[33], which stand for prices, that have to be paid by purchasers on the market to obtain a good. Furthermore use tables contain also information on the elements of value added, "[…] compromising the compensation of employees, other taxes less subsidies on production, consumption of fixed capital and net operating surplus […]."[34]A simplified use table can be seen in Table 3.

	Industries	**Final Uses**	**Σ**
Products	Output of products distributed over industries	Final consumption Gross capital formation Exports	
Value added			
Σ			

Table 3 Simplified Use Table

[31] **Karlics** (2010), p. 77.

[32] The basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale; it excludes any transport charges invoiced separately by the producer. **Eurostat** (2008), p. 551.

[33] The purchaser's price is the amount paid by the purchaser, excluding any deductible VAT or similar deductible tax, in order to take delivery of a unit of a good or service at the time and place required by the purchaser; the purchaser's price of a good includes any transport charges paid separately by the purchaser to take delivery at the required time and place. **Eurostat** (2008), p. 571.

[34] **Eurostat** (2008), p. 19.

The transformation approach from SUTs to symmetric input-output tables can be roughly summarized as follows: in the first step data from supply as well as use tables is aggregated and harmonized. All values in SUTs are valued at basic prices. Costs of transport and taxes are not included, which is very useful to separate due to the more precise differentiation of costs. Before the actual transformation of SUTs to input-output tables it is necessary to choose the desired structure of input-output tables, whether they should be of the type 'product-by-product' or 'industry-by-industry'. Two different assumption approaches arise: technological assumption and fixed sales structure assumption.[35] Again both assumptions result in two theoretical models each:[36]

Technical assumption ('product-by-product')

- Model A: 'Each product is produced in its own specific way, irrespective of the industry where it is produced.'
- Model B: 'Each industry has its own specific way of production, irrespective of its product mix.'

Fixed sales structure assumption ('industry-by-industry')

- Model C: 'Each industry has its own specific sales structure, irrespective of its product mix.'
- Model D: 'Each product has its own specific sales structure, irrespective of the industry where is produced.'

The product-by-product assumption is focused on technological connections between products and its relating sub-products it was produced of. From a statistical and analytical perspective such input-output tables are more homogeneous and the cost structure is clearer, due to its step-by-step building approach (product composition can be analysed on a very granular level). On the other hand the industry-by-industry assumption focuses on the inter-industrial relations e.g. which industry uses products from other industries for producing its own commodities. Both assumptions have advantages and disadvantages and hence it depends on the type of input-output analysis which kind of input-output table should be used. For example product-by-product structured tables are more feasible for the analysis of new emerging technologies and relating changes in productivity. Industry-by-industry structured tables are more feasible for changes in economic correlations and their impacts, as well as are more closely linked to statistical sources.[37]

On the main diagonal of a symmetric input-output table, primary activities can be determined. Primary activities represent the main line of an industry operating with other industries. Off this diagonal all secondary activities can be found.[38] See Table 4 for a simplified example.

[35] **Eurostat** (2008), p. 296.
[36] ibid., p. 297.
[37] ibid., p. 301-310.
[38] **Karlics** (2010), p. 78.

Output →

Input ↓

Industries	Industries				
	34	2	1	1	3
	1	55	4	2	3
	3	3	21	1	1
	1	1	2	41	0
	0	1	1	0	19

Table 4 Simplified Input-Output Table - Primary & Secondary Activities

Figure 3 provides an example for an 'industry-by-industry' structured input-output table.

Output →

Input ↓

industries	1	2	3	...j...	n	Final Demand	Exports	∑ Total Output
1	z_{11}	z_{12}	z_{13}	...	z_{1n}	y_1	exp_1	u_1
2	z_{21}	z_{22}	...	...	...	y_2	exp_2	u_2
3	z_{31}	...	...	...	...	...	...	...
...i...	...	...	...	z_{ij}	...	...	...	...
n	z_{n1}	...	...	...	z_{nn}	y_n	exp_n	u_n
Imports	imp_1	imp_2	...	...	imp_n	y_{imp}		
∑ Total Intermediate Consumption	v_1	v_2	...	...	v_n			
taxes, subsidies, etc.	ta_1	ta_2	...	...	ta_n			
Value-Added	va_1	va_2	...	...	va_n			
∑ Total Output	u_1	u_2	...	...	u_n			

Figure 3 National Input-Output Table (Industry-by-Industry) [39]

2.3. Sectorial Differentiation of the Economy

2.3.1. Evolution of Economic Sectors

The differentiation of economic activity has a long history. In the ancient world, China had already some kind of classification of its people where the recognition of roles followed a hierarchy e.g. people who were responsible for agricultural activities were rated higher than people operating in the commercial sector. Besides in ancient Greece there was a comparable distinction too. Aristotle viewed the agricultural activities and people who carried out household management as honourable. On the other side activities like trade or precursors of credit institutes were seen as not very honourable, due to the involvement of usury. During the Medieval age, Europe adopted the Aristotle mind and declared the activities of trade as a sinful profession.[40]

Some centuries later Sir William Petty, a British economist, inferred in the year 1691 that "There is much more to be gained by Manufacture that Husbandry; and by Merchandise than Manufacture…".[41] Later in 1756 Francois Quesnay indicated in his famous 'Tableux Economique'

[39] **Timmer** (2012), p. 63.

[40] **Kenessey** (2009), p. 360-361.

[41] **Clark** (1951), p. 395.

(see appendix 11.1) that the net output of society is mainly created by the productive class e.g. agriculture, mining, fishing, etc., whereas the proprietary class and workers should serve for public purposes.[42]

In the contemporary history two directions of current dominated the perception of economists. On the one side there were the classical economists like Adam Smith or Karl Marx who "[…] accepted the doctrine of 'material production' which distinguished productive and non-productive activities on the basis of their proximity (direct involvement) in the creation of physically tangible output."[43] On the other side there was the historical school in Germany with e.g. Adam Müller or Friedrich List, who represented a counterpart to the classical economics. The principle was to combine social activities of man with economic theories and not to treat every part isolated. With this approach the historical school in Germany laid the foundation for the upcoming social theory of economics.[44] Friedrich List for example "considered education, administration and communication to be historically important productive forces"[45]. These two economic streams can be seen hence as the first predecessors for tripartite differentiation of economic activity.

In the early and mid 20th century three economists contributed mainly to the nowadays known three-sector-model of the economy, namely Fisher, Clark and Fourastié. Allan G. Fisher came from an earlier period (1920-1930), where economies had to struggle with high unemployment rates. In this time there were only two economic sectors known – the primary and secondary one. The primary sector was producing vital goods which are necessary for living and further economic activities whereas the secondary sector included goods which are not vital.[46] As economy was getting better and the standard of living rose, Fisher recognized the evolvement of a new demand structure. In former times solely people of a higher income class could afford such goods (already some pioneers of services), but with the rise of standards of living, lower classes were from now on empowered to afford such goods too.

In the early 1950s Colin Clark manifested the distinction of sectors as well as the passing through with the famous work 'The Conditions of Economic Progress'. Clark indicated in his publication that "[…] the term tertiary industries was originated by Professor A.G.B. Fisher in New Zealand, and became widely known through the publication of his book, The Clash of Progress and Security, in 1935. […] The phrase 'tertiary industries' therefore immediately carries […] a suggestion of those excluded by the official definition of 'secondary industries'."[47] Thus Clark's revised definition of the tertiary sector can be treated as a residual category. Clark also conceptualized the development of economic progress – see Figure 4. Jean Fourastié's theory of economic classification was mainly based on the issue of productivity. He indicated that in the first two economic sectors productivity is an important measurement and the level as well as the growth potential of productivity is high.[48] Industries belonging to the tertiary sector have none of these characteristics as they are mainly labour and capital intensive and thus the expected level of productivity is lower.

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[42] **Kenessey** (2009), p. 360.
[43] ibid., p. 361.
[44] **The Historical School** <http://www.encyclopedia.com/doc/1G2-3045000336.html#I> (accessed August 2013).
[45] **Suranyi-Unger** (1968), p. 455.
[46] **Karlics** (2010), p. 69.
[47] **Clark** (1951), p. 395-396.
[48] **Karlics** (2010), p. 70.

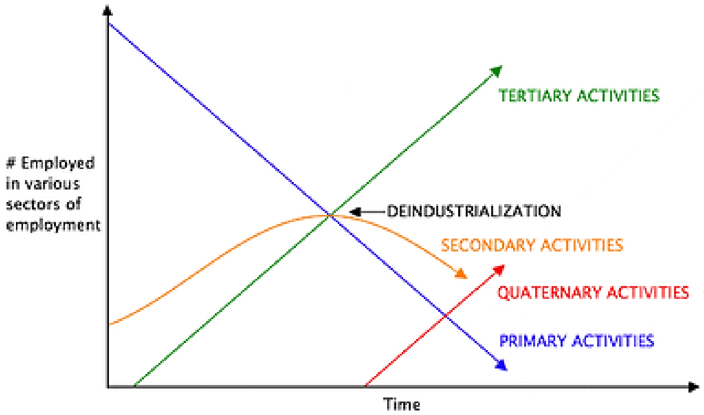

Figure 4 Clark's Sector Model (1950)[49]

Around 1980 Homa Katouzian substantiated with his work 'Ideology and Method in Economics' the preliminary work of the historical school in Germany. He proposed that "List's descriptive scheme of Agricultural, Agricultural-and-Manufacturing and Agricultural-Manufacturing-and-Commercial stages of economic development can be now explained in terms of the Primary, Secondary, Tertiary stages associated with the names of Allan G. Fisher, Colin Clark and Simon Kuznets."[50]

Kuznets is one of the most famous researches from the last century, who focused mainly on economic growth theories and the development of a country's economic structure. With his study "Toward a Theory of Economic Growth" he put all his findings together e.g. structural change from agriculture to higher sectors or long-term changes in the U.S. production sector and overseas.[51]

The continuous rise over decades of the tertiary sector initiated a self-division and resulted in the evolution of a quaternary sector. Nowadays there exist national and international standards, how industries can be grouped together and how they can be classified in terms of sectoral coherence. The Statistics Division of the United Nations provides a granular distinction of industries, which is called 'International Standard Industrial Classification' (ISIC)[52] – a detailed classification can be found in the appendix 11.2. American government agencies use a four-digit classification system - The 'Standard Industrial Classification' (SIC), specifies the following distinction of economic sectors:

[49] **Clark's Sector Model** <http://theneedleblog.wordpress.com/2012/07/10/peak-employment/> (accessed August 2013).

[50] **Katouzian** (1980), p. 37.

[51] **Kuznets** (1968), p. 25.

[52] **ISIC Rev.2** <http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=8&Lg=1> (accessed August 2013).

Name	SIC Group[53]
Primary Sector	
Agriculture, Forestry and Fishing	01, 02, 07,08, 09
Mining	10, 11, 12, 13, 14
Secondary Sector	
Construction	15, 16, 17
Manufacturing	20-39
Tertiary Sector	
Transportation, Electric, Gas and Sanitary Services	40-49
Wholesale Trade	50, 51
Retail Trade	52-59
Quaternary Sector	
Finance, Insurance, Real Estate Services	60-67, 70, 72, 73, 75, 76, 78-89
Public Administration	91-97

Table 5 Economic Sectors - SIC Group[54]

The evolution of the quaternary sector can be also traced back to the fact that more and more companies start operating in IT-related fields and financial as well as intellectual activities. The classification of these companies is changing over time slowly because when the main line of its business is shifting to new areas, the classification of such companies will be shifted from tertiary to quaternary too. Moreover the subdivision of the tertiary sector is also caused by the different growth rates of industries within this sector. More and more rising 'quaternary companies' show a higher degree of innovation, productivity growth and are more capital intense too.[55] Quaternary activities e.g. include transport, commerce, communication, finance and administration.[56] The quaternary sector represents the information sector.

In recent years there the quinary sector was being considered as a new economic sector. It includes e.g. medical care, government education, research, non-profit, culture, etc. In some countries like Australia, the quinary sector classifies activities carried out by homemakers and parents who stay at home to educate their kids or care for their parents. This is currently not calculated in monetary units, but it is a first essential step to reveal that these people contribute to the national economy too. The definition and usage of the fifth sector has to be considered carefully because there is no official and consistent definition of it.

2.3.2. The Shift to Services

The shift to the service sector and hence to tertiary activities has started in the U.K. in the early 20th century. After the industrialization-phase had its zenith a shift from (manufacturing) goods to services was coming up little by little. The U.S. were early adopters of this structural change and thus they are nowadays almost the leading nation regarding the employment rate in the service sector. Today most of the higher developed countries (≈ most of the OECD member

[53] **SIC Manual** <https://www.osha.gov/pls/imis/sic_manual.html> (accessed August 2013).
[54] **Kenessey** (2009), p. 363.
[55] **Kutscher** (1983), p. 21-24.
[56] **Foote** (1953), p. 366.

states) have a predominant share of employment in the service sector. Table 6 gives an exemplary overview.

#	Country	2000 (in %)	2012 (in %)
1	Netherlands	76.71	86.58
2	U.S.	75.19	81.19
3	U.K.	73.28	79.65
4	France	74.18	79.71 (2011)
14	Spain	62.18	74.80
18	Germany	63.69	70.09
22	Austria	63.58	68.63 (2011)
23	Italy	62.22	68.14
25	Portugal	52.51	63.63

Table 6 Civilian Employment in Services as % of Civ. Emp.[57]

There are three main theories how this structural shift in economy can be substantiated. The first hypothesis is formulated by the classical economist Colin Clark. In his famous work "The Conditions of Economic Progress" he emanates from the 'hypothesis of needs'[58], which proves the hierarchy of needs. The assumption is that services have a higher level of need satisfaction than (manufactured) goods. This implies when income rises, people will spend more and more money on services than goods. A final conclusion out of this is an increase in service demand and therefore an increase of employment in the service sector.[59]

The second theory was mainly formulated by William Baumol, an American economist, and Victor Fuchs, an American health economist. They were not much satisfied with the hypothesis of Clark and therefore formulated some kind of contra-theory. Clark's theory is mainly constituted of demand effects, whereas Baumol and Fuchs proceed from supply effects. Their theory signifies the different levels of productivity. The level of productivity as well as the growth potential in the service sector is lower than in the manufacturing sector.[60] This lower productivity implies a required increase of employment in services. Furthermore an increase of wages in general will cause an increase of employment in the tertiary sector because in high-income countries there are generally more people working in services than in manufacturing.[61]

The third theory is based on inter-industrial relations and consequent labour shifts. More and more manufacturing companies are starting to outsource their services to specialized companies, which are operating mainly in the services business. If there is a new classification round of all companies e.g. made by National Income and Product Accounts (NIPA), numbers have changed slightly because in previous rounds when 'service employees' were working in manufacturing companies, they were classified under manufacturing. But when they have been outsourced to specialized service companies, these employees will now be classified under

[57] **OECD ALFS** <http://stats.oecd.org/Index.aspx?DataSetCode=ALFS_SUMTAB> (accessed August 2013).
[58] **Clark** (1951), p. 374.
[59] **Schettkat** (2003), p. 3.
[60] **Baumol** (1967), p. 417.
[61] **Schettkat** (2003), p. 37.

service, although they had always been there just with a different declaration. Hence it can be seen as some kind of reallocation of employees.[62]

2.4. Macro-Economic Effects of New Information Technologies

Already in the late 90s a research was carried out regarding the macro-economic modelling of the information sector.[63] A big effort was to set up a clear distinction with the trade-off not using a too general scope of information-related industries whereas a too specific and granular definition could neglect essential industries. Therefore it was tried to strike a balance between including all important industries with respect to a certain threshold of granularity.
For measuring middle- and long-term economic impacts like the European integration process or the effects of new information technologies, the Austrian model 'AUSTRIA 3'[64] was constructed. The model is evolutionary and modular-based due to the dynamic context, learning process and time structure of the decision makers. On the one hand it tries to cover the sectoral linkage level of industries but on the other hand there is also the focus on a manageable amount of equations as well as endogenous and exogenous variables to avoid unnecessary complexity. Thus a simulation run of the model is subjected to endogenous and exogenous dynamics. Endogenous dynamics are e.g. fiscal policy of the government or processes on the labour market. What would a simulation be without different outcome scenarios? It is an essential exogenous dynamic of a model which provides lots of information for decision makers.
Once AUSTRIA 3 was used for introducing the economic effects of new information technologies and used therefore four different explanation scenarios. The first one is called 'demand policy' which describes the influence of demand for information goods or services. The second one, 'supply policy', explicates the interventions of wage increases within the information sector. The third scenario characterizes the role of the government e.g. control of mail, telecommunication, etc. If the government is backtracking of the information sector and let take over control by private companies, national and international linkages within this sector can be strengthened as well as private profits can increase too – this policy is called 'regulation policy'. The last policy, namely 'education policy', treats changes in the school and university sector. One powerful impact of this policy emerges out of a rise of government and R&D spendings for the educational sector. This would cause a slowly increasing demand for information goods and services. The following bullet points summarize the main outcome of the simulation run. The time horizon of the results starts in the year 1998 and ends in 2005.[65]

Macro-economic effects:[66]

- An elusive expectation of a technological boost is the increase of unemployment due to economization of sectors. This fact is only partly true because certain jobs can be carried out more efficiently by machines or computers. On the other side there is a structural change of the employment in general. The labour force will switch to jobs within the

[62] **Schettkat** (2003), p. 4.
[63] **Hanappi** (1997), p. 1-62.
[64] ibid., p. 239.
[65] ibid., p. 238-276.
[66] ibid., p. 270-276.

information sector which results in increased global competitiveness of the labour force and sustainable growth potential.

- The previously mentioned regulation policy is the one and only, which would cause long-term improvement of budget deficit. The education policy instead would cause also positive long-term effects but elicits also financing problems which have to be compensated by finding new means of income.
- Focusing only on technological policies to decrease unemployment or foster economic growth is not the right strategy. In a middle- and long-term scope technological evolution can just increase efficiency and productivity, but not solve structural problems.
- On a macro-economic perception the rise of new information technologies can result in positive employment effects but on a long-term view the growth incentives can just last that long as the according policies are being carried out carefully, otherwise the negative effects e.g. increase of unemployment grow out of perspective.

3. Data Source Evaluation

3.1. Conceptual Introduction

Drawing conclusions on structural changes and economic impacts of several industries or sectors requires a robust and consistent data base. Attributes like time-horizon, regional scope, adherence to industry classification standards, to name just some of them, are very essential decision variables. Grand institutions like the OECD or Eurostat provide many statistical frameworks and enable researchers with myriads of possibilities to carry out their field of studies. It always depends on the type of study purpose, which data source fits best. Therefore it is necessary to be very precise and strict regarding the decision.

Generally all institutions or companies which provide comprehensive data bases, supply prospective users with detailed guides and information e.g. correct usage of the data, aggregation information, adhered international standards, dimensions, taxonomies, etc. These guides have to be considered very carefully, because mainly on basis of them decisions for the most appropriate data source are taken. Moreover it is important to keep the scope of research in mind and also try to retain the methodological approach as simple as possible for avoiding unnecessary or hardly predictable errors e.g. when combining too many sources, there is the danger of losing consistency, which ends up in an almost inexpressive aggregation of data.

The following sub-chapters provide a broad outline of considered data sources and the final decision, why exactly one single source is most appropriate for the field of research of this thesis.

3.2. Data Sources

3.2.1. OECD - STAN

The OECD provides a powerful database called STAN (Structural Analysis)[67]. This tool enables researchers to draw conclusions on structural changes in an economy or carry out analysis on industrial performances. It also includes an input-output database which is certainly of a great interest for this thesis. Input-output statistics are very essential for national accounts as well as economic analysis.[68] The underlying input-output table system provides a universal data base for carrying out statistical and economic analysis.

The STAN database provides tables for 32 OECD countries and reaches up to the year 2009. There exist many different tables which cover information about gross industry output, international trade, employment in sector, value-added, etc. The data is usually expressed in national currency at current prices. If there are constant prices given, the reference year therefore is 2000. The OECD rarely publishes input-output tables – only all 10 years they are being provided. The correct industrial classification is guaranteed by ISIC Rev. 4 (up-to-date standard). The dimensions of input-out tables vary depending on the purpose: In some cases like product-flows and inter-industrial connections, product-by-product tables are preferable. In

[67] **OECD STAN** <http://www.oecd.org/industry/ind/stanstructuralanalysisdatabase.htm> (accessed September 2013).

[68] **OECD** (1995), p. 4.

other cases like structural analysis and impact analysis, industry-by-industry structured tables are more appropriate. Figure 5 shows a visualization of the OECD input-output system.
The aggregation and construction of an input-output table consists mainly of six parts:[69]

- domestic intermediate goods flows sub-matrix of the input-output tables
- imported intermediate goods flows sub-matrix of the input-output tables
- domestically-sourced investment goods flows sub-matrix of the input-output tables
- imported investment goods flows sub-matrix of the input-output tables
- sub-matrices of final demand vectors for expenditures on both domestic and foreign products
- the sub-matrix of value-added sectors

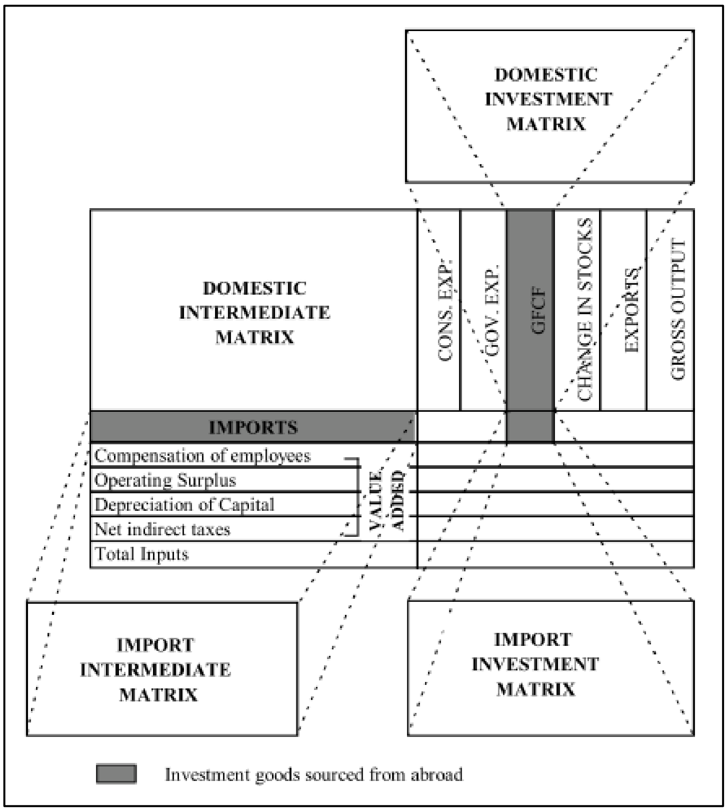

Figure 5 The OECD Input-Output System[70]

3.2.2. Eurostat – ESA 1995

Besides the OECD, Eurostat provides information on supply and use as well as input-output tables too. The European System of National and Regional Accounts (ESA), is an international compatible and comprehensive accounting framework for an efficient description of an economy (especially an EU member).[71] The ESA was first invented in the year 1995. It was designed to be fully compatible with the global System of National Accounts (SNA 1993). The input-output framework within the ESA is a similar to the OECD STAN and consists of three parts:[72] supply tables, use tables and symmetric input-output tables. The supply and use as well

[69] **OECD** (1995), p. 4-5.
[70] ibid., p. 5.
[71] **Eurostat** (2008), p. 5.
[72] ibid., p. 17.

as the input-output tables are provided for the 27 member states and also cover intra trade data. The value is given in million EUR at current prices. The current industry classification is implemented in accordance to the ESA 1995. In June 2013 a newer version was published – ESA 2010. For this thesis ESA 1995 is going to be used because the new standard is being implemented for all member states not until fall of 2014. Besides the three mentioned parts, the ESA covers also information about final usage and value-added. Eurostat provides input-output tables at regular 5-year intervals, reaching from 1995 to 2009 (the last interval is shorter). Figure 6 provides a visual example of a resulting symmetric input-output table in the ESA 1995.

Products / Products	Homogeneous units of production			Final uses			Total use
	Agricultural products	Industrial prodcts	Services	Final con-sumption	Gross capital formation	Exports	
Agricultural products Industrial products Services	Intermediate consumption by product and by homogeneous units of production			Final uses by product and by category			Total use by product
Value added	Value added by component and by homogeneous units of production						
Imports for similar products	Total imports by product						
Supply	Total supply by homogeneous units of production			Total final uses by category			

Figure 6 Symmetric Input-Output Table (Product-by-Product) ESA 1995

3.2.3. World Input-Output Database

The World Input-Output Database (WIOD) is a project funded by the European Commission. The main goal is to provide a world input-output table to empower researches with the capabilities of analysing the process of globalization as well as international trade. It covers all 27 member states of the EU and 13 other large countries for the period 1995-2009. The industry classification is standardized by ISIC Rev2. The primary content of WIOD is as follows:[73]

- Annual World Tables
  - International Supply & Use Table at current prices and previous year prices
  - 35 industries by 59 products
- Annual National Tables
  - National SUTs at current prices and previous year prices (35 industries by 59 products)
  - National Input-Output tables in current prices (35 industries by 35 industries)
- Annual Socio-Economic Accounts
  - Industry Output, value added at current and constant prices (35 industries)
  - Capital stock, investment (35 industries)
  - Wages and employment by skill type (low-, medium- and high-skilled) (35 industries)
- Annual Environment Accounts
  - Gross energy use by sector and energy commodity
  - Emissions to air by sector and pollutant
  - etc.

[73] **Timmer** (2012), p. 3.

Figure 7 provides a visualization of the construction approach of the world input-output tables. The construction of national input-output tables follows the same procedure, except the one difference of the regional dimension.

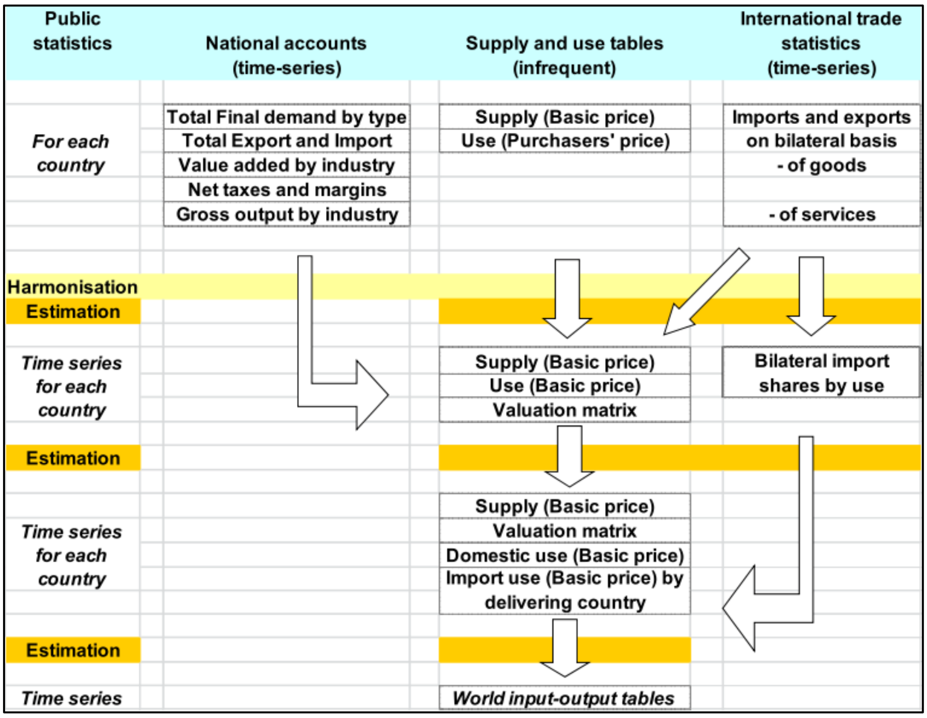

Figure 7 Dataflows and Construction Steps in WIOT[74]

3.2.4. Result of Evaluation

The OECD, Eurostat and WIOD provide rich and comprehensive data bases. The consistency within all of them is permanently assured due to the adherence of many international standards. Moreover there is no need for additional harmonization or refinement of data e.g. data transformations, change of data types, cleansing, data validation, etc. This is a huge time/cost advantage and also a cause for decreasing the error risk of data adaption. Summarizing all different attributes by each institution/project e.g. availability, frequency, accessibility etc. and breaking it down to a decision is not the only task. It is rather more important to consider the required attributes for the own field of research – in this thesis input-output analysis with respect to economic impact and structural analysis. Subsequent cross-comparing and evaluating the most appropriate data source, the WIOD project performed best due to the following ranked criteria:

1. Annual national input-output tables
2. Long time-span (1995-2009)
3. Free to public
4. Very compatible industrial classification standard (ISIC Rev. 2)

As the desired analysis time horizon reaches up to 2011, data prolongation is necessary. For this purpose data from Eurostat (nama_nace64_c) is used.[75] For more information see chapter 5.

[74] **Timmer** (2012), p. 65.

4. Definition Approaches for the Information Sector

4.1. Introduction

The first important task to be able to measure the economic impact of the information sector is the distinction of national industries which are mainly operating in an information environment or are related to it with a certain threshold. Important scientists in this field are Machlup, Porat and Jonscher. Fritz Machlup was one of the first, who analysed the production and distribution of knowledge in the U.S. in the early 60s. Marc Uri Porat introduced already two information sectors, where market vs. non-market information goods are distinguished. Charles Jonscher followed a pretty radical approach and divided the whole economy into just two sectors. Furthermore the OECD and some others introduced concepts regarding the distinction of an information sector. The several approaches are being discussed more precisely in the following sub-chapters.[76]

4.2. Approach by Machlup

In the late 50s and early 60s Fritz Machlup measured as one of the first scientists the production and distribution of knowledge in the U.S.[77] He followed a more employment-related approach, whereas many others followed a more industry related approach. This means that he analysed the employment structure of people working in knowledge-related fields instead of only classifying industries after their main field of action. Machlup therefore determined knowledge-related industries "[…] as a group of establishments – firms, institutions, organizations, and departments, or teams with them, but also, in some instances, individuals and households – that produce knowledge, information services or information goods, either for their own use or for use by others".[78] He sub-divided the defined knowledge industries into five categories:[79]

(1) Education
(2) Media of communication
(3) Information machines
(4) Information services
(5) Other information activities

Machlup mentioned that many activities regarding knowledge production are not covered by the National Accounts. Thus he carried out a sophisticated calculation of knowledge production and measured the impact and growth. The results were one of the first in the fields of measuring the impact of the information sector. In the year 1958 the information sector had a share of

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[75] **Eurostat nama_nace64_c** <http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_nace64_c&lang=en> (accessed September 2013).
[76] **Karlics** (2010), p. 81-83.
[77] ibid., p. 81.
[78] **Machlup** (1980), p. 228.
[79] **Rubin** (1986), p. 8.

approx. 28.6 % of the U.S. GNP whereas in 1980 this share increased up to approx. 34 %.[80] His work was continued by his assistants Rubin and Taylor.

4.3. Approach by Porat

Some years later in the 70s Marc Uri Porat took up again the issue of defining and measuring the information sector. He framed an information activity as follows: "[…] all resources consumed in producing, processing and distributing information goods or services."[81] The new approach of Porat consisted of the two-type distinction model of the information sectors, namely the primary and secondary information sector. The primary information sector covers "information goods and services exchanged in a market context."[82] The secondary information sector addresses "all the information services produced for internal consumption by government and non-information firms."[83] As input for the secondary information sector Porat focuses on two factors:

- number of employees in information-related industries
- "depreciation taken on information capital goods purchased by non-information industries"[84]

Besides the primary and secondary information sector he classified the economy into four additional sectors: The classification of industries after Porat is as follows: [85]

1. As already mentioned the primary information sector covers mostly information goods and services, which are exchanged on the market. This involves all industries producing information machines or selling information services
2. The secondary information sector deals with administration in general and is sub-divided into two sub-sectors:
   2.1. Public administration: informational functions of the federal, state and local governments
   2.2. Private administration: includes the portion of every non-information firm which engages in purely informational activities
4. Public productive sector: Addresses mainly the production of non-informational goods by the public e.g. highway construction, maintaining a navy
5. Private productive sector: Covers all activities which do not include information goods and services e.g. agriculture, mining and transportation sectors, most of construction and manufacturing industries
6. Household: provides all the labour resources used by the other sectors of the economy.

What is one of the most interesting parts of Porat's distinction is the quite precise classification. He indicated the following industries as part of the primary information sector:[86]

- Knowledge production and inventive industries e.g. private R&D industries
- Information distribution and communication industries e.g. education, regulated communication media, etc.

[80] ibid., p. 19.
[81] **Porat** (1977), p 2.
[82] ibid., p. 6.
[83] ibid., p. 6.
[84] ibid., p. 6.
[85] ibid., p. 15.
[86] ibid., p. 23.

- Risk management e.g. insurance/finance industries
- Search and coordination industries e.g. advertising industries
- Information processing and transmission services e.g. telecommunication infrastructure
- Information goods industries e.g. (non)-electronic consumption/investment goods
- Selected government activities e.g. postal services, state and local education
- Support facilities e.g. information structure construction and rental, etc.

Moreover he was one of the first who classified industries like medical, construction or real estate as part of the primary information sector. As they are not fully part of it, he assigned weights with a certain threshold to them e.g. “15 percent of the construction industries were allocated to the primary information sector.”[87]

Porat’s approach is also closer linked to National Accounts, which has some advantages e.g. better/easier comparable over years due to the standardized structure. He was one of the first who sub-divided the information sector. Another new approach was that he considered the ‘value-added’ as a base for calculation the GNP and not the final demand as many others.[88] All these findings and approaches provide very fundamental information regarding the distinction of an information sector and hence Porat’s concept is being used by many other researches.

4.4. Approach by Jonscher

Charles Jonscher was one of the few who followed a quite strict but simplified approach. He divided the whole economy into just two sectors:[89]

1. Information sector: “[…] activity of all individuals whose primary function is to create, to process and to handle information.”
2. Production sector: “[…] creating, processing and handling of physical goods.”

Jonscher’s distinction is based on the type of output. Thus if the output is some kind of information, this industry is being assigned to the information sector. In addition he considered input factors for a good as not that important, because information is important in every production step and hence input factors are not that expressive for the type of output. Jonscher describes that the output of the information sector is generally used for final consumption/within the same industry or within other industries.[90] The main findings regarding the evolution and the future development of the information sector can be summarized as follows:[91]

- The increase of the information sector is and will be greater that the increase of the production sector.
- The output of the information sector is mainly used by other industries and not by final demand.
- The huge and steadily increase of the production sector is resting upon the positive correlation to the information sector.

[87] **Porat** (1977), p. 23.
[88] **Rubin** (1986), p. 8.
[89] **Jonscher** (1983), p. 16.
[90] **Karlics** (2010), p. 85.
[91] ibid., p. 85.

4.5. OECD Approach

4.5.1. Primary- and Secondary Information Sector

Besides many famous economists there are also concepts and guidelines how the information sector can be distinguished, provided by several institutions – one of them is the OECD. A little similar to Porat's approach, the OECD also differentiates a primary and a secondary information sector. The primary information sector is defined that "[…] product or service must intrinsically convey information, or be directly useful in its production, processing or distribution."[92] In their definition the OECD also includes industries like education and R&D funded by the government to the primary information sector. During many investigations one specific result emerged several times e.g. the level of growth and the lag of development varies from country to country. As for instance the primary information sector established pretty early in the U.K, U.S. or Japan, many other countries started one or two decades later. This development-lag can describe the current situation of a countries status regarding its primary information sector to a certain extent. The U.S. or Japan are still able to live off its head start but as circumstances are changing rapidly within the information industry, many countries are catching up e.g. Germany.

The OECD definition of the secondary information sector includes industries that do not belong to the primary information sector. To be able to form the secondary information sector, the OECD is using the 'value-added' from the public and private sector. These information goods and services which are not sold on the regular market belong to the secondary information sector – some examples are "the cost of organizing departments and firms, maintaining and regulating markets, of developing and transmitting prices, the monitoring of performance and the making and enforcing of policy"[93]. One deeply interesting finding of the secondary information sector is that the absolute percentage increase over years but the relative percentage declined continually. This discrepancy arises from the common task of outsourcing information goods and services. Since already two decades many companies started to separate the production of information goods/services and delegate these economic activities to specialized companies in this field of action. This outsourcing-approach causes an increase of transactions on the regular market for information goods and services.[94]

4.5.2. Agreed Definition of the ICT-Sector

An essential lead of the OECD approach is also the definition of an 'information economy sector', which is comprised of two main sub-sectors – the ICT sector and the content & media sector. First we treat the ICT sector and its agreed definition of 1998. As the ICT sector is part of the information sector the definition of it is very essential to this thesis, in particular the segmentation step. In 1997 at an ad hoc meeting a big agenda was dealing with the definition of the ICT sector. Canada submitted an approach of defining this sector with all related industries. As they figured out that there are many cross-dependencies and intersections (e.g. ICT products are also produced by industries, which are not directly assigned to it), a Venn-diagram was implemented to visualize the problematic (see Figure 8).

[92] **OECD** (1981), p. 34.
[93] **Schmoranz** (1983), p. 43.
[94] **OECD** (1981), p. 39.

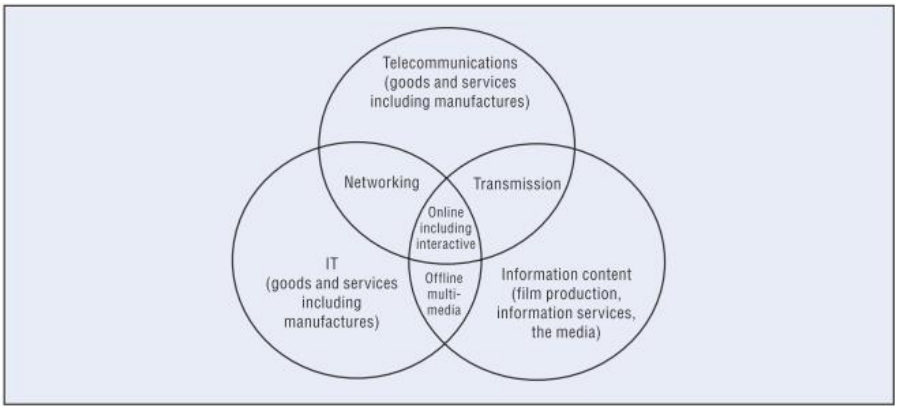

Figure 8 Overlap between IT, Telecommunications and Information Content Activities[95]

The OECD took this first definition approach, adapted it and after the meeting a first official definition of the ICT sector was born. Four years later in 2002 the OECD revised the definition again and once more in 2007. This is the most recent definition of the ICT-sector – see Figure 9.

ICT manufacturing industries
- 2610 Manufacture of electronic components and boards
- 2620 Manufacture of computers and peripheral equipment
- 2630 Manufacture of communication equipment
- 2640 Manufacture of consumer electronics
- 2680 Manufacture of magnetic and optical media

ICT trade industries
- 4651 Wholesale of computers, computer peripheral equipment and software
- 4652 Wholesale of electronic and telecommunications equipment and parts

ICT services industries
- 5820 Software publishing
- 6110 Wired telecommunications activities
- 6120 Wireless telecommunications activities
- 6130 Satellite telecommunications activities
- 6190 Other telecommunications activities
- 6201 Computer programming activities
- 6202 Computer consultancy and computer facilities management activities
- 6209 Other information technology and computer service activities
- 6311 Data processing, hosting and related activities
- 6312 Web portals
- 9511 Repair of computers and peripheral equipment
- 9512 Repair of communication equipment

Figure 9 The 2006-07 OECD ICT Sector Definition (Based on ISIC Rev. 4)[96]

4.5.3. Agreed Definition of the Content and Media Sector

By definition of the OECD the 'information economy sector' consists also of the content and media sector. Industries operating in this sector are mainly specialized in producing content (in a broader sense 'information'), but still with a substantial connection to information communication technologies.[97] Also in 1997 the OECD held a meeting regarding the extension of the ICT-sector with content producing industries. After many years and step-by-step approaches how these industries could be included without distorting the definition of the ICT sector, the

[95] **OECD** (2011), p. 152.
[96] ibid., p. 159.
[97] **Karlics** (2010), p. 89.

OECD released in the year 2007 their final definition of the content and media sector[98] - see Figure 10.

Publishing of books, periodicals and other publishing activities
- 5811 Book publishing
- 5812 Publishing of directories and mailing lists
- 5813 Publishing of newspapers, journals and periodicals
- 5819 Other publishing activities

Motion picture, video and television programme activities
- 5911 Motion picture, video and television programme production activities
- 5912 Motion picture, video and television programme post-production activities
- 5913 Motion picture, video and television programme distribution activities
- 5914 Motion picture projection activities

Sound recording and music publishing activities
- 5920 Sound recording and music publishing activities

Programming and broadcasting activities
- 6010 Radio broadcasting
- 6020 Television programming and broadcasting activities

Other information service activities
- 6391 News agency activities
- 6399 Other information service activities n.e.c.

Figure 10 The 2006-07 OECD Content and Media Sector Definition (Based on ISIC Rev. 4)[99]

4.5.4. Short Summary

The OECD is providing a distinction of the primary and secondary information sector, where there is a strict differentiation of products/services that have to convey information intrinsically.[100] Likewise the scope of distinction includes also education as well as R&D, both funded by the government, which constitutes an essential extension. The concise definition of the so called ‘information economy sector’ can be treated as some kind of precursor for the definition of the information sector in this thesis. The detailed sub-structure of it, referring to the fragmentation into an ICT sector and content and media sector is a good starting point. The standardization of the structure is assured by ISIC Rev. 3 + 4.[101] This is good for comparison issues and also to be able to project the structure on different data sources. Thus the OECD approach allocates agreed definitions for the implementation of an information sector as well as in combination with the standardization it does represent a fertile basis for the segmentation step in this thesis.

4.6. NAICS Information Sector

The United States Department of Commerce published a document where they point out a formal definition of the North American Industry Classification System (NAICS) Information Sector. This information sector mainly operates in the following domains: “producing and distributing information and cultural products […], providing the mean to transmit or distribute these products as well as data or communications […] and processing data.”[102] Thus the information sector is grouped into these three big parts, where industries are operating in. The

[98] **OECD** (2011), p. 162-164.
[99] ibid., p. 164.
[100] **OECD** (1981), p. 34.
[101] **OECD** (2011), p. 152.
[102] **U.S. Department of Commerce** (2012), p. 324.

distinction of information products from regular goods or services can be verified optimally as follows:[103]

- information products are intangible
- no need for a direct connection between the consumer and the supplier (services require a direct linkage)
- content-based value for consumer e.g. informational or cultural content of an information product - this value is mostly protected by copyrights
- production of information goods requires such rights to be authorized – linked to high costs; technology makes distribution easier e.g. TV-broadcast or the Web
- adding value to the actual product is simple e.g. broadcasters gain revenue from giving somebody the privilege to add value to the original products – externals attach advertisements to the regular TV-program

There are also some industries listed, which operate mainly in the information sector or are somehow related to it, to provide a better and practical understanding – for example:[104]

- publishing industries like newspapers
- film and sound industries
- ICT industries like broadcasters or telecom providers
- information providers/processors

4.7. Approach by Peneder

Michael Peneder, a researcher at the Austrian Institute of Economic Research (WIFO), engages in the fields of ‘quaternarisation’[105] (process of structural change in the whole economy e.g. increase of knowledge-based services, evolution of the information sector - includes industries from the II and III sector). The methodology when evaluating these changes requires very precise and consistent data. When analysing for example the industrial classifications, economic impacts of such changes or inter-industrial connections, a huge amount of data has to be processed. These data is normally spread over many standards, taxonomies, geographical/political regions or time-horizons. To ensure comparability and consistency it is very important to stick to several standards (e.g. industry classification, record settings etc.) to avoid external distorting influences or other drawbacks. Peneder indicated to avoid heterogeneity by means of simplifying the aggregation approach of the huge data set. When it comes down to the classification of industries to knowledge-based related services or the information sector, his findings can be summarized as follows:[106]

- manufacturing (ISIC3)
- distributive services (wholesale and retail trade, transport; ISIC 61, 62, 71)
- knowledge-based services (communications, financial services, real estate and business services; ISIC 72, 81, 82, 83)
- personal and social services (restaurants and hotels, community services, etc.; ISIC 9, 63)
- other sectors (agriculture, mining, construction, utilities; ISIC 1, 2, 4, 5)

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[103] **U.S. Department of Commerce** (2012), p. 324-325.
[104] ibid., p. 325-327.
[105] **Peneder** (2001), p. 1.
[106] ibid., p. 8-9.

4.8. Concluding Distinction Approach for the Information Sector

4.8.1. Overview of the Distinction Approaches

Machlup	Information sector related domains:[107] 1. Education 2. Media of communication 3. Information services/activities
Porat	Secondary information sector:[108] • Public Administration: informational functions of government • Private Administration: non-information firms, which operate purely in information-related domains More precise classification:[109] • private R&D • education/regulated communication • advertising industries • telecommunication infrastructure • insurance & finance industries • postal services, state & local education • information structure construction and rental • 15 % of construction industry • medical & real estate

Jonscher	Output focused approach:[110]
	• output of information sector generally used for
	  ○ final consumption
	  ○ within the same industry
	  ○ within other industries

OECD	ICT industries + Content media sector main basis (see Figure 9 and Figure 10) Resulting classification (ISIC Rev. 4):[111] • (26..) Manufacturing of electronic equipment e.g. computers, communication, electronic components, etc. • (46.., 58.., 61.., 62.., 63.., 95..) Software Publishing / Telecommunication / Computer Programming / Consultancy for IT / Data processors and hosts / Repair of computers • (58..) Publishing activities e.g. newspapers, books, mailings lists, etc. • (59..) Motion picture, TV programming activities, sound recording • (60..) TV & Radio broadcasters • (63..) News agencies

[107] **Rubin** (1986), p. 8.
[108] **Porat** (1977), p. 15.
[109] ibid., p. 23.
[110] **Karlics** (2010), p. 85.
[111] **OECD** (2011), p. 152.

NAICS	Content-based value: informational and cultural content is essential Information sector related industries:[112] • TV broadcasts and the Web • Film and sound industries • ICT industries e.g. telecommunication providers • information providers/processors
Peneder	Industry classifications for the quaternary sector (ISIC):[113] • (3) Manufacturing • (61, 62, 71) Wholesale, retail and transport • (72, 81, 82, 83) Communications, financial services, real estate & business services • (9, 63) Restaurant, hotels, community services • (1, 2, 4, 5) Agriculture, mining, construction, utilities

Table 7 Aggregation of Distinction Approaches

4.8.2. High-Technology Aggregation & Knowledge Intensive Activities

For the final distinction of the information sector, the following hybrid of several approaches and sources is used:

- Already introduced distinction approaches (see chapter 4.8.1)
- Eurostat classification of 'high-technology' and 'knowledge based services' based on NACE Rev. 2
- OECD high-technology industries and R&D intensity

Deliberating the previously introduced distinction approaches already leads to a fairly precise distinction of industries. Nevertheless of approaches' heterogeneity, all of them have something in common. Especially industrial sectors like 'Telecommunication', 'Publishing Activities', 'Education', 'Public Administration' or 'Financial Activities'. Some approaches like the one of Porat suggests applying weights on industrial sectors, which indicate the ratio of what amount can be classified from industry X to the information sector. This methodology appears to be very feasible and precise due to the higher granularity of the industry classification and thus a more specific definition of the information sector. The one and only hitch is the required information for such an approach. Often there is no availability for very detailed information on scope of industrial activities. Furthermore it is very hard to estimate how much involvement in information activities results in what amount of industry output. Probably such an approach is more appropriate when operating on the micro-economic level e.g. agglomerations of industries or within a national scope. As this thesis investigates the economic impact of ICT on a macro-level, it is hardly possible to get such granular data from statistical departments. Moreover gathering these data would imply immense costs. Therefore this thesis follows the approach 'completely or not at all', which means that the essential distinction factor is the main activity of business within an industry. If it is mainly operating on information-related activities and generates its major part of output with it, it will be classified to the information sector, although there are still some divisions, which will not fulfil this classification.

[112] **U.S. Department of Commerce** (2012), p. 324-325.
[113] **Peneder** (2001), p. 8-9.

Eurostat and the OECD provide precious information regarding the R&D intensity as well as knowledge intensive activities – these are also very good indicators for distinction issues. The OECD defines high-technology industries where the R&D intensity is very high (approx. 10% of production). These are industries like ‘Aircraft and spacecraft’, ‘Pharmaceuticals’, ‘Office, accounting and computing machinery’, ‘Radio, TV and communications equipment’ and ‘Medical, precision and optical instruments’.[114]

Eurostat provides also information on high-technology industries as well as knowledge intensive activities. Their classification of high-tech industries covers ‘Manufacture of basic pharmaceutical products and pharmaceutical preparations’, ‘Manufacture of computer, electronic and optical products’ and ‘Manufacture of air and spacecraft and related machinery’.[115] Not only manufacturing industries but moreover service industries represent the major part of the information sector as they perform many knowledge intensive activities. According to Eurostat’s classification, the following industries (NACE Rev. 2) are involved:[116]

- Water transport, Air transport
- Publishing activities, Motion picture, video and television programme production, sound recording, and music publishing activities, Programming and broadcasting activities, Telecommunications, Computer programming, consultancy and related activities, Information services activities
- Financial and insurance activities
- Legal and accounting activities, Activities of head offices; management consultancy activities, Architectural and engineering activities; technical testing and analysis, Scientific research and development, Advertising and market research, Other professional, scientific and technical activities, Veterinary activities
- Employment activities
- Security and investigation activities
- Public administration and defence, compulsory social security, Education, Human health and social work activities, Arts, entertainment and recreation’.

From all these classification approaches, industry categorizations and analysis on R&D intensity as well as knowledge intensive activities we finally construct the information sector. The last task is to examine the industry classifications after ISIC Rev. 2 to determine the main business activity.[117] Especially when there are aggregations of several industries, it is not simple to make a clear distinction. In such cases we follow the approach of leaving them out and only include industries, which have a more transparent and precise definition of its main business activities. Furthermore it is essential to keep the differences of industry classifications in mind (e.g. textual descriptions or industry-codes) and not to be tempted of making rash decisions. The final definition of the information sector and its industry classification, applied on the 35x35 industry structure of WIOD, can be found hereafter (see chapter 4.8.3).

[114] **OECD** (2011a), p. 5.
[115] **Eurostat** (2009), p. 1.
[116] ibid., p. 2.
[117] **OECD** (2011), p. 152.

4.8.3. Final Information Sector Classification

Table 8 covers the final industry classification of the information sector after ISIC Rev.2, which results mainly out of the overview of distinction approaches as well as the high-technology aggregation and knowledge intensive activities (chp. 4.8.1 and 4.8.2).

Code	Industry Name	#	IS
AtB	Agriculture, Hunting, Forestry and Fishing	c1	
C	Mining and Quarrying	c2	
15t16	Food, Beverages and Tobacco	c3	
17t18	Textiles and Textile Products	c4	
19	Leather, Leather and Footwear	c5	
20	Wood and Products of Wood and Cork	c6	
21t22	**Pulp, Paper, Paper , Printing and Publishing**	**c7**	**X**
23	Coke, Refined Petroleum and Nuclear Fuel	c8	
24	Chemicals and Chemical Products	c9	
25	Rubber and Plastics	c10	
26	Other Non-Metallic Mineral	c11	
27t28	Basic Metals and Fabricated Metal	c12	
29	Machinery, N.e.c	c13	
30t33	**Electrical and Optical Equipment**	**c14**	**X**
34t35	Transport Equipment	c15	
36t37	Manufacturing, N.e.c; Recycling	c16	
E	Electricity, Gas and Water Supply	c17	
F	Construction	c18	
50	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	c19	
51	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	c20	
52	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	c21	
H	Hotels and Restaurants	c22	
60	Inland Transport	c23	
61	**Water Transport**	**c24**	**X**
62	**Air Transport**	**c25**	**X**
63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	c26	
64	**Post and Telecommunications**	**c27**	**X**
J	**Financial Intermediation**	**c28**	**X**
70	Real Estate Activities	c29	
71t74	**Renting of M&Eq and Other Business Activities**	**c30**	**X**
L	**Public Admin and Defence; Compulsory Social Security**	**c31**	**X**
M	**Education**	**c32**	**X**
N	**Health and Social Work**	**c33**	**X**
O	**Other Community, Social and Personal Services**	**c34**	**X**
P	Private Households with Employed Persons	c35	

Table 8 WIOD - 35 Industry Classification (ISIC Rev. 2)

5. Data Prolongation

5.1. Introduction

5.1.1. Methodological Approach

This chapter covers the step of data prolongation. It is necessary to extend the provided time span of WIOD's input-output tables from 1995-2009 up to 2011, to retrieve a more topical data set. As the required data originates from Eurostat and differs therefore from the data of WIOD, some harmonization approaches have to be conducted e.g. mapping from NACE Rev.2 to NACE Rev. 1., currency transformation from EUR to USD or computation of the average growth rate (AGR). For automatizing purposes the self-written Matlab function 'eurostat_to_wiod()' is being introduced.

To facilitate a smooth transition from WIOD data of 2009 to 2010 and 2011, it is more feasible not utilizing the absolute values of Eurostat but rather calculating an AGR out of it and applying this on the data of WIOD. The differences in the industry structures and also exchange rate issues do not make it possible, to get precise fitting absolute values from Eurostat.

The latter part of the data prolongation step covers the conduction of the GRAS-algorithm. A short example and the methodology are provided, to give a comprehensive outline for the complex task.

The concluding part treats the emerging barriers during the prolongation step, some adaption tasks and the final resulting data base of input-output tables for the years 1995-2011. See Figure 11 for an overview of the methodological approach.

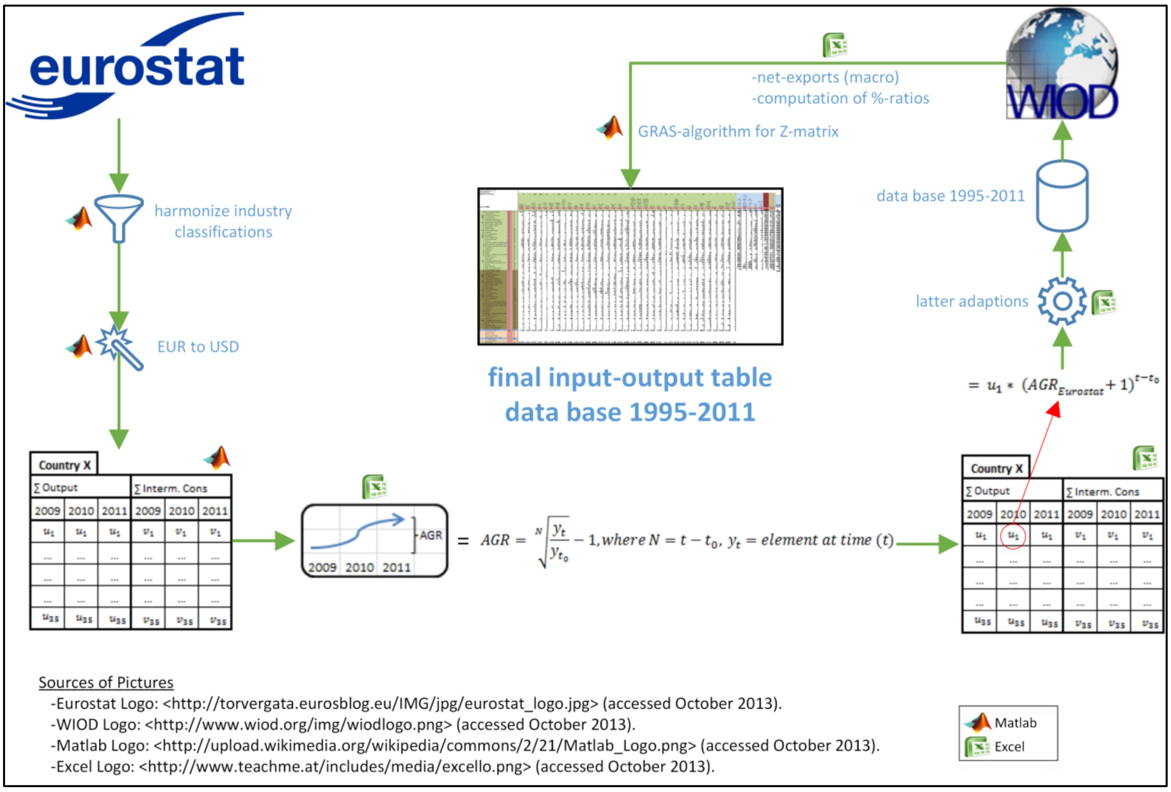

Figure 11 Data Prolongation - Methodological Approach

5.1.2. Mapping from NACE Rev. 2 to NACE Rev. 1

The extension step by the GRAS-algorithm retrieves data from Eurostat. These data from the national accounts has a different structure e.g. different sectoral aggregation, national currencies, etc. To be able conduct a prolongation of the data set provided by WIOD, several changes have to be done before. Regarding the different economic structure Table 9 provides an overview of the field mapping. The source field originates from the Eurostat tables and qualifies the NACE R2 codes (Statistical classification of economic activities in the European Community). The target field contains the abbreviation (code) for the respective industry in the input-output tables of WIOD. For example A01-A03 are mapped to c1, which means that 'Crop and animal production, hunting and related service activities', 'Forestry and logging' and 'Fishing and aquaculture' are aggregated to solely 'Agriculture, Hunting, Forestry and Fishing'. For more information on the separation approach, it is necessary to have a look at the detailed aggregation structure to be able to assign every economic sector correctly – therefore see 'Correspondence table NACE Rev. 2 – NACE Rev. 1.1' by Eurostat[118]. The following chapter will introduce the auxiliary function 'eurostat_to_wiod()', which was implemented in Matlab to automatize this aggregation approach and ease adaptations.

<table>
<tr><th>Source</th><th>Target</th></tr>
<tr><td>A01</td><td rowspan="3">c1</td></tr>
<tr><td>A02</td></tr>
<tr><td>A03</td></tr>
<tr><td>B</td><td>c2</td></tr>
<tr><td>C10-C12</td><td>c3</td></tr>
<tr><td>C13-C15</td><td>c4, c5</td></tr>
<tr><td>C16</td><td>c6</td></tr>
<tr><td>C17</td><td rowspan="3">c7</td></tr>
<tr><td>C18</td></tr>
<tr><td>J58</td></tr>
<tr><td>C19</td><td>c8</td></tr>
<tr><td>C20</td><td rowspan="2">c9</td></tr>
<tr><td>C21</td></tr>
<tr><td>C22</td><td>c10</td></tr>
<tr><td>C23</td><td>c11</td></tr>
<tr><td>C24</td><td rowspan="2">c12</td></tr>
<tr><td>C25</td></tr>
<tr><td>C26</td><td rowspan="2">c14</td></tr>
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<table>
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<tr><td>C30</td></tr>
<tr><td>C31-C32</td><td rowspan="2">c16</td></tr>
<tr><td>C33</td></tr>
<tr><td>D</td><td rowspan="3">c17</td></tr>
<tr><td>E36</td></tr>
<tr><td>E37-E39</td></tr>
<tr><td>F</td><td>c18</td></tr>
<tr><td>G45</td><td>c19</td></tr>
<tr><td>G46</td><td>c20</td></tr>
<tr><td>G47</td><td>c21</td></tr>
<tr><td>H49</td><td>c23</td></tr>
<tr><td>H50</td><td>c24</td></tr>
<tr><td>H51</td><td>c25</td></tr>
<tr><td>H52</td><td rowspan="2">c26</td></tr>
<tr><td>N79</td></tr>
<tr><td>I</td><td>c22</td></tr>
<tr><td>H53</td><td rowspan="4">c27</td></tr>
<tr><td>J59-J60</td></tr>
<tr><td>J61</td></tr>
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<tr><td>L</td><td>c29</td></tr>
<tr><td>M69-M70</td><td rowspan="8">c30</td></tr>
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<tr><td>M72</td></tr>
<tr><td>M73</td></tr>
<tr><td>M74-M75</td></tr>
<tr><td>N77</td></tr>
<tr><td>N78</td></tr>
<tr><td>N80-N82</td></tr>
<tr><td>O</td><td>c31</td></tr>
<tr><td>P</td><td>c32</td></tr>
<tr><td>Q86</td><td>c33</td></tr>
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<tr><td>R93</td></tr>
<tr><td>S94</td></tr>
<tr><td>S95</td></tr>
<tr><td>T</td><td>c35</td></tr>
</table>

Table 9 Mapping NACE R2 to ISIC R1

[118] **Correspondence Table** <http://epp.eurostat.ec.europa.eu/portal/page/portal/nace_rev2/documents/CORRESPONDENCETABLENACEREV.2NACE-REV.1.1.pdf> (accessed September 2013).

5.1.3. Auxiliary Matlab Function 'eurostat_to_wiod()'

The Matlab function 'eurostat_to_wiod()' (see Appendix 11.3) automatizes the harmonization approach of the differing industry classification structure from Eurostat and WIOD. Moreover the conversion of currency from EUR to USD is being accomplished too.
To provide a brief overview of the functional principle, the following pseudocode can be considered:

1. Definition of variables e.g. range variables, which indicate certain areas in the input Excel file, where essential information is being extracted
2. Preparation of raw structure for the output file e.g. 14 sheets for every country, names, indic_na, years, table structures, etc.
3. Iteration over all seven countries (two sheets per country – output and intermediate consumption)
   3.1. Sequential import of values from Eurostat table – for the year 2009, 2010 and 2011
   3.2. Call of the auxiliary function '[hV] = harmonize(V, year)', which changes the industry classification from NACE R2 to ISIC R1 (see Table 9)
   3.3. Conversion of currency from EUR to USD – annual exchange rates (tec00033) [119] used from Eurostat
   3.4. Writing harmonized and converted Eurostat values into prepared table

5.1.4. Computation and Usage of the Average Growth Rate

The average growth rate (AGR), also known as 'Compound Annual Growth Rate', describes the average growth rate of a certain time span in years - starting at year t_0 up to year t. In economic terms the AGR is generally used to compensate growth fluctuations and provide a comparable measurement for different assets e.g. checking growth rates of investments in real estates against investments in stocks. The following formula determines the calculation approach of the AGR:[120]

$$AGR = \sqrt[N]{\frac{y_t}{y_{t_0}}} - 1, where\ N = t - t_0,\ y_t = element\ at\ time\ (t)$$

Besides this field of application it is also possible to use the AGR for estimating anticipated values e.g. computing an expected revenue for time $t_f = t + t_n$, where t_f equals the desired point of time in the future and $t + t_n$ the base year extended with n years. The importance consists in for which time span the AGR is calculated and thus the base year for the anticipation approach is designated. The formula for calculating anticipated values is as follows:

$$x_{t_f} = x_{t_0} * \left[AGR^{(t_f - t_0)} + 1\right], where\ x_{t_0} = \ base\ year\ for\ anticipation\ approach$$

[119] **Eurostat Exchange Rates** <http://epp.eurostat.ec.europa.eu/portal/page/portal/exchange_rates/data/main_tables> (accessed October 2013).
[120] **Wissmann** (2006), p. 2.

In the optimal case, all the required data is available and thus many tasks can be automatized. But as there were some lacks of data, it was not possible to conduct this comprehensive approach (see chapter 5.2.4 for detailed information on these issues). The subsequent example should provide a brief overview of the computation approach. Therefore we want to extend the WIOD data (1995-2009) of Germany for the industry 'agriculture, hunting, forestry and fishing' from 2009 to 2011 via using harmonized data from Eurostat (2009-2011).

- ⇨ computing AGR of Eurostat data: $AGR_{Eurostat} = \sqrt[2]{\frac{y_{2011}}{y_{2009}}} - 1$
- ⇨ first extension step for 2010: $x_{2010} = x_{WIOD,2009} * \left[AGR_{Eurostat}{}^{(2010-2009)} + 1\right]$
- ⇨ second extension step for 2011: $x_{2011} = x_{WIOD,2009} * \left[AGR_{Eurostat}{}^{(2011-2009)} + 1\right]$

5.2. Data Prolongation Task

5.2.1. The GRAS-Algorithm

WIOD provides annual input-output tables for the time span 1995-2009. To be able to work on the latest data it is desirable to extend this time span. Therefore the Generalized RAS-algorithm[121] is used in this thesis to construct input-output tables for the years 2010 and 2011.[122] The acronym RAS is derived from three main parts of the algorithm:[123]

1. R – diagonal matrix of modifying rows (≙ vector u)
2. A – modified coefficient matrix
3. S – diagonal matrix of modifying columns (≙ vector v)

Depending on the domain of research, there are also synonyms for the RAS-algorithm like 'iterative proportional fitting' or 'biproportional fitting'.
The core methodology of the RAS consists in the estimation of an updated matrix A^k derived from a base matrix $A(0)$ and only two sum vectors u and v, which are calculated iteratively. Rows and columns get updated alternately, while the difference between new row/column totals and the target row/column totals is decreasing continually. At a certain threshold of minimal difference, the algorithm terminates and releases the updated matrix A^k, where k signifies the number of iterations necessary. The row/column totals of matrix A^k correspond exact or almost to initial provided target totals u and v. There are is drawback which has to be considered when applying the RAS-algorithm. The base matrix A (0) has a fixed structure of inter-industry relations. These relations will stay the same in the updated matrix A^k and only the total outputs (row/column sums) will change. This can be seen as a disadvantage as the economy and its sectors are changing over time and hence a projection implemented with RAS can only be seen as an abstracted model. As it will be a minor part in this thesis and the projection is implemented for only two years, this drawback is acceptable.

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[121] Mainly based on the work of: **Temurshoev** (2013).
[122] See also **Miller** (2009), p. 313: „To begin, assume that we have an input-output direct input coefficients table for an n-sector economy for a given year in the past (in what follows, we will designate this as year '0') and that we would like to update those coefficients for the n sector in the economy for the more recent or current year."
[123] **Miller** (2009), p. 318.

The difference between RAS and GRAS is that GRAS allows the base matrix to contain negative elements too. For simplicity and comprehensive insight issues, only the RAS-algorithm will be introduced. Further details on the GRAS-algorithm can be found in the appendix – see 11.4. To give a clear and understandable picture of the algorithm methodology, see the following pseudocode:

1. Required input factors:
   - A(0) – base matrix where the algorithm starts from e.g. year 0 (not inevitably square)
   - u(1) – vector of row marginals (also vector or row sums) for e.g. year 1
   - v(1) – vector of column marginals (also vector of column sums) for e.g. year 1
   - ε - optional tolerance threshold – mostly close to zero e.g. 0.1e-5
2. Calculation of row and column sums from A
3. Calculation of row and column adjustment matrices, where A is 3x3 matrix:[124]
   - r – row adjustments

$$r = \begin{bmatrix} u_1^1/u(1)_1 & 0 & 0 \\ 0 & u_2^1/u(1)_2 & 0 \\ 0 & 0 & u_3^1/u(1)_3 \end{bmatrix}$$

$where: u_i^k \ sum\ of\ row\ i\ at\ iteration\ k$

$A^1 = A(0) * r$

   - s- column adjustments

$$s = \begin{bmatrix} v_1^1/v(1)_1 & 0 & 0 \\ 0 & v_2^1/v(1)_2 & 0 \\ 0 & 0 & v_3^1/v(1)_3 \end{bmatrix}$$

$where: v_i^k \ sum\ of\ column\ i\ at\ iteration\ k$

$A^2 = A^1 * s$

4. Termination conditions:[125]

$|u_i(1) - u_i^k| < \varepsilon$

$|v_i(1) - v_i^k| < \varepsilon$

where: $\dim(u) = \dim(v), \forall\, i = \dim(u\ \ or\ v), k = number\ of\ iterations$

5. Output:

$$A^k, where\ k = number\ of\ iterations$$

[124] **Miller** (2009), p. 314-318.
[125] ibid., p. 322.

5.2.2. Preparations for the GRAS-algorithm

The GRAS-algorithm is being conducted for the inner 35x35 Z-matrix of an input-output table. The computed totals with AGR though include the whole values of an input-output table. Therefore it is necessary to find a way of retrieving only the row and column totals for the inner matrix. The conceived approach for solving this problem is centrically focused, which means that the outer parts of an input-output table like ‘Final Demand’, ‘Imports’, etc. are being calculated initially, which is then followed by computing the residual value for the row and column total. The calculation of the outer parts is based on the assumption of constant ratios. De facto demand or import structures do not change drastically in short periods of time. Thus the hypothesis made is appropriate for assuming that these structures stay constant for the years 2010 and 2011. Relative ratios were calculated for the final demand, gross fixed capital as well as exports. For the 35x35 import matrix it was also necessary to compute the relative ratios, which resulted in a 35x35 factor matrix. Having now all relative ratios it is possible to derive from the output as well as intermediate consumption totals, all required values for the outer part of an input-output table. The last preparation task is to compute the difference between each row/column total and the sum of the previously calculated outer parts, which results in row/column totals for the inner 35x35 Z-matrix. The following steps should summarize the conducted preparation approach – of course every step has to be repeated for each country and the years 2010 and 2011. See also Figure 12 for a visual representation.

1. Preparation of empty input-output table structure
2. Importing of computed output and intermediate consumption totals
3. Computation of relative ratios on basis of the input-output table for the year 2009
4. Deriving the outer parts of the input-output table for the year 2010/2011, by multiplying each row/column total with the previously computed relative ratios
5. Calculating the difference for each row/column total between the output total/intermediate consumption total and each corresponding row/column sum of the outer parts
6. These differences represent new row/column totals for the inner 35x35 Z-matrix - they can be now used for conducting the GRAS-algorithm

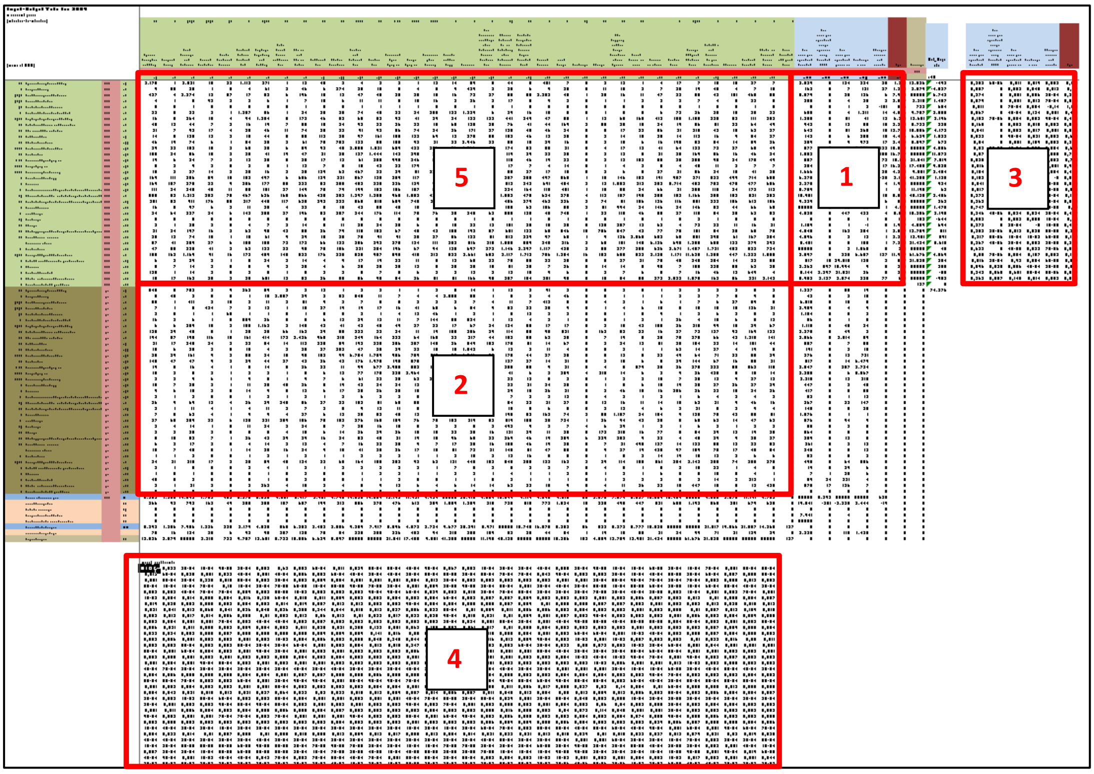


Figure 12 WIOD Input-Output Table Prolongation – A Visual Overview

1: Outer part of the input-output table - Final consumption expenditure by households, Final consumption expenditure by non-profit organisations serving households (NPISH), Final consumption expenditure by government, Gross fixed capital formation, Changes in inventories and valuables and Exports

2: Outer part of the input-output table – imports (35x35)

3: Computed relative ratios for (1)

4: Computed relative ratios for (4)

5: Computer Z-matrix (35x35)

5.2.3. Conducting the GRAS-algorithm

Having now the residual values for the row/column totals it is possible to determine the Z-matrix by conducting the GRAS-algorithm. Figure 13 and Figure 14 provide an exemplary overview how to compute the 35x35 Z-matrix for Austria and the year 2010. The input variables therefore are the inner matrix of the Austrian input-output table of the year 2010 and the previously computed residual values, which represent the new row/column totals. The precision of the GRAS-algorithm can be also calibrated with a fourth input variable. This was sometimes necessary, due to infinite small variations in the data. The value for an accepted variation was $|0.0001 < \varepsilon < 0.1|$. In the example it took 23 iterations of the algorithm to determine the 35x35 Z-matrix. The result matrix was then copied to the already prepared input-output table, where it now fills up the last missing part – the inner 35x35 matrix. This procedure has to be conducted for every country and the years 2010 and 2011. The overhead for automatizing these steps only with Matlab proved to be too effortful and thus it was decided to utilize also Microsoft Excel – with some help of self-written macros and copy-paste formulas. For more information on this topic see chapter 5.2.5.

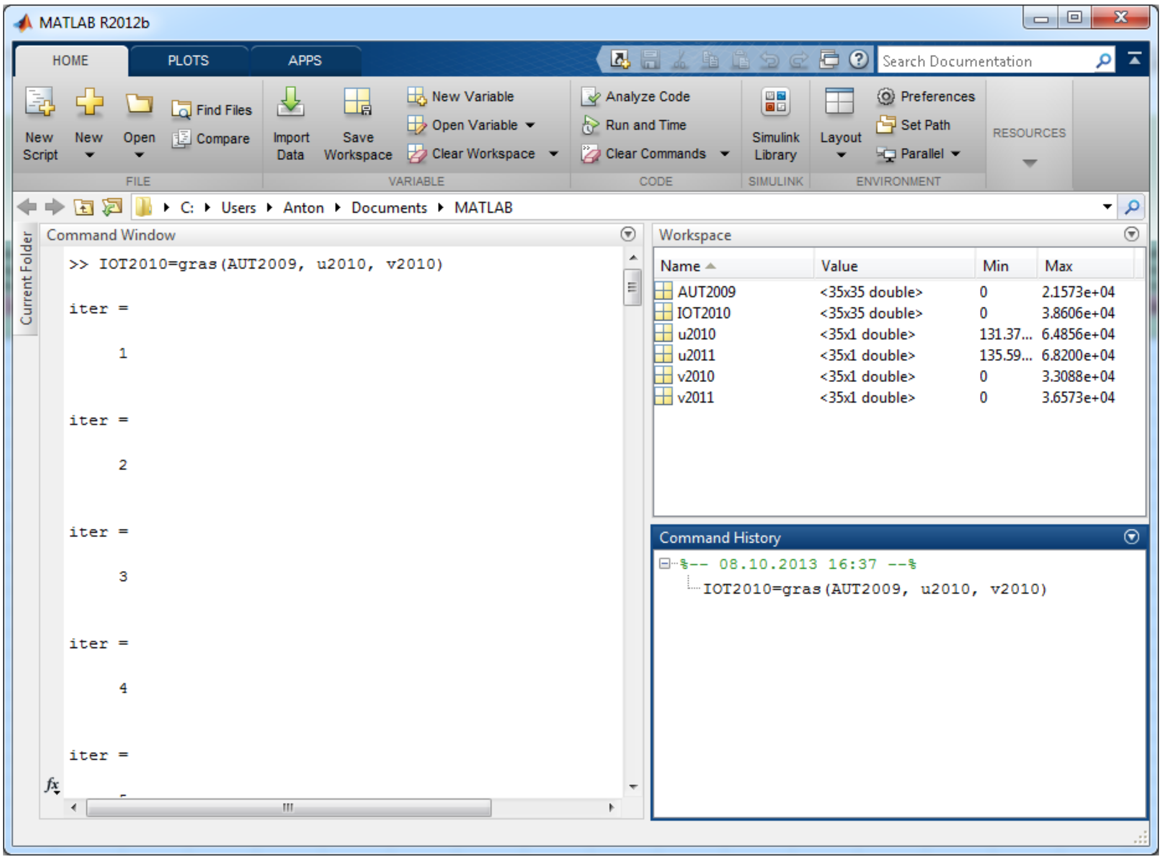


Figure 13 Matlab-Example: Computation of Input-Output Table 2010 for AUT with GRAS (1/2)

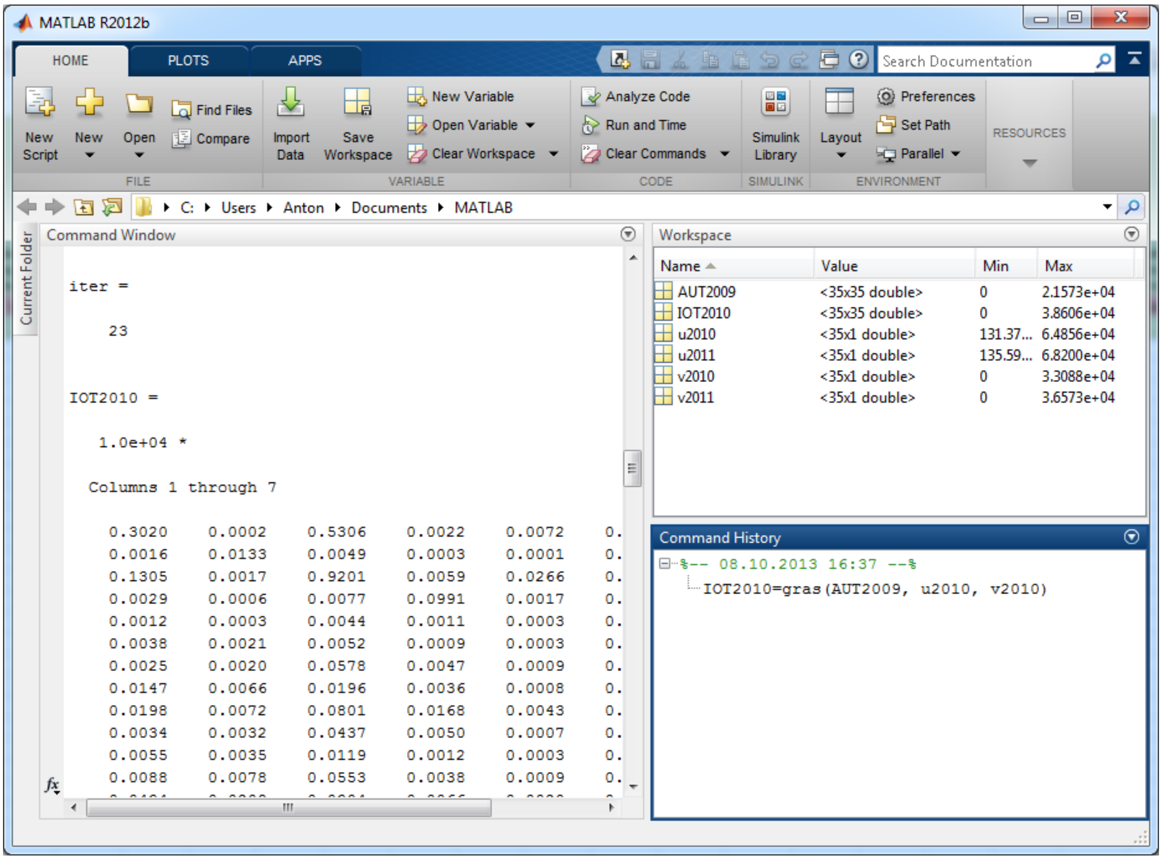


Figure 14 Matlab-Example: Computation of Input-Output Table 2010 for AUT with GRAS (2/2)

5.2.4. Emerged Barriers

In the course of data prolongation four major problems emerged:

- Unacceptable discrepancy of absolute values from Eurostat and WIOD
- Italy: Approx. 65 % missing values for the year 2011
- Spain: values for just approx. 50 % of industries for the years 2009-2011
- GRAS-algorithm row/column precisions

The first practical harmonization approaches of Eurostat data showed that however the classification of industries suits better and better to the one of WIOD, there was still a big discrepancy in the absolute values of the row and column totals (output and intermediate consumption). Also the more precise specification of the currency exchange rate did not lead to improving results. Thus the decision was taken not to use the absolute values of Eurostat but rather calculate AGRs and apply these on the last given year of WIOD (2009). Thus these AGRs are based on statistical and robust data of Eurostat and by using just the relative growth, it was possible to accomplish a smooth and stable transition from the year 2009 to 2010 and 2011.

While assembling data for the countries of investigation (AUT, ESP, FRA, GER, ITA, PRT and UK) from Eurostat, it emerged that there is not the full set of data available. The Italian data extract had a lack of almost 65 % of values (output as well as intermediate consumption) for the year 2011. To compensate this data loss it was necessary to compute the AGR from given Eurostat data, to be able to make a small forecast for missing values in the year 2011. Several different calculations showed that computing the AGR on basis of the year 2009-2010 performed best. This step was realized manually in excel, before the automatized Matlab function 'eurostat_to_wiod()' was conducted.

The provided data of Spain caused most of the troubles as almost half of values were missing – for all three years 2009-2011, as well as for the output and intermediate consumption. As it was not possible to retrieve the missing values of former years from Eurostat and extend it by means of AGR, the major part of the computation had to be done to manually. Hence the self-written Matlab function 'eurostat_to_wiod()' was performed before starting with the manual calculations in the output file. The first task was to carry out the harmonization of existent Eurostat data manually by grouping them together, according to the mapping rules (see Table 9). Afterwards the AGR was calculated for every resulting industry from the years 2009-2011. These results were pasted in the final output file, where the rest of missing values had to be finalized. As Eurostat could not provide the full required data set, the best solution in this situation was to use data from WIOD and compute the missing values by means of AGR. Therefore the row and column totals of WIOD input-output tables were put into the final output file, to be able to calculate the AGR for the years 2005-2009. Having now the AGRs calculated from Eurostat and WIOD data, it was possible to apply these growth factors on the given WIOD data of the year 2009, to be able to compute the missing values for the years 2010-2011. This approach was then conducted analogically for the intermediate consumption too.

These two big lacks of data – on the one hand Italy and moreover Spain – have to be considered, when conducting the GRAS-algorithm for computing input-output tables for the years 2010-2011. Although there are many values originating from Eurostat and WIOD, but still a bigger part is only a projection, calculated on historic data, and thus not empirically proved. This circumstance cannot be improved tremendously, but as the prolongation of input-output tables

is just for two years of the long time-span and the major part is still gathered from Eurostat and WIOD, this drawback can be accepted also with reference to the scope of this step.
When conducting the GRAS-algorithm for determining the Z-matrix of an input-output table it became apparent that the sums of each row and column do not fit accurate to the row and column totals, which were provided as input variables (u and v) before. The row totals show a variance of approx. 0.01%, which is negligible. The column totals however show a higher variance up to 1%. On the first sight this does not seem that much either but when considering that all values in the input-output tables of WIOD are given in million USD, importance can be ascribe to it. After conducting the GRAS-algorithm several times and checking its results for accuracy, the conclusion was satisfactory. The variations did not exceed the previously mentioned thresholds. The best part about all this is the very precise structure of the results, meaning that the ratios within all the industries were very similar to the one of the year before. This fact is far more important as the inter-industry relations reflect a very essential base of information for drawing latter conclusions. Referring to the inaccuracy of the column totals it can be noted that the variation of max. 1% is spread homogeneously over 35 different industries, which is then becoming tolerable too.

5.2.5. Latter Adaption Tasks

For retrieving the final version of the input-output table data base, some latter adaption tasks are necessary. One major issue is the refinement of import and export data. To be able to concentrate the scattered values into one expressive vector, a new column 'Net-Exports' is being implemented. Actually it calculates only the difference of exports minus imports for each single industry, but possessing this single value for every industry, eases many analysis and upcoming conclusion issues a lot. For this purpose a simple Excel macro was written, which basically adds a new column to every input-output table and computes the differences between exports and imports - the result is 35x1 vector of residuals. The macro code can be found in the appendix, see chapter 11.5.
With minor priority but still importance structural changes were necessary at the end. The structural issues were already treated in the preparation task of the input-output table prolongation step, but a final check with little adaptions was necessary anyway. A homogeneous structure for every year from 1995 up to 2011 is very essential because of later automation purposes e.g. construction of the technical coefficient matrices with Matlab.

5.2.6. Final Data Base - Input-Output Tables for the Years 1995-2011

The final version of the input-output table database is now accomplished and is going to be used in the following steps of this project. The key data is as follows:

- input-output tables for each country for the timespan 1995-2011
- industry-by-industry structure, with 35 respective ISIC Rev. 2 industry classifications
- imports, exports and net-exports are provided separately
- final consumptions, gross fixed capital formation and changes in inventories and valuables are provided separately
- all values in millions of USD
- total output and total intermediate consumption for the years 1995-2011
- value added for the years 1995-2009

6. Time Series Analysis of the Information Sector

6.1. Introduction

The first evaluation part is dealing with the development of the information sector over time. Therefore a time series analysis is being performed, which reveals key data on growth, progress and change of the information sector. The following attributes are the most essential ones:

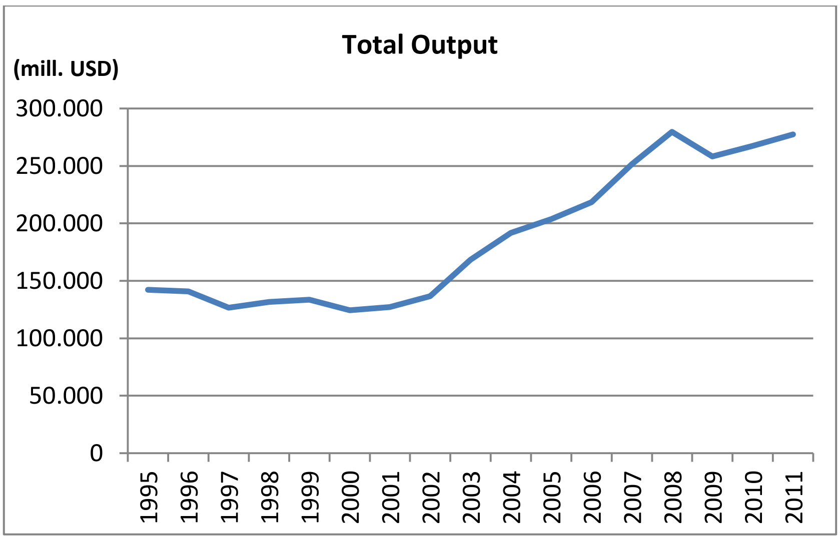
- development of total output of the information sector
- percentage share of the information sector
- analysis of final demand structures
- growth/decline of net-exports
- employment within the information sector
- high-skilled labour compensation within the information sector

To be able to perform a robust and automatable time series analysis for the 119 input-output tables, Excel macros constitute an efficient aid mechanism for the further methodology. The homogeneous structure of the input-output tables, especially of the prolonged ones for 2010 and 2011, is therefore a crucial prerequisite. The time series analysis is performed for every single country and the time-span from 1995-2011. The following chapter (6.2) covers the evaluation of results, where the approach, outcomes and a short interpretation is provided.

6.2. Evaluation in an Economic Context

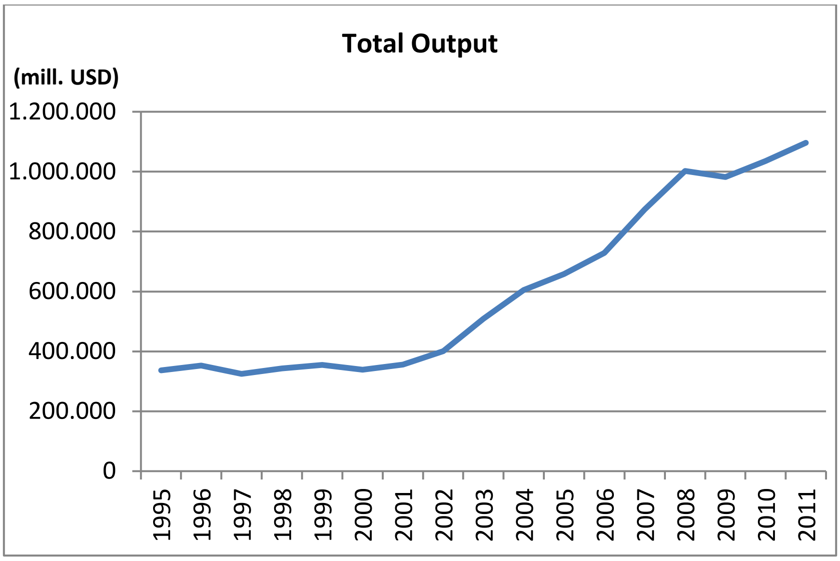
6.2.1. Development of Total Output of the Information Sector

The first and most obvious attribute when investigating the development of the information sector, is to analyse its total output. Therefore the output (in absolute values) of every information sector industry is accumulated. For extension purposes the growth rate for 1995-2011 is computed, as well as the AVG. Moreover the minimal and maximal values should provide a better overview for the interval of development. Table 10 provides the total output of the information sector for every single country. Table 11 aggregates all total outputs and gives a comparison view. Unless otherwise indicated, values are provided in millions of USD.



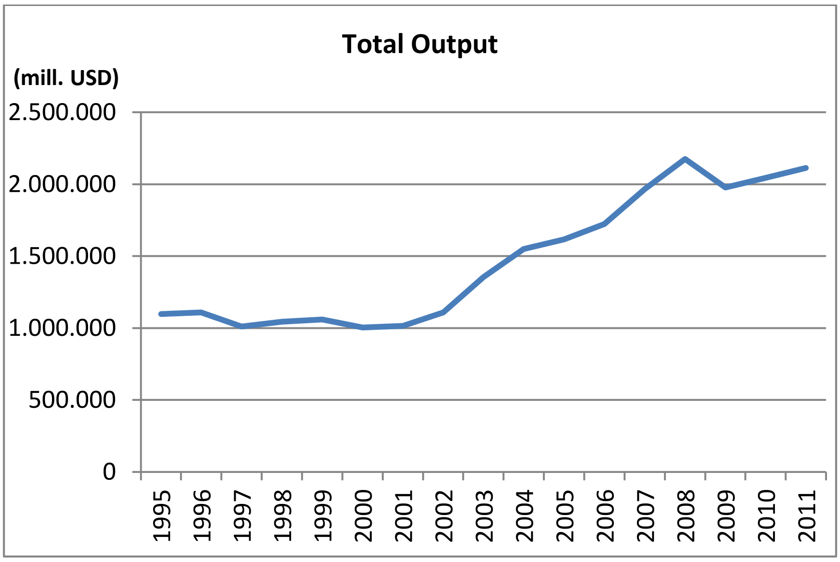
AUT

growth (%):	94.97
AVG (%):	4.26
min:	124,473
max:	279,853



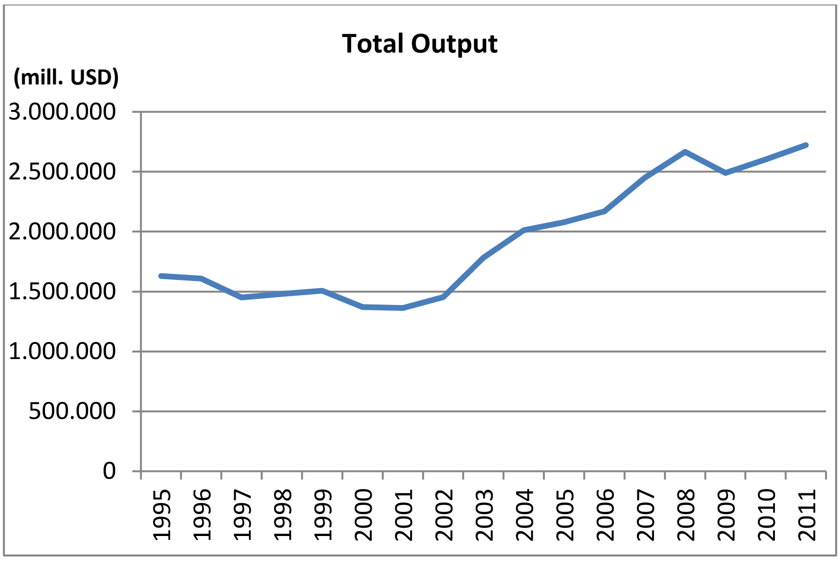
ESP

growth (%):	225.81
AVG (%):	7.66
min:	324,246
max:	1,096,215



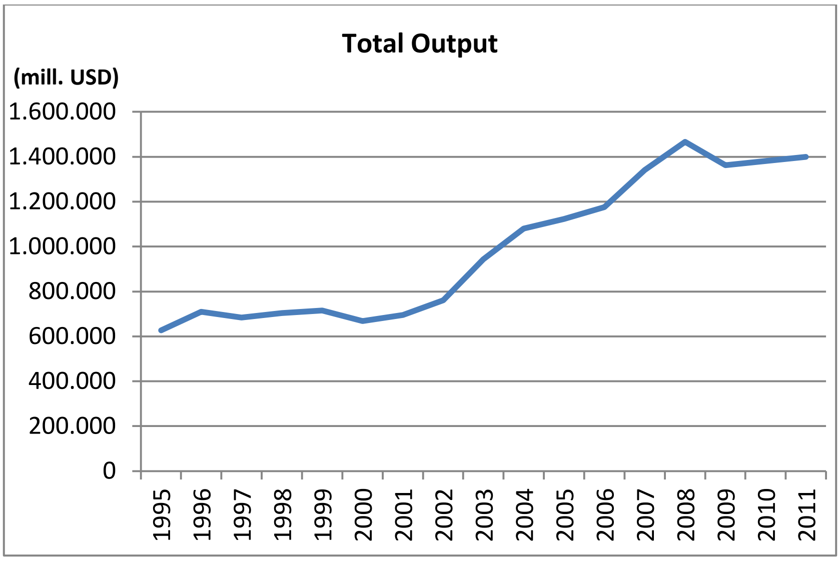
FRA

growth (%):	92.70
AVG (%):	4.18
min:	1,004,228
max:	2,175,199



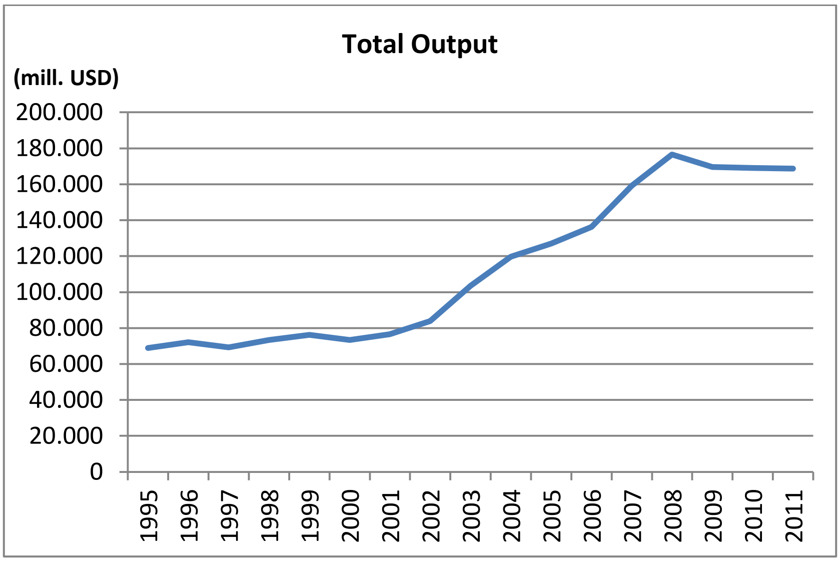
GER

growth (%):	67.21
AVG (%):	3.27
min:	1,362,297
max:	2,724,075



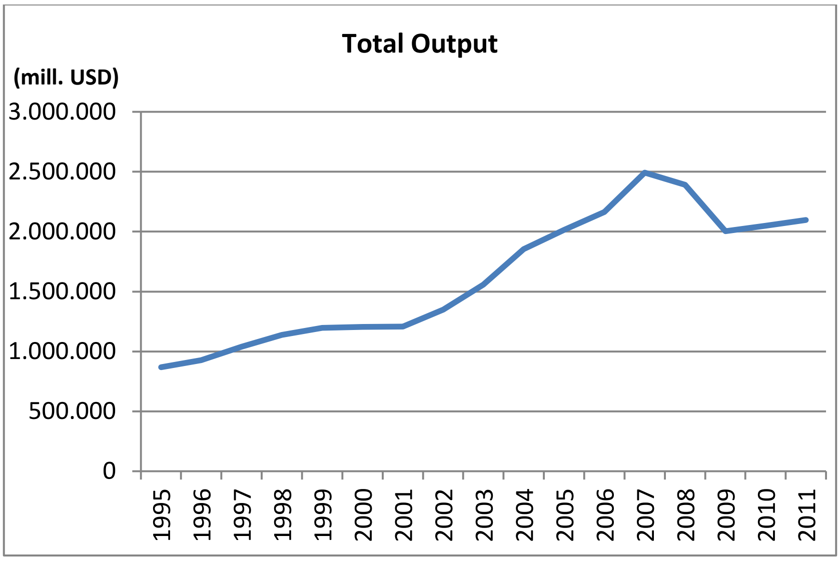
ITA

growth (%):	123.52
AVG (%):	5.16
min:	626,221
max:	1,465,945



PRT

growth (%):	144.65
AVG (%):	5.76
min:	68,930
max:	176,495



UK

growth (%):	141.67
AVG (%):	5.67
min:	868,255
max:	2,492,444

Table 10 Total Output of the Information Sector – AUT, ESP, FRA, GER, ITA, PRT, UK

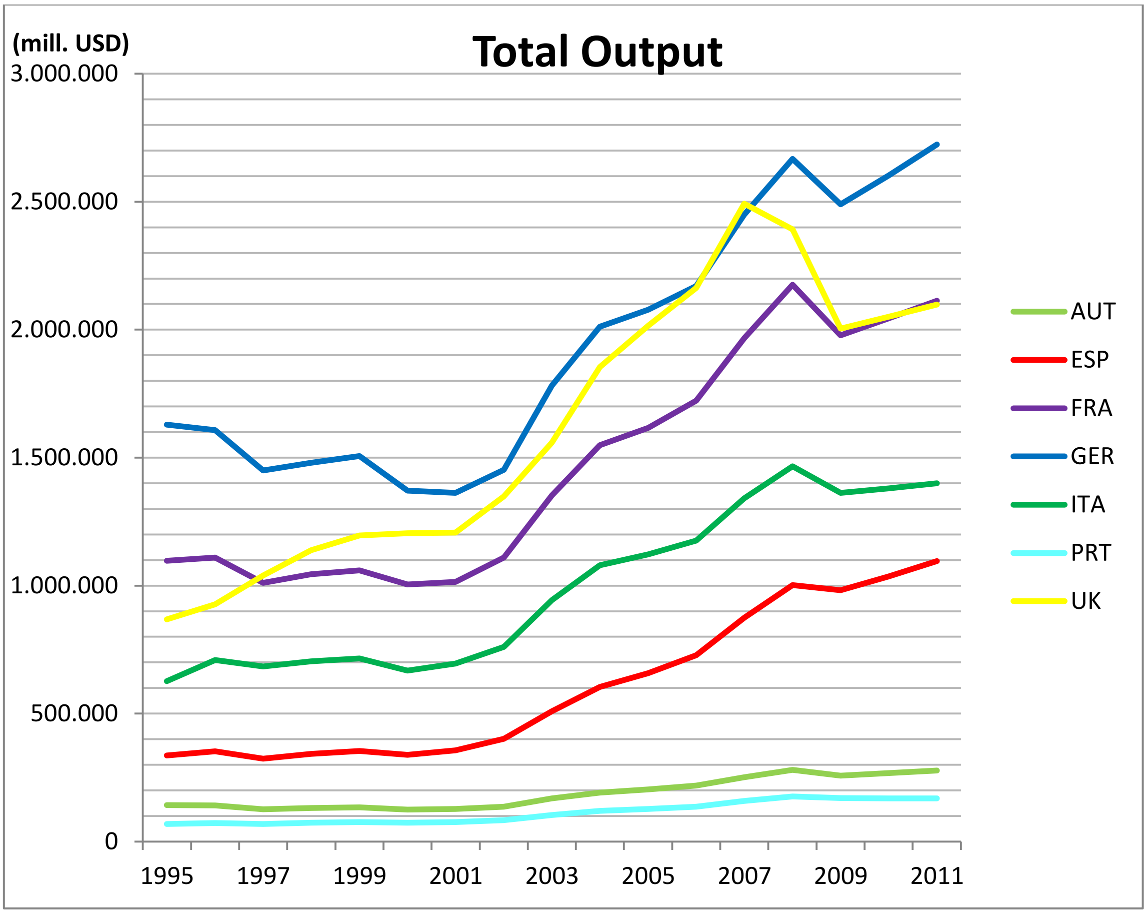


Table 11 Total Output of the Information Sector - All Countries

Table 11 illustrates a similar behaviour of the information sector's total output for each country. Almost every investigated country shows a boost of its information sector output in the early- and mid-2000s. Especially Germany and the United Kingdom can register an immense absolute growth between 2000 and 2009. The South European countries Italy, Spain and Portugal indicate also a high growth potential due to their growth rates (1995-2011) between 123-225 %.

The consequences of the financial crisis affected every country – some more and some less. The United Kingdom for instance had to register the highest absolute loss of total output. Also in the year 2010 where other countries were already able to moderate the decline, the UK still had to face the rigorous cuts in its economy. By far Germany is one of few countries, which was empowered to dive through the crisis with manageable scratches.

What is pretty interesting in Table 11 is the development of Spain's total output of its information sector. They were able to produce the highest growth rate with 225.81 %. Moreover the negative effects of the crisis did not harm its information economy as much as others. Concerning the two smallest countries of investigation, Austria and Portugal, there is a perceivable divergence of development. When decreasing the metric of the vertical axis it becomes more evident. Portugal is struggling with the post-impacts of the crisis and still not able to be on its feet. For 2011 there is a negative trend, whereas Austria and many other countries were able to gain control in 2-3 years. Portugal is suffering from its administrative inefficiencies, derelictions in educational policies and delay of structural change of its economy.

6.2.2. Percentage Share of the Information Sector

The detailed analysis of the absolute output of the information sector is essential for providing an initial and comprehensive insight. Nevertheless the relative point of view reveals different information which is of interest e.g. better comparison base between the countries as well as linkage to the rest of the industries.

In contrast to the absolute analysis, the relative approach yields very different results (see Table 12). The noticeable increase of the relative output, which every country shows, can be interpreted with the main reason of a higher resilience of information sector industries to exogenous impacts. The leap in growth around the year 2009 demonstrates this very decisive. While the rest of the industries were more exposed to the crisis, information sector industries were not primarily affected. This yields to the sudden change of relative ratios of the information sector, due to the ability of gaining ground in the economy through the crisis.

Spain shows again one of the highest advancements regarding the development of its information sector industries. France, Germany and the UK hold the highest shares of information sector output. Austria's development of its information sector appears not to be very pleasant. Although it was able to produce a very stable and sustainable growth over years, the ratio of its information sector is almost on the level of 1995, which is very negative for the outlook of advancement and expansion of its quaternary sector.

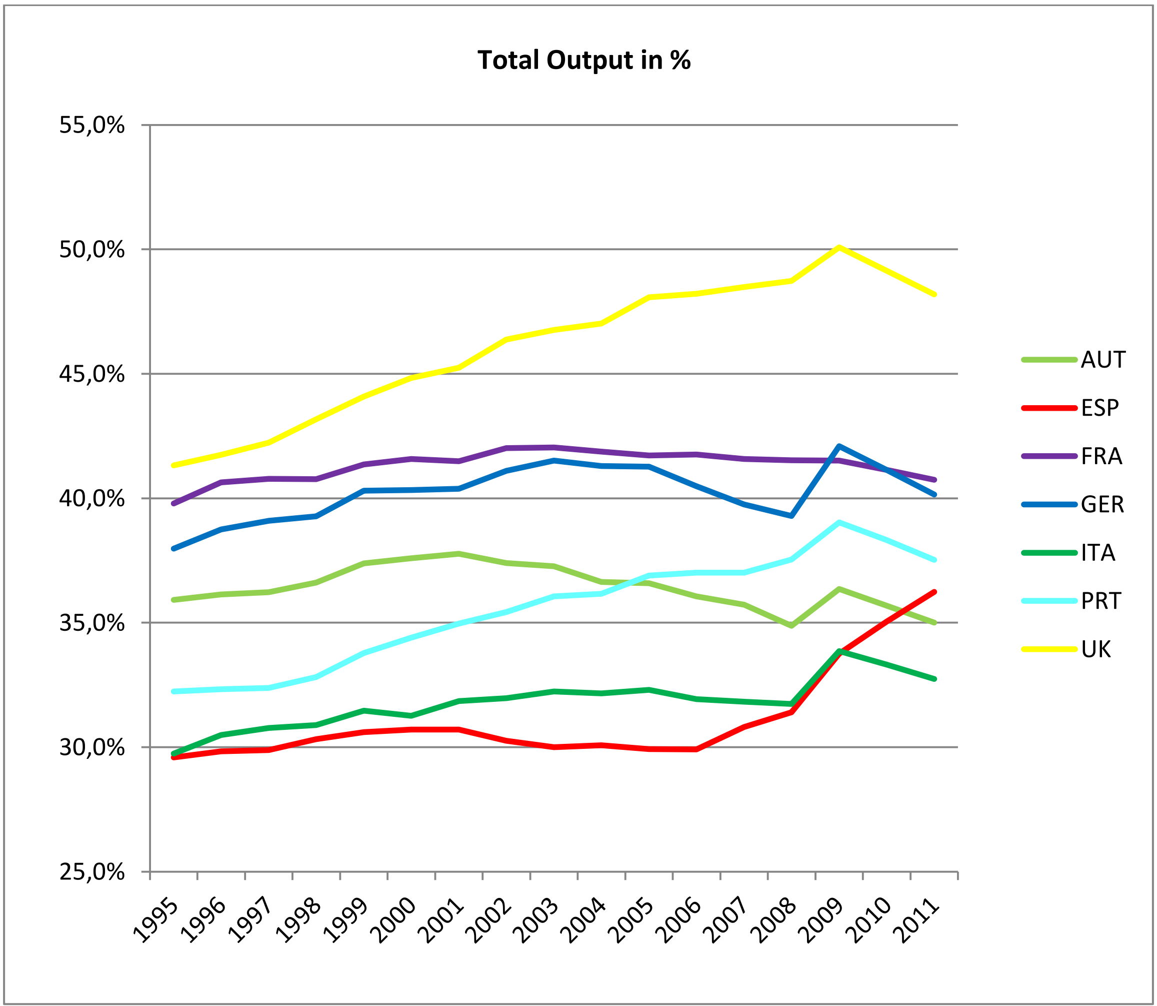


Table 12 Total Output of the IS in % of a Country's Overall Output

6.2.3. Changes in Final Demand Structures

The final demand of information sector goods and services is quite similar for each country (see Table 13). Spain shows the highest increase, followed by Portugal. The financial crisis in 2008 left quite visible marks on the final demand. Almost every country had to register heavy losses around 5 %, which did not pick up the years after. This shows how rigid the final demand structure is – not only to exogenous changes but also its intrinsic development.

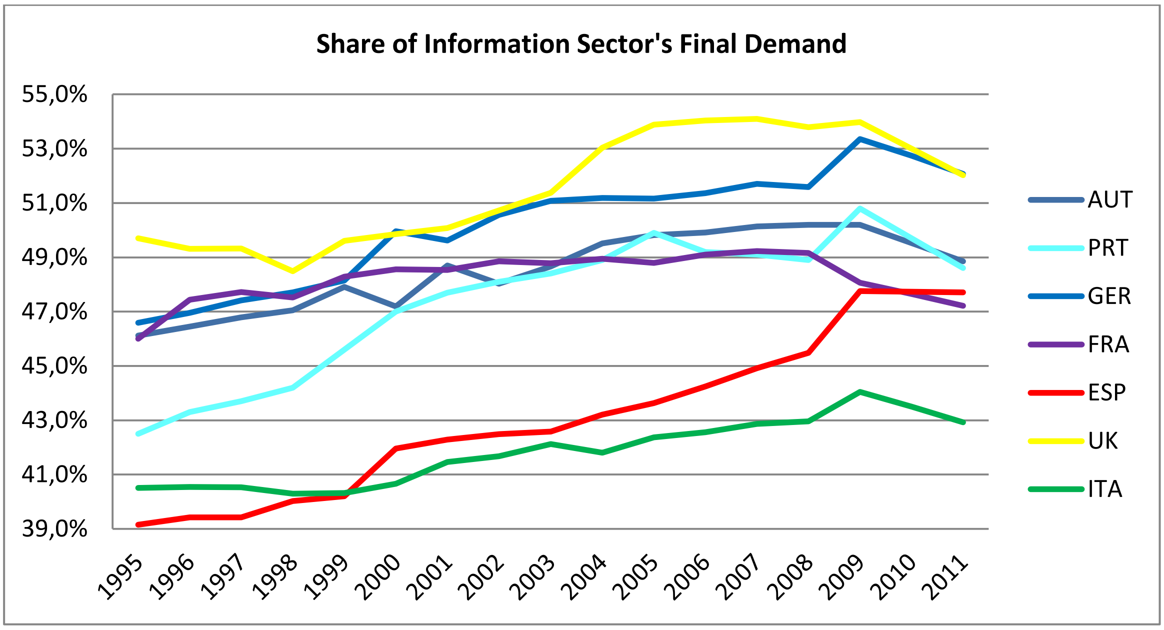


Table 13 Share of Information Sector's Final Demand

6.2.4. Progress of Net-Exports

The UK is by far leader of information sector net-exports. Austria, Germany and France have a constant share around 30 %. Portugal shows pretty remarkable figures, but the volatility is still too high, due to the instable economic structure. Italy and Spain come in last with net-exports of their information sector only around 10 % - see Table 14.

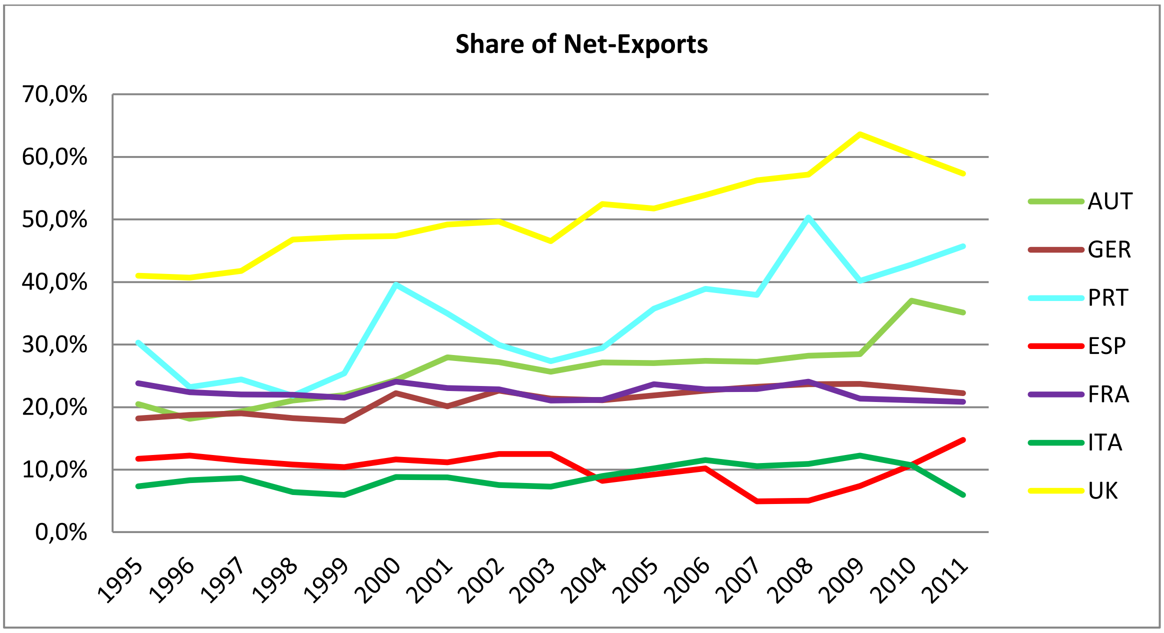


Table 14 Share of Information Sector's Net-Exports

6.3. Evaluation in a Socio-Economic Context

6.3.1. Employment within the Information Sector

Not only economic indicators as output and growth but also social aspects like employment play a central role in the time series analysis. Fortunately WIOD is providing statistical information on employment too.[126] The bid advantage compared to other sources is that the industry structure fits perfectly to the one used in the input-output tables, which saves quite a lot of effort. As with input-output tables the provided time span of socio-economic account data is again 1995-2009. To adopt the years of investigation to the current structure it becomes necessary to prolong the data for 2010 and 2011. Again this step is accomplished by computing the AGR for every country and applying it on the required attributes like employment or skills of labour. The years 2005-2009 serve as calculation base for the AGR.

For analysing the total employment within the information sector, each associated industry is being accumulated for every year between 1995 and 2011. Table 15 provides a visual overview of the absolute number of employees (in thousands) within the information sector. The development of absolute values does not show conspicuities, as every country has a very similar growth of employees within the information sector. Having a closer look at the relative values will yield again better results – therefore see Table 16. The UK, France and Germany feature the highest ratio of employment in this sector, which has already climbed above 50 %. Spain was able to increase its employment within the information sector appreciable over the last 5 years. Italy and moreover Portugal show a very low level of information sector employees. What stood already out when analysing Portugal's output of information sector, is again confirmed by the low employment there. The failures of the last decades result obviously in the low output and employment - it has to gain a lot of ground the next years to become competitive.

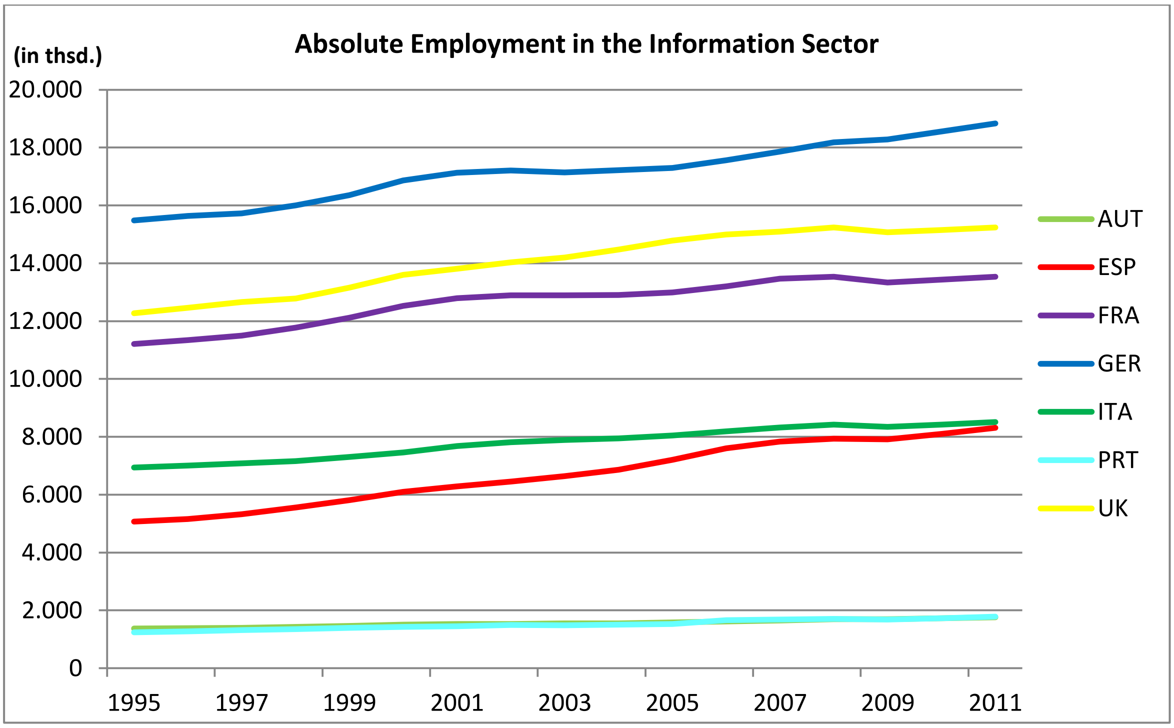


Table 15 Absolute Employment within the Information Sector

[126] **WIOD Socio-Economic Accounts** <http://www.wiod.org/database/sea.htm> (accessed October 2013).

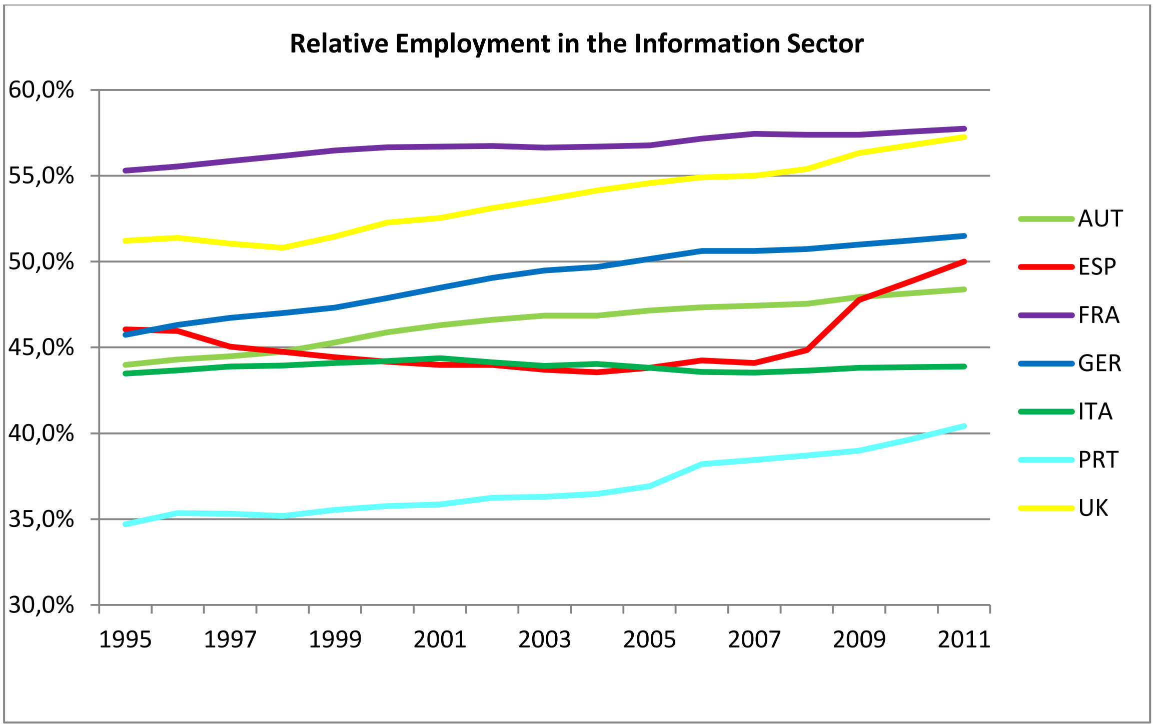
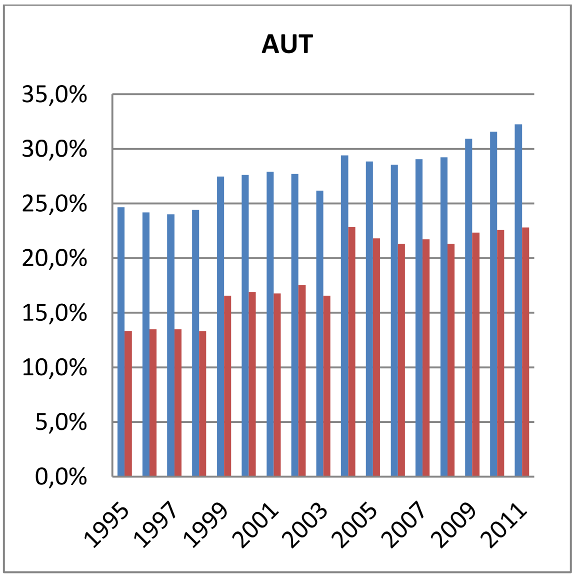
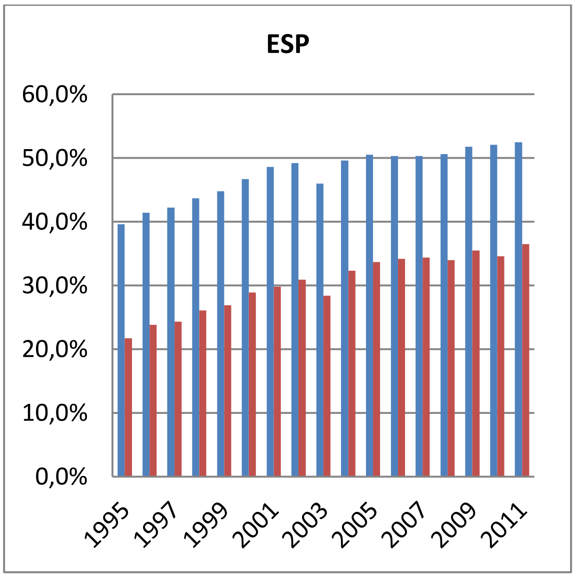


Table 16 Relative Employment within the Information Sector

6.3.2. High-Skilled Labour Compensation

By our definition of the information sector high-tech industries were also included. Thus analysing the high-skilled labour compensation inside and outside the information sector represents an interesting investigation issue. The required data is also provided by WIOD and its Socio-Economic Accounts. As with the absolute and relative employment it is also necessary for the high-skilled labour compensation, to extend the provided time span by means of AGR for 2010 and 2011. Table 17 provides a comparative overview of high-skilled labour compensation inside the information sector (blue) and outside the information sector (red). The percentage values represent the mean of high-skilled labour compensation. Table 18 visualizes the development and its differences between the investigated countries – see interpretation after the tables.





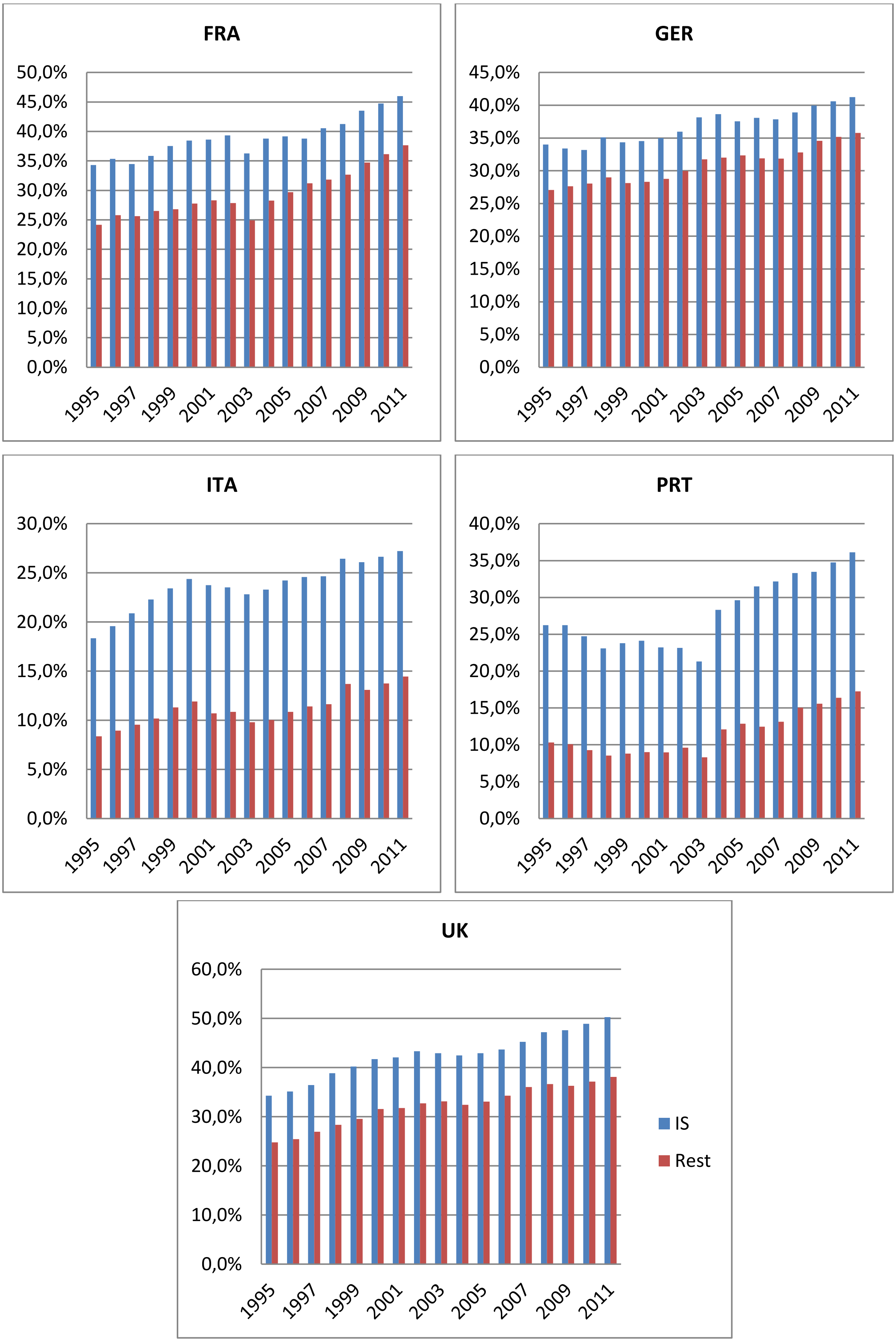


Table 17 High-Skilled Labour Compensation by Country

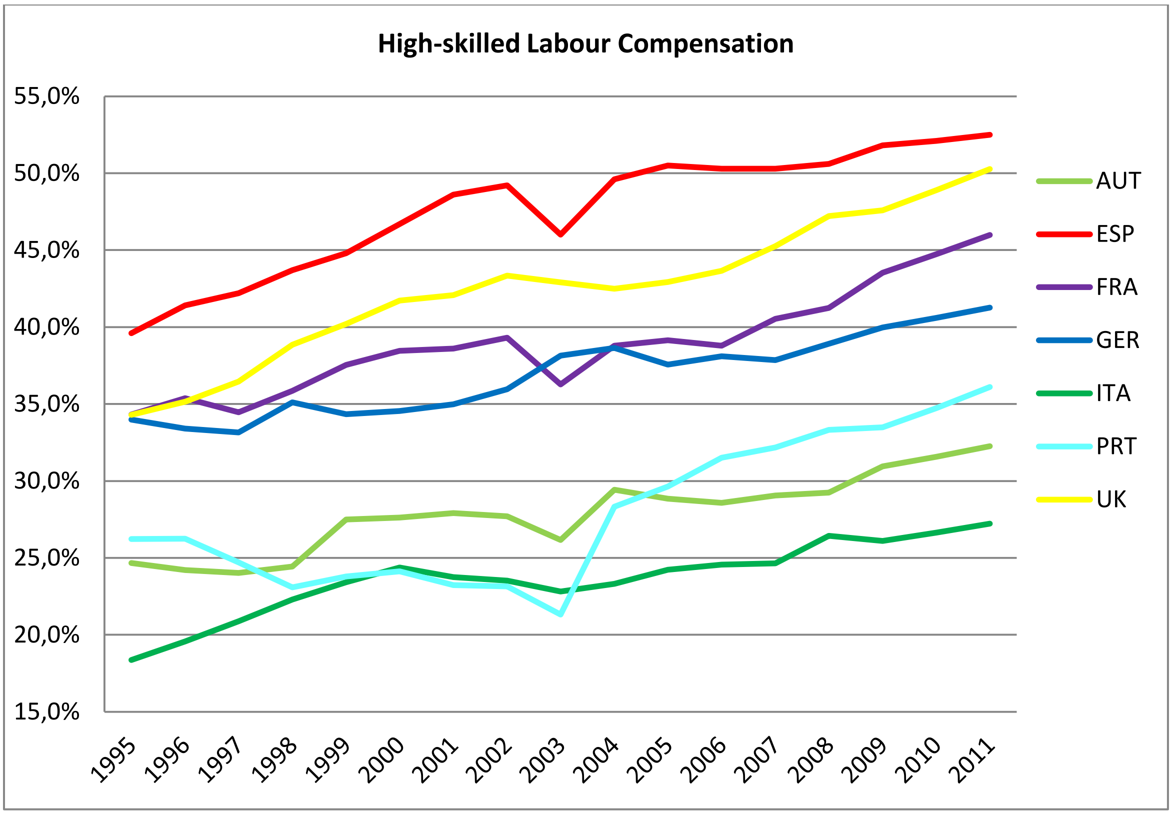


Table 18 High-Skilled Labour Compensation Comparison

One hypothesis is being confirmed: The high-skilled labour compensation inside the information sector is a lot higher than outside. Comparing the results showed that there are differences of approx. 15 to 110 %. Germany for instance has the smallest difference, which indicates a smaller gap between information sector industries and the rest of industries. The high-skilled labour is spread more homogeneously over all industries. Although some countries like Spain or France have a higher rate of high-skilled employees inside the information sector, this is not inevitable positive due to the requirement of educated employees for other industries as well. It is essential that all of the industries feature a greater degree of high-skilled employees.

Portugal, Austria and Italy belong to the taillights as they have only around one third of their employees characterised as high-skilled labour inside their information sectors. All of them should reconsider their education structures to provide the labour market with more well-educated people and thus strengthen not only the industries inside the information sector, but all of them.

Around 2002 numerous ICT-related firms have carried out extensive cost-cuts in the domain of personnel expenses.[127] This radical action condenses on the compensation of high-skilled employment, especially inside the information sector. As the share of well-educated employees and thus the wages are higher compared to other industries, countries like Spain, France, Austria or Portugal show a short-term collapse around 2002. One reason might have been that Germany and the UK do not present such dramatic behaviour due to the more homogeneous distribution of its high-skilled labour, as they have a smaller difference of approx. 15-31 % (based on the evaluation of WIOD's Socio-Economic Accounts).

[127] **OECD** 2009, p. 26.

7. Leontief-Inverse Matrices and Multiplier Effects

7.1. Introduction

Chapter 7 represents the core part of the thesis as herein the Leontief-Inverse matrices (also known as technical coefficient matrices) are being constructed. The first part gives an introduction to the theoretical background concerning technology matrices, Leontief-Inverse matrices and multiplier effects. In the next step the construction approach, mainly based on preparation tasks and the self-written Matlab function 'computeTechnCoeffMatr()' (see appendix 11.6), is being illustrated. The principal results encompass the final Leontief-Inverse matrices, whereupon sophisticated analysis methods are being conducted. For the complex tasks like the initial researching process or elaboration into the methodology, literature from three authors is mainly used: Holub (1994), Miller (2009) and Raa (2005).

7.2. Theory of Technology Matrices

The technology matrix is computed from the absolute values of the Z-matrix and contains input coefficients. The formula for these coefficients is as follows:

$$input\ coefficient\ a_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}}$$

In words each value of the Z-matrix is divided by its column total (≙ total output). The ex-post condition is $\sum_{i=1}^{n} a_{ij} \leq 1$. Why actually is a technology matrix necessary? Due to the special requirements of the Leontief production function and also the construction of the Leontief-Inverse matrix: "In short, Leontief production functions require inputs in fixed proportions where a fixed amount of each input is required to produce one unit of output."[128]
The technology matrix then is being used at the inverting step (≙ A in the following formula).

$$L = (I - A)^{-1}$$

In this thesis the technology matrices are computed automatically for every year and each country. The Matlab function 'computeTechnCoeffMatr()' processes the construction in three steps: (for detailed information see chapter 7.5)

1. import industry output as a vector
2. compute ICM_{35x35} (input coefficient matrix) with Z-matrix and the industry output totals
3. return ICM_{35x35} as input for the construction step of the Leontief-Inverse matrix

7.3. Theory of Leontief-Inverse Matrices

7.3.1. Background Information

Wassily Leontief (1906-1999), an American-Russian economist, was the first famous scientist in the fields of input-output analysis. His insights on the correlations of economic sectors and his resulting mathematical system are from significant magnitude. The key question Leontief was

[128] **Miller** (2009), p. 19.

able to answer is: For a given final demand, how much has to be produced of what, keeping also the intermediate consumption within the industries in mind?[129]

“Traditional input-output analysis (Leontief 1966) is characterized by two simplifying assumptions. First, a common classification is used for commodities and production units: The economy is classified by ‘sector’. Second, although sectors may have a variety of commodities as inputs, their outputs are not mixed. Each sector is identified with ‘the’ commodity that it produces.”[130]

The input-output analysis is based on the Leontief-Inverse matrices, as they contain technical coefficients, which describe the input requirements per unit of output.[131] These technical coefficients “[…] summarize the interdependence between the sectors of production.”[132] Thus Leontief-Inverse matrices can be seen as transducers for input requirements. Taking a closer look at the structure yields the following properties:[133]

$$L = \begin{bmatrix} l_{11} & l_{12} & \cdots & l_{1n} \\ l_{21} & l_{22} & \cdots & \vdots \\ \vdots & \cdots & \ddots & \vdots \\ l_{n1} & l_n & \cdots & l_{nn} \end{bmatrix}$$

- coefficients along columns (l_{n1}) represent the amount of money input for industry i to deliver goods in the amount of e.g. 1€ to final demand
- coefficients along the main diagonal of the matrix represent intra-industry transfers
- coefficients off the main diagonal represent the inter-industry flows

The perception on the composition of Leontief-Inverse matrices is being extended, when having a look at the so called ‘Power Series Approximation’ – therefore see chapter 7.3.4.

In application terms a Leontief-Inverse matrix is multiplied with the vector of final demands to retrieve the vector of total domestic production by product. Other than that mentioned purpose of use there exist different approaches too, which are more important for this thesis e.g. change of final demands and its impacts, adjustment of coefficients in the technology matrix under specific assumptions, impacts on employment etc.

7.3.2. Mathematical Model

The following steps provide an overview of the underlying mathematical model of Leontief-Inverse matrices:[134]

(1) Static open quantity model (final demand is exogenous) – equation system for the total output is as follows: X_{n1} output of a single industry, Y_n final demand of industry n, X_n total output of industry n

[129] **Wassily Leontief** <http://www.econlib.org/library/Enc/bios/Leontief.html> (accessed November 2013).
[130] **Raa** (2005), p. 14.
[131] **Leontief** (1966), p. 138.
[132] **Raa** (2005), p. 14.
[133] **Hartner** (2011), p. 5.
[134] **Holub** (1994), p. 92-95.

$$X_{11} + X_{12} + \cdots + X_{1n} + Y_1 = X_1$$
$$X_{21} + X_{22} + \cdots + X_{2n} + Y_2 = X_2$$
$$\dots \quad \dots \quad \dots$$
$$X_{n1} + X_{n2} + \cdots + X_{nn} + Y_n = X_n$$

sum notation:

$$\sum_{j=1}^{n} X_{ij} + Y_i = X_i \ , \forall\, i = 1, \dots, n$$

(2) Replacement of X_{ij} with the input coefficient a_{ij} multiplied with X_j:

$$a_{11} * X_1 + a_{12} * X_2 + \cdots + a_{1n} * X_n + Y_1 = X_1$$
$$a_{21} * X_1 + a_{22} * X_2 + \cdots + a_{2n} * X_n + Y_2 = X_2$$
$$\dots \quad \dots \quad \dots$$
$$a_{n1} * X_1 + a_{n2} * X_2 + \cdots + a_{nn} * X_n + Y_n = X_n$$

sum notation:

$$\sum_{j=1}^{n} (e_{ij} - a_{ij}) * X_j = Y_i \ , \forall\, i = 1, \dots, n$$

$$with\ e_{ij} = \begin{cases} 1, where\ i = j \\ 0, where\ i \neq j \end{cases}$$

(3) Transformation into matrix notation of the equation system:

$$A * x + y = x$$

$$\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} * \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{pmatrix} + \begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{pmatrix} = \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{pmatrix}$$

(4) Formulate the equation system by X yields:

$$(I - A) * x = y \ , where\ I \ \triangleq identity\ matrix_{nxn}$$

$$\begin{pmatrix} 1 - a_{11} & -a_{12} & \cdots & -a_{1n} \\ -a_{21} & 1 - a_{22} & \cdots & -a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ -a_{n1} & -a_{n2} & \cdots & 1 - a_{nn} \end{pmatrix} * \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{pmatrix} = \begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{pmatrix}$$

(5) Equation system of (4) and sum notation of (2) is solvable under the following condition:

$$x = (I - A)^{-1} * y$$

In words: The equation system is definitely solvable if the inverse matrix $(I-A)^{-1}$ or also known as 'Leontief-Inverse'[135] exists.

7.3.3. The Question of Existing Solutions

There is no doubt if the inverse matrix $(I-A)^{-1}$ exists, a mathematical solution can be found. The existence of a solution can be checked quite easily, just looking at the determinant of $(I-A) \neq 0$, but there is still the problem of economic appropriateness of the solution because the strict positivity of elements of the output vector x cannot absolutely be precluded.[136] The following example should give a better insight to the problem:[137] $(I-A) * x = y$

Random technology matrix is as follows:

$$A = \begin{pmatrix} 0.2 & 0.5 \\ 0.9 & 0.5 \end{pmatrix}$$

The Leontief-Inverse is then:

$$(I-A)^{-1} = \begin{pmatrix} -10 & -10 \\ -18 & -16 \end{pmatrix}$$

The determinant of $(I-A) \neq 0$ and hence the matrix is invertible. The difficulty is that in this Leontief-Inverse there is no non-negative output vector $x \neq 0$ for a non-negative final demand vector $y \neq 0$. Thus this mathematical correct solution does not make sense in economic terms due to the assumption if there is a quantity of output which barely satisfy the endogenous demand and beyond that the exogenous final demand as well. Considering this argumentation, it may arise that this problem does not seem to appear with constructed input-output tables, because they already fulfil all the requirements and thus there is no problem of negative outputs or final demands, but if exogenous variables or input coefficients are being changed and a Leontief-Inverse matrix is computed again, the non-negativity of entries cannot be assured anymore. Not going beyond the scope of the thesis, the following statements facilitate the approval of non-negative entries, when changing variables:[138] (For $A \geq 0$ they are pairwise equivalent)

- I. There is $x \geq 0$ and $y > 0$ with $(I-A) * x = y$
- II. For every $y \geq 0$ there is one $x \geq 0$ with $(I-A) * x = y$
- III. There is a $p \geq 0$ and a $z > 0$ with $(I-A)' * p = z$
- IV. For every $z \geq 0$ there is a $p \geq 0$ with $(I-A)' * p = z$
- V. $(I-A)$ is invertible and $(I-A)^{-1} \geq 0$
- VI. All gradual principal minors of $(I-A)$ are positive
- VII. The real parts of all eigenvalues of $(I-A)$ are positive
- VIII. All eigenvalues of A are in absolute values < 1
- IX. For a n-row diagonal matrix $D > 0$, all column- (or row-) sums of $D * A * D^{-1} < 1$

[135] **Holub** (1994), p. 94.
[136] ibid., p. 114.
[137] ibid., p. 114-116.
[138] ibid., p. 116.

7.3.4. The Power Series Approximation

In past days it was not that easy to invert matrices with large dimensions, as this step requires a lot of computational power. In the 1940s, when Leontief-Inverse matrices came up, the inverting of e.g. 150x150 input-output matrix had to be solved somehow. Therefore a partitioning matrix approach was conceived to be able to compute only parts of Leontief-Inverse matrices sequentially, which add up as a very effective approximation. The Power Series Approximation is as follows:[139]

$$L = (I - A)^{-1} = (I + A + \ A^2 + A^3 + \cdots)$$

When considering impact analysis of exogenous changes e.g. final demand the equation is as follows: $\Delta x = (I + A + \ A^2 + A^3 + \cdots) * \Delta y$, where Δx represent the change in output and Δy the change in final demand. Decomposing the series yields the following information:[140]

- The first element of the power series $I * \Delta y$ represents the initial effect of a change in final demand => the total output for industry i has to increase at the same extent as the final demand has changed.
- The second element $A * \Delta y$ outlines the direct consequences of the affected industry i
- The further elements $((A^2 + A^3 + \cdots + A^n) * \Delta y)$ represent all indirect effects – all industries which are related to industry i
- $n \rightarrow \infty$ decreasing effects of Δy
- The decomposition of the power series does not allow drawing conclusions on the chronology of production processes. It only represents a logical partition of the Leontief-Inverse matrix, with information about direct and indirect effects in every step.

7.4. Theory of Multiplier Effects

7.4.1. Introduction

"Leontief input-output economics derive their significance largely from the fact that output multipliers measuring the combined effects of the direct and indirect repercussions of a change in final demand were readily calculated."[141] In short words the main aim of input-output analysis is the investigation of exogenous changes and their endogenous impacts. Multipliers represent an essential numeric measurement for the extent of an initial exogenous change and its affectations on economic sectors through the endogenous interdependence system within the industries.[142]

Two major approaches of the input-output analysis are being distinguished. On the one hand there is the view of short-term impacts and few involved agents. This approach is likely to be called impact analysis, as only single variables, coefficients etc. are being changed ('ceteris paribus') and the comprehensive impacts are then being investigated e.g. changes in government spendings or consumer demand for special goods. On the other hand there is the

[139] **Miller** (2009), p. 31-33.
[140] **Holub** (1994), p. 111-113.
[141] **Steenge** (1990), p. 377.
[142] **Input-Output** <http://faculty.washington.edu/krumme/207/inputoutput.html> (accessed October 2013).

long-term view which is more focused on estimating projections and constructing forecasts.[143] Changes in final demand, exports, etc. are investigated in the long run, wherefrom conclusions on structural changes can be drawn. One example for such a forecast is an expected final demand for the next five years. Based on these assumptions the coefficient matrices are being updated and the Leontief-Inverse matrices are being computed newly. Through this approach it is possible to estimate the demanded output for each industry for the next years. The major drawback is the decreasing accuracy for longer periods, due to the complex task of estimating final demand for the future. Coefficient and also Leontief-Inverse matrices are losing their representative character as they might project a different inter-industry structure.
Considering the several fields of applications of multipliers and also their limitations or drawbacks, they still take in a key part of the input-output analysis. It is important knowing for which field of application what multiplier is best. Moreover it is a rule of great generality that the largest multiplier is not implicitly the best for positioning the lever – further information on this issue will be provided in the following sub-chapters. The four most common types of multipliers are as follows:[144]

- impacts on outputs of the sectors in the economy
- impacts on income earned by households in each sector
- impacts on (absolute) employment
- impacts on value-added of each sector in the economy

7.4.2. Output Multiplier

The output multiplier for a specific sector j is by definition "the total value of production in all sectors of the economy that is necessary in order to satisfy a dollar's worth of final demand for sector j's output."[145] The formula for the simple output multiplier is as follows:[146]

$$m(o)_j = \sum_{i=1}^{n} l_{ij} \qquad for\ sector\ j$$

The following example provides a good methodological overview:[147]

1. The given technology matrix and its corresponding Leontief-Inverse

$A = \begin{bmatrix} 0.15 & 0.25 \\ 0.20 & 0.05 \end{bmatrix}$ and the corresponding $L = \begin{bmatrix} 1.254 & 0.330 \\ 0.264 & 1.122 \end{bmatrix}$

2. Additional € of final demand for only sector 1 or 2

$\Delta f(1) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ and $\Delta f(2) = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$

[143] **Miller** (2009), p. 243-244.
[144] ibid., p. 244.
[145] ibid., p. 245.
[146] ibid., p. 246.
[147] ibid., p. 245.

3. Multiplication of L with one of the final demand vectors

$$\begin{bmatrix} 1.254 & 0.330 \\ 0.264 & 1.122 \end{bmatrix} * \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 1.254 \\ 0.264 \end{bmatrix}$$ matrix multiplication: *[2x2]*[2x1]=[2x1]*

$\begin{bmatrix} 1.254 \\ 0.264 \end{bmatrix}$ → € 1 for 1 additional € of FD and € 0.254 for interm. consumption
→ € 0.264 only for interm. consumption

4. Obviously the result of step 3 is the first column vector of the Leontief-Inverse. Thus the simple output multiplier consists only in computing the sum of this vector. No matter to what extent final demand is being increased (e.g. € 200 or € 3 bill. etc.), the output multiplier for sector 1 will always be this sum.

   $m(o)_1 = 1.254 + 0.264 = 1.518$ analogue for sector 2: $m(o)_2 = 1.452$

5. $m(o)_1 > m(o)_2$ means, that an investment for increasing the final demand of sector 1 has in return a higher output than an investment in sector 2. Hence an investment in sector 1 seems preferable.

Superficially the decision for the highest multiplier seems rational, but there are some constraints which have to be considered. In a simple-world context: What if some industries already work at their capacities? Pushing their final demand for increasing the output would not provoke the expected effects due to the production limitation. Hence this extra money would only raise prices and imports for the demanded goods will increase, which on the other hand debits the balance of trade.[148]
Another drawback is the exogenous intervention itself. Raising additional money for certain industries could cause instabilities within an economy's equilibrium. Although the benevolent influence would spread over many other industries, the major part of investment still remains at the initial industry.[149]
Keeping these restrictions in mind, we will focus only on the simple output multiplier in the thesis, as including all aspects would exceed the scope due to the additional required information and system of constraints. The chosen methodology should demonstrate inter-industrial relations and effects of exogenous impacts. In a further step it is still possible to analyse such interventions on their operationality relating to the mentioned constraints.

7.4.3. Income/Employment/Value-Added Multiplier

When analysing economic impacts of exogenous changes, gross output is not the most important issue economists or politicians are interested in. Socio-economic repercussions on attributes like income, employment or value-added are of prime importance. The formula for the simple household income multiplier is as follows: [150]

$$m(h)_j = \sum_{i=1}^{n} \left(a_{n+1,i} * l_{ij}\right)$$

[148] **Miller** (2009), p. 246.
[149] ibid., p. 246.
[150] ibid., p. 250.

For investigating the impacts on household income, it is necessary to extend the technology matrix with one additional row and column. These two vectors contain also input coefficients regarding the payments for labour services and the consumer expenditures on goods. Adding them to the original technology matrix endogenizes household income. The following example explains it more in detail:[151]

1. Adding a new row and column to the original technology matrix $A \rightarrow \bar{A}$ yields:

$$\bar{A} = \begin{bmatrix} 0.15 & 0.25 & 0.05 \\ 0.20 & 0.05 & 0.40 \\ 0.30 & 0.25 & 0.05 \end{bmatrix} \text{ and } L = \begin{bmatrix} 1.254 & 0.330 \\ 0.264 & 1.122 \end{bmatrix}$$

2. A change in final demand for sector 1 is again the vector $\Delta f(1) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ which yields the first column of L

3. Labour input coefficients (last row of $\bar{A}$) are computed as follows:

$h' = [z_{n+1,1}, \dots, z_{n+1,n}]$ e.g. wages earned

$h_c{}' = h' * \hat{x}^{-1}$, where $\hat{x}^{-1} = \begin{bmatrix} 1/x_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1/x_n \end{bmatrix}$

$h_c{}'$ is a row vector covering the input coefficients of labour input e.g. wages earned per unit of output

4. Computing the multiplier with $a_{n+1,1} = 0.30$ and $a_{n+1,2} = 0.25$ (last row of $\bar{A}$)

$$m(h)_1 = 0.3 * 1.254 + 0.25 * 0.264 = 0.376 + 0.066 = 0.442$$
$$m(h)_2 = 0.3 * 0.33 + 0.25 * 1.122 = 0.099 + 0.281 = 0.380$$

The simple household income multiplier $m(h)_1$ yields that one additional € of final demand for sector 1 generates € 0.442 of new household income. Sector 1 receives € 0.376 and sector 2 benefits indirectly with € 0.066 – analogue to $m(h)_2$.[152]

The just presented methodology for computing the simple household income multiplier is also applicable for e.g. number of employees. The mathematical computation procedure remains unchanged with the only difference that the multiplier then does not yield a change in monetary units but in absolute numbers of employees.

Another important socio-economic multiplier is the value-added multiplier, which provides a good measurand for the contribution of a sector to the output of an economy, as it represents "[…] the difference between a sector's total output and the cost of its intermediate inputs."[153]

The methodology is identic to the one before but with different input coefficients, which are now computed for value-added payments.

[151] **Miller** (2009), p. 247-251.
[152] ibid., p. 251.
[153] ibid., p. 256.

7.5. Construction of Leontief-Inverse Matrices

7.5.1. Matlab Function 'computeTechnCoeffMatr()'

The construction of Leontief-Inverse matrices is accomplished by the Matlab function 'computeTechnCoeffMatr()' [154] – the source code is provided in the appendix 11.6. To give a short introduction about the functionality, see the following steps:

1. For all seven countries (AUT, GER, ESP, FRA, ITA, PRT and UK) and the years 1995-2011 construct the Leontief-Inverse matrices
2. The final input-output tables (see chapter 5.2.6) represent the basis for the construction approach
3. Import the column totals (total output in the input-output tables)
4. Compute the technology matrices for the essential intermediate step
   4.1. For every industry of the 35x35 Z-matrix compute the input coefficient (see chapter 7.2)
   4.2. Return the 35x35 technology matrix ICM (input coefficient matrix)
5. Construct the Leontief-Inverse by *inv(eye(35,35)-ICM)* – ad hoc creation of a 35x35 identity matrix followed by the subtraction of the previously computed technology matrix
6. Aggregate and write the Leontief-Inverse matrices to the respective Excel file

7.5.2. Final Leontief-Inverse Matrix

	c1	c2	c3	c4	c5
c1	1,2462567	0,0021264	0,1828992	0,0065141	0,0774356
c2	0,0019717	1,01852	0,002337	0,001066	0,0013296
c3	0,0510688	0,0023166	1,1188727	0,0059425	0,0925568
c4	0,0005968	0,0002789	0,0006461	1,0298881	0,0025475
c5	4,937E-05	2,726E-05	6,64E-05	8,075E-05	1,0000937
c6	0,0045146	0,0051223	0,0036821	0,003034	0,0038651
c7	0,0059882	0,0064344	0,0205611	0,011347	0,0122181
c8	0,0080454	0,0070603	0,0057829	0,0045998	0,0053872
c9	0,0050403	0,0036957	0,0074033	0,0075021	0,0091578
c10	0,0029112	0,0038261	0,0086761	0,0057355	0,0047782
c11	0,007635	0,0095035	0,0073632	0,0042491	0,005279
c12	0,0083582	0,011533	0,0148826	0,006971	0,0086834
c13	0,0143321	0,0130825	0,0067936	0,0053277	0,0078014
c14	0,003644	0,0037464	0,0039897	0,0040651	0,0047725
c15	0,0008204	0,0007736	0,000936	0,0011488	0,0010079
c16	0,0018633	0,0018287	0,0027235	0,0057774	0,0037912
c17	0,0491464	0,081999	0,0581568	0,0532553	0,0504961
c18	0,0271309	0,0442304	0,0293741	0,0217784	0,0263287
c19	0,0159081	0,0108358	0,0187697	0,0174819	0,0234393
c20	0,0619922	0,0329054	0,082155	0,0899177	0,1158247
c21	0,0458277	0,02104	0,056408	0,0616145	0,0822486
c22	0,0032625	0,0034565	0,0076109	0,0038318	0,0054104
c23	0,0071491	0,0217933	0,0208574	0,0148375	0,0146423
c24	3,035E-05	2,897E-05	4,26E-05	3,222E-05	3,521E-05
c25	0,0008013	0,0011158	0,0022783	0,0016003	0,0015182
c26	0,0058322	0,0145394	0,015783	0,0099619	0,0104242
c27	0,0067703	0,0074743	0,0095456	0,0079027	0,007793
c28	0,0208385	0,0243667	0,0325521	0,0262005	0,0264765
c29	0,0172143	0,0276044	0,0296625	0,0293175	0,0244093
c30	0,04911	0,0826976	0,1073723	0,0657818	0,06939
c31	0,0013472	0,0016988	0,0025607	0,0016634	0,0018922
c32	0,001346	0,0026695	0,0015432	0,0012037	0,0011679
c33	0,014662	0,000588	0,0030012	0,0007935	0,0017442
c34	0,0061031	0,010342	0,0157471	0,0153523	0,0115496
c35	0	0	0	0	0

$$c_{3,3} = 1.1189$$

The output of industry c3 (Food, Beverages and Tobacco) has to increase by € 1.1189 when there is € 1 additional final demand for industry c3.

$$\sum_{i=1}^{35} c_{i3} = 1.8810$$

The column sum of industry c3 indicates that all industries together of c3 have to produce additional output in the amount of € 1.8810 to satisfy an increase of final demand by € 1 for industry c3.

$$\sum_{j=1}^{35} c_{3j} = 1.5116$$

The row sum of industry c3 indicates that c3 has to produce € 1.5116 in total, to be able to satisfy an increase of final demand by € 1 for the industries 1-35.

Figure 15 Extract of a Final Leontief-Inverse Matrix (Industries c1-c5)

[154] Helpful literature: **Angermann** (2005), chp. 2-3.

8. Impact Analysis of the Information Sector

8.1. Preliminaries

Arguably the most delicate task of this thesis consists in conducting the impact analysis for the information sector. The limitation of how to define impact measurement is already an essential assignment. From the previous chapter (7) we see that Leontief-Inverse matrices represent the basis for impact conclusions. Furthermore multipliers and their effects indicate crucial points for supporting decision making and comparing exogenous changes. In the following sub-chapter (8.2) ampliative theoretical concepts are being introduced, where Leontief-Inverse matrices again provide the main basis. These concepts should widen the perception of a causal impact and its underlying relations. The determination of a coefficient’s importance facilitates finding the starting point, where to focus with the analysis or which parts of an input-output table should be extended with additional data e.g. which economic sector should be investigated on a more granular level due to its high importance. Chapter 8.3 covers the applied methodology for determining and measuring the economic impact of the information sector. This includes a compound of introduced theoretical concepts on the one hand and on the other some modifications to retrieve compatible results regarding the thesis’ context.

8.2. Theory of Impact Analysis

8.2.1. Final Demand vs. Supply-Side Model

The final demand model is given as $x = (I - A)^{-1} * f$. In this model the coefficients of the Leontief-Inverse matrix correlate sectoral output to final demand.[155] Technical coefficients (input coefficients) are being derived out of the final demand model (see chapter 7.2). In the year 1958 Gosh followed a vice versa approach – he wanted to correlated the sectoral output not with final demand but with the primary input.[156]

Basically this changes just the way of computing the corresponding coefficients. The technical coefficients (input coefficients) for the final demand model are being computed by dividing each transaction value z_{ij} with its total output of column j (column sum in the Z-matrix). After the Gosh definition we are now interested in the inputs, which just implies a transposition of the computation approach. Instead of dividing each z_{ij} with the column sum, it is now divided by its row sum, which results in the B-matrix containing ‘allocation coefficients’ (output coefficients). This matrix is defined as follows:[157]

$$B = \begin{bmatrix} 1/x_1 & 0 \\ 0 & 1/x_2 \end{bmatrix} * \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

[155] **Miller** (2009), p. 543.
[156] **Gosh** (1958), p. 59.
[157] **Miller** (2009), p. 543.

A single coefficient b_{ij} indicates the "distribution of sector i's output across sectors j that purchase inter-industry inputs from i"[158]. The construction of B^{-1} is analogue to the Leontief-Inverse – the 'Gosh-Inverse' is as follows:[159]

$$G = (I - B)^{-1} = [g_{ij}]$$

The main difference of the supply-side mode is the assumption of a stable output distribution, instead of fixed input-coefficients.[160] The allocation coefficients are important for the comprehensive understanding of the following chapter 8.2.2.

8.2.2. Linkages

Generally two types of linkages are being distinguished: backward-linkages and forward-linkages.

Backward-linkages are built on the demand-focused model. The causal relationship is the following: If sector j increases its output, final demand increases too. This in turn leads to an increased inter-industry demand. Summing up direct as well as indirect linkages, results in the total backward linkage for time t:[161]

$$BL(t)_j = \sum_{i=1}^{n} l_{ij} \quad (\triangleq \text{column sum of Leontief-Inverse for sector j})$$

Avoiding l_{ij} where i=j, describes the 'net backward dependence' of sector j.[162] In diverse literatures it is indicated that this net linkage is more expressive, because leaving out the diagonal element, which is the highest coefficient, characterizes the impact on the rest of industries more clearly.

Forward-linkages are built on the supply-side model of Gosh. The causal relationship is the following: If sector j increases its output, the amount of products j within the economy of course raises. These products are being used as inputs for other sectors production, which again leads to an increase of sector j's supply to sector i. The total forward linkage for time t is defined as follows:[163]

$$FL(t)_i = \sum_{j=1}^{n} g_{ij} \quad (\triangleq \text{row sum of Gosh-Inverse for sector i})$$

In general the linkage of sectors can be a good benchmark when identifying a weighty sector from its forward and backward relations e.g. strongly dependent/independent on/from others or dependent on inter-industry supply/demand.[164]

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[158] **Miller** (2009), p. 543.
[159] ibid., p. 544.
[160] ibid., p. 544.
[161] ibid., p. 555-557.
[162] ibid., p. 558.
[163] ibid., p. 558-559.
[164] ibid., p. 559-560.

8.2.3. Determining the Importance of Coefficients

Being aware of a coefficient's importance, no matter what type it has, is advantageous, as it is more obvious where to make changes and investigate its impacts effectively. An important coefficient is defined as a "strong influence on one or more elements […] usually on the associated Leontief-Inverse matrix and/or one or more gross outputs – meaning that $\Delta\, a_{ij} \rightarrow$ a 'large' $\Delta\, l_{rs}$ or that $\Delta\, a_{ij} \rightarrow$ a 'large' $\Delta\, x_r$ for one or more r and s."[165] The simplest approach is to compare each coefficient with the computed average:[166]

$$z_{ij} \ll\gg \frac{\sum_{i=1}^{n} z_{ij}}{n^2}$$

The mathematical computation approach is mainly built on researches of Sherman & Morrison[167] and Woodbury[168] - it can be summarized as follows:[169]

$M \ldots non-singular\ matrix\ with\ elements\ m_{ij}$
$M^{-1} \ldots inverse\ matrix\ of\ M\ with\ elements\ \mu_{ij}$

Changing one or more elements of M is characterized as
$m_{ij}^{*} = m_{ij} + \Delta m_{ij}$ or in matrix notation
$M^{*} = M + \Delta M$

The essential task is now to show how the changed elements in M^{-1} can be found.
$(M^{*})^{-1} = [\mu_{ij}^{*}]$ by adjusting elements μ_{ij}

In the simplest case if a single element changes (Δm_{ij}), it can be found in the inverse matrix by:

$$\mu_{rs}^{*} = \mu_{rs} - \frac{\mu_{ri} * \mu_{js} * \Delta m_{ij}}{1 + \mu_{ji} * \Delta m_{ij}}$$

→ Applied to the Leontief-Inverse matrix $(I - A)^{-1}$ - only the signs change due to $(I - A^{*})^{-1}$

$$l_{rs}^{*} = l_{rs} + \frac{l_{ri} * l_{js} * \Delta a_{ij}}{1 - l_{ji} * \Delta a_{ij}}$$

8.2.4. Relative Size of Coefficients

The relative size of coefficients e.g. in the Leontief-Inverse matrix allows drawing conclusions on their importance and thus reduces the efforts in the exploration phase of an impact analysis. There are three key observations, which determine the relative size of a coefficient:[170]

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165 **Miller** (2009), p. 567.
166 ibid., p. 568.
167 see therefore **Sherman** (1949) and **Sherman** (1950).
168 see therefore **Woodbury** (1950).
169 **Miller** (2009), p. 568-569.
170 **Miller** (2009), p. 569-570.

1. The main diagonal elements of a Leontief-Inverse matrix are always > 1 and the rest of elements are < 1

   $l_{ii} > 1 > l_{rs} \qquad \forall\, r \neq s$

2. The largest ratio for a given i and j has its maximum at $r = i$ and $s = j$

   $$\max_{r,s=1,\ldots,n} {l_{ri} * l_{js}}/{l_{rs}} = {l_{ii} */l_{jj}}/{l_{ij}}$$

3. Maximal gross output influence is caused by diagonal coefficients of the Leontief-Inverse matrix - proved by Tarancón[171].

   $$\max_{r=1,\ldots,n} {l_{ri}}/{x_r} = {l_{ii}}/{x_i}$$

8.2.5. 'Inverse-Important' Coefficients

To make a basic measurement available, how the change of coefficients can be assessed, the previously mentioned observations (see chapter 8.2.4) are of importance. The formula for the percental change is as follows:[172]

$$p_{rs(ij)} = 100 * \left[\frac{l_{ri} * \ l_{js} * \ \Delta a_{ij}}{1 - l_{ji} * \Delta a_{ij}}\right] * \left[\frac{1}{l_{rs}}\right] \geq \beta$$

"[…] for any l_{rs} and given α and β. For example, let $\alpha = 20$ and $\beta = 10$. This means a_{ij} will be considered inverse important if a 20 percent change in its value generates a 10 percent or larger change in one or more elements in the Leontief inverse."[173]

This approach ensures the determination of a change in the inverse, without actually computing a new inverse. In former times this step was very time-consuming, especially for larger matrices, and thus the approach by Sherman & Morrison and Woodbury has its advantage right there.[174]

One important and crucial task was to determine the threshold of importance (α and β) as this decision has great impact on the outcome of found coefficients.[175]

Considering the methodology for this thesis, some observations and proved regularities are of great value. In some points e.g. avoiding the computation of a new Leontief-Inverse matrix, the used approach will differ, as there are better techniques nowadays (see chapter 8.3). Nevertheless it was introduced for comprehensive issues – see Miller (2009), p.572-577 for a schematic example.

[171] for further explanation see **Tarancón** (2008).
[172] **Miller** (2009), p. 571.
[173] ibid., p. 571.
[174] ibid., p. 571.
[175] ibid., p. 573.

8.3. Applied Methodology

8.3.1. Scope of Analysis

In this chapter the realization of the following approaches are being introduced: impacts of changed input coefficients, multiplier effects as well as inter-industrial linkages. In all three cases it is necessary to automatize the computation approach as there is a huge amount of data, which has to be processed: data from 7 countries for a time-span of 17 years and each with 35 different industries. In some cases it is possible to reuse certain parts of already written code, which saves some time and effort. The computed results are being cross-compared through the countries of investigation. Due to the scope of the thesis a few but comprehensive set of outputs is being provided. Generally all coefficients, multipliers or linkages are being computed for every single year and each of the 35 industries. But only the most topical (year 2011) and industries belonging to the information sector are being investigated. In the next chapter further impact analysis approaches are being introduced to highlight the wide field of research possibilities. For a wider scope of analysis see also some chapters in the appendix, as there is information for all 35 industries being provided. It is also the intention to limit the provided results to the scope of investigation – and this is clearly the information sector and its corresponding industries. In case of a higher interested reader, there is the possibility to use the provided contact details for retrieving the whole set of computed data e.g. Excel files, Matlab source codes, etc.

8.3.2. Impact of Changing Input Coefficients

The most effortful but though interesting task in this whole chapter is the analysis of impacts caused by changed input coefficients in the technology matrix. The main computation principle can be explained in five steps:

1. Computation of the Leontief-Inverse matrices for the unchanged technology matrices (keep a backup of this version)
2. Modification of a specific a_{ij} in the technology matrices (e.g. important coefficient – see chapter 8.2)
3. Computation of a new Leontief-Inverse matrices - due to inter-industrial relations a single changed input coefficient results in numerous altered l_{ij}
4. $L_{new} - L_{old} = \Delta$[176]
5. 3D-Visualization of Δ provides a very descriptive view[177]

The Matlab function 'delta_input_coeff' performs all these steps for the seven countries of investigation, all 17 years and each single industry. Furthermore every 3D-visualization of Δ is exported as a png-picture, to allow subsequent interpretations. For more details on the code see appendix 11.8.

8.3.3. Multiplier Effects

For having a mixture of multipliers, two different types are being investigated. On the one hand a very simple but, in economic terms, expressive multiplier, namely the output multiplier is

[176] see therefore **Miller** (2009), p. 593-594.
[177] see therefore **Hartner** (2011), p. 14-16.

being computed. This multiplier indicates the required output of sector j, when there is an additional unit of final demand for the products of sector j. The computation approach in this case is not very effortful, as the already computed Leontief-Inverse matrices are being used and thus column sums have to be calculated only. This step is included in the self-written Matlab function 'compute_Multiplier' – see appendix 11.7 for detailed information.
On the other hand the socio-economic context is of great importance too. Therefore an 'employment multiplier' as well as a measure for sensitivity of employment change related to final demand is being constructed. In the first step it is necessary to connect absolute employment with the industrial output, by dividing the number of employees of each sector with the output of the corresponding sector. This resulting coefficient expresses how a change of output influences the number of employed people in a sector (taking some restrictions not into account due to simplifying issues). Multiplying the employment coefficient with its associated coefficient sum of industry j of the Leontief-Inverse matrix, we retrieve the employment multiplier for industry j, which relates now a change in final demand directly to an impact on absolute employment. As the technical coefficients l_{ij} are (except the diagonal element) < 1 and the employment coefficients are in the range of E-05, the resulting employment multipliers are very small. This is because of a multiplier's characteristic itself, as it expresses in this case the change of one unit in final demand on a given domain.
Final demand is usually provided in millions or even billions, thus it endows the magnitude of a multiplier, when applying it for a change in final demand in the range of hundreds of millions or relative amounts. Therefore a measure of sensitivity for a percental change in final demand is being computed, which indicates when final demand for sector j is changed by 1 % (increased or decreased), how much it will change the employment of sector j (in percent). For this purpose it is necessary to include the absolute number of employees into the mathematical model. Moreover it is a good and comparable measurement, where impacts on employment get more obvious. The computation of the employment multiplier as well as the sensitivity measure is also provided in appendix 11.7.

8.3.4. Linkages

Besides coefficient and multiplier analysis, there is also an interesting aspect of a sector's linkage within an economy. The concept of backward- and forward-linkages was already introduced, also the advantages of computing the net backward-linkage. As the linkages are based on the Leontief-Inverse matrices, the calculation is less time-consuming. For the net backward-linkage it is required to omit the diagonal element l_{ij} where i=j when aggregating by each column.
The forward-linkage is computed on the base of the Leontief-Inverse matrices too (row sums), as there is a lack of information for constructing the Gosh-Inverse matrices as well as it would exceed the scope of this thesis. The computation of both linkages is again covered by the Matlab function 'compute_Multiplier' – see therefore appendix 11.7.

8.4. Effects of Changing Input Coefficients

8.4.1. Set of Changed Input Coefficients

The effects of changing input coefficients (sequentially and 'ceteris paribus') are being computed for the year 2009, as the topicality is not that essential for this step and the required data is also fully available (national input-output tables by WIOD), without any additional calculation or approximation approaches. As we know diagonal elements of the Leontief-Inverse matrix represent the largest technical coefficients, thus this is being part of the first phase of the investigation. Furthermore Table 19 contains three additional input coefficients from the technology matrices, which are being analysed due to their point of interest and exemplary effects. Chapter 8.4.2 covers the result evaluation and interpretation.

Coeff.	Point of Interest
$a_{7,28}$	paper, printing, publishing input for financial intermediation
$a_{27,28}$	post and telecommunication input for financial intermediation
$a_{20,14}$	wholesale input for production of electrical and optical equipment

Table 19 Analysis Set of Input Coefficients

8.4.2. Evaluation of Results & 3D-Visualizations

All changes of the input coefficients, no matter if it is an increase or decrease, are illustrated positively in the 3D-visualizations e.g. in case of a negative Δ, it is being indicated specially. This is because a positive application features the change of coefficients more clearly than a negative one. Unless otherwise stated $\Delta\, of\ a_{ij} = 0.1$. Table 20 contains the affected industries of each country, when there is a change in a diagonal input coefficient of the information sector e.g. $a_{7,7}$, AUT: affected column industries are c17, c30, c20, c34, c21 and row industries c30, c28, c27, c3, c19 sorted descending by their absolute change. Regarding the absolute changes it is more feasible to exclude them, as they are pretty small and hard to interpret directly. Moreover the key task of the impact analysis is to reveal inter-industry correlations and show the most significant impact on other industries rather than focusing on the absolute deltas of the technical coefficients. If there is a request this data can be provided immediately or computed with the Matlab function 'delta_input_coeff()', but it is not being published in the scope of this thesis.

Coeff		AUT	ESP	FRA	GER	ITA	PRT	UK
$a_{7,7}$	r	30, 28, 27, 3, 19	30, 16, 34, 3, 31	34, 30, 3, 9, 28	21, 5, 4, 27, 16	26, 20, 19, 3, 27	30, 34, 26, 20, 27	3, 10, 28, 5, 32
	c	17, 30, 20, 34, 21	30, 17, 23, 20 ,28	30, 20, 28, 21, 26	30, 34, 29, 17, 20	30, 20, 17, 21, 23	30, 20, 17, 28, 21	30, 21, 20, 17, 34
$a_{14,14}$	r	13, 15, 17, 27, 18	13, 15, 18, 27, 17	15, 13, 27, 18, 12	18, 13, 15, 17, 2	15, 13, 27, 33, 18	27, 15, 13, 18, 20	13, 15, 27, 33, 18
	c	30, 20, 21, 12, 17	12, 30, 20, 21, 17	30, 12, 20, 21, 28	30, 12, 20, 21, 29	30, 12, 20, 21, 23	12, 30, 20, 21, 28	30, 21, 20, 12, 28
$a_{24,24}$	r	25, 23, 26, 30, 20	26, 6, 9, 4, 20	26, 3, 6, 9, 1	26, 25, 2, 20, 8	3, 5, 25, 15, 26	31, 26, 2, 11, 7	18, 4, 23, 9, 12
	c	30, 26, 20, 18, 17	26, 30, 23, 8, 17	30, 26, 28, 8, 20	26, 30, 23, 8, 28	26, 30, 20, 23, 3	26, 30, 28, 8, 20	26, 30, 28, 29, 27

$a_{25,25}$	r	26, 24, 20, 23, 28	26, 24, 23, 31, 2	26, 24, 28, 34, 30	26, 31, 2, 27, 24	24, 26, 5, 30, 27	26, 34, 24, 31, 30	26, 28, 27, 24, 19
	c	26, 30, 20, 29, 22	26, 30, 8, 23, 28	30, 8, 26, 15, 28	26, 30, 8, 23, 28	30, 26, 20, 23, 8	26, 30, 8, 28, 20	30, 26, 28, 29, 27
$a_{27,27}$	r	28, 20, 30, 34, 26	30, 31, 17, 25, 4	28, 30, 20, 21, 34	21, 7, 28, 26, 31	26, 19, 30, 25, 28	34, 30, 20, 21, 25	28, 20, 31, 22, 26
	c	30, 29, 18, 17, 20	30, 17, 18, 28, 29	30, 28, 29, 18, 20	30, 29, 28, 26, 34	30, 18, 20, 28, 29	30, 28, 14, 18, 20	30, 28, 21, 18, 29
$a_{28,28}$	r	20, 30, 21, 31, 19	29, 3, 5, 4, 21	20, 24, 27, 3, 21	23, 29, 26, 21, 1	20, 24, 25, 23, 26	29, 30, 6, 17, 7	29, 21, 6, 9, 31
	c	30, 29, 27, 17, 18	30, 18, 29, 27, 17	30, 27, 29, 7, 18	30, 29, 34, 27, 17	30, 29, 27, 20, 18	30, 27, 29, 17, 31	30, 27, 29, 18, 26
$a_{30,30}$	r	28, 24, 20, 27, 23	25, 27, 9, 11, 3	24, 9, 14, 20, 28	28, 1, 3, 9, 7	26, 20, 19, 25, 21	24, 28, 34, 20, 25	28, 34, 26, 23, 21
	c	28, 29, 20, 34, 7	34, 7, 27, 18, 28	28, 29, 27, 20, 7	34, 29, 28, 32, 7	29, 28, 20, 18, 27	28, 27, 34, 20, 31	28, 27, 34, 7, 26
$a_{31,31}$	r	30, 28, 7, 24, 34	9, 27, 24, 26, 14	34, 6, 17, 7, 9	17, 2, 11, 18, 16	3, 24, 7, 34, 9	30, 34, 24, 20, 25	23, 29, 30, 16, 25
	c	30, 29, 17, 18, 28	30, 17, 27, 18, 28	30, 18, 28, 29, 27	30, 28, 34, 29, 18	30, 28, 18, 34, 17	30, 17, 28, 26, 27	30, 18, 28, 27, 34
$a_{32,32}$	r	31, 25, 28, 2, 30	12, 4, 9, 17, 19	25, 23, 14, 27, 15	30, 31, 25, 28, 23	25, 27, 30, 15, 20	14, 30, 15, 26, 7	31, 33, 28, 27, 30
	c	17, 30, 18, 29, 20	18, 17, 30, 29, 28	30, 17, 3, 18, 20	30, 28, 17, 23, 34	29, 30, 17, 28, 18	30, 17, 28, 27, 34	30, 7, 23, 17, 21
$a_{33,33}$	r	1, 3, 6, 5, 31	1, 27, 20, 3, 19	34, 1, 3, 22, 4	1, 3, 34, 31, 32	7, 1, 27, 31, 19	1, 6, 3, 13, 4	1, 28, 34, 9, 14
	c	30, 17, 29, 20, 18	30, 9, 18, 29, 17	30, 20, 28, 29, 17	30, 29, 34, 28, 20	30, 29, 20, 9, 21	30, 20, 28, 9, 3	30, 21, 20, 34, 28
$a_{34,34}$	r	7, 29, 30, 28, 22	30, 7, 27, 19, 25	7, 17, 5, 30, 11	7, 21, 30, 9, 31	7, 31, 3, 21, 19	30, 27, 16, 21, 24	7, 33, 31, 22, 27
	c	30, 17, 18, 29, 28	30, 18, 17, 29, 28	30, 28, 29, 20, 17	30, 28, 29, 17, 27	30, 29, 28, 20, 17	30, 17, 27, 28, 18	30, 28, 27, 21, 29

Table 20 Analysis of Changed Diagonal Elements of the IS

Figure 16 provides an exemplary illustration, how the changes of technical coefficients in the Leontief-Inverse matrix can be visualized, when a single input coefficient $a_{30,30}$ is being increased by 10 %. In words this means that industry c30 increases its output and uses this as input for the own production straightaway. As mentioned before it is not the purpose of the impact analysis to investigate reasons, why and how an input coefficient can be increased/decreased, but rather how much a change at a specific coefficient affects other industries. These principles have to be investigated in further analysis or studies to examine potential savings or efficiency enhancements e.g. automation of processes to save expenses or more efficient allocation of materials to be able to use less inputs for the production of goods.
The data for the technology as well as the Leontief-Inverse matrix dates from the year 2009 and Spain. Table 20 contains the top 5 affected row and column industries, which are in this case: c25, c27, c9, c11, c3 (row) and c34, c7, c27, c18, c28 (column). The changes along column 30 can be explained through the higher demand for inputs of other industries, as the own production is being increased by 10 % e.g. more need for paper (c7) or financial services (c28). The went up output of industry c30 in turn leads to a higher amount of products available on the market, which are being used by all other industries as inputs for their production – these correlations are visualized along row 30. Of course this leads to myriads of changes in inputs and outputs of

all other industries, but they are getting smaller and smaller and thus they are not that prominent in the following visualization. As it is not possible to publish all visualizations, see appendix 11.9, which provides a comprehensive example of a change in all diagonal input coefficients of the information sector and its impacts on the technology coefficients (ESP, $\Delta = 0.1$).

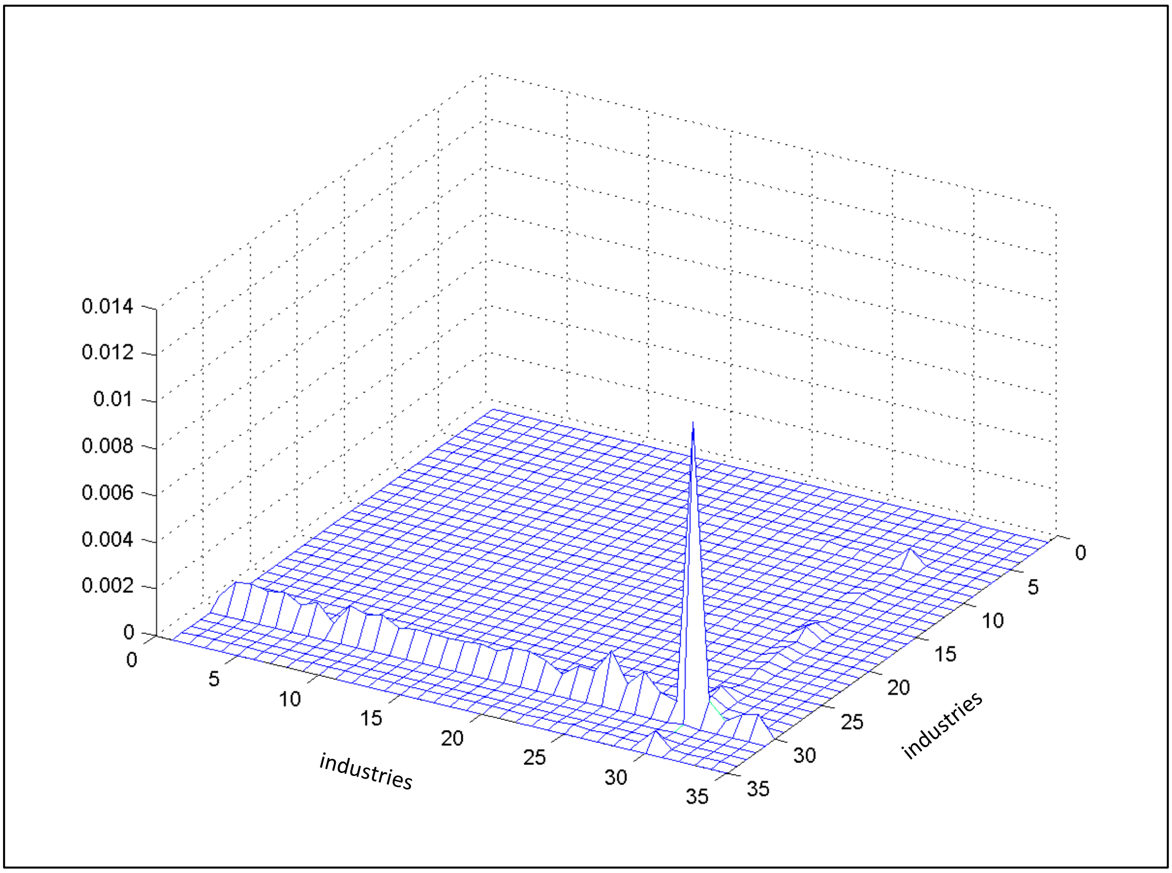

Figure 16 Effects on Techn. Coeff. where: a(30,30), Δ=0.1, ESP

Now changes of the three input coefficients (Table 19) from the technology matrix and their impacts are being analysed – see therefore Table 21 for the top five affected industries. Again due to limitation issues only a small number of visualizations are being provided – see appendix 11.10 for the illustrated effects of the three changed input coefficients based on Austria.

Coeff		AUT	ESP	FRA	GER	ITA	PRT	UK
$a_{7,28}$	r	20, 30, 21, 31, 19	29, 3, 5, 4, 21	20, 24, 27, 3, 21	23, 29, 26, 21 ,1	20, 24, 25, 23, 26	29, 30, 6, 17, 7	29, 21, 6, 9, 31
	c	17, 30, 20, 34, 21	30, 17, 23, 20, 28	30, 20, 28, 21, 26	30, 34, 29, 17, 20	30, 20, 17, 21, 23	30, 20, 17, 28, 21	30, 21, 20, 17, 34
$a_{27,28}$	r	20, 30, 21, 31, 19	29, 3, 5, 4, 21	20, 24, 27, 3, 21	23, 29, 26, 21, 1	20, 24, 25, 23, 26	29, 30, 6, 17, 7	29, 21, 6, 9, 31
	c	30, 29, 18, 17, 20	30, 17, 18, 28, 29	30, 28, 29, 18, 20	30, 29, 28, 26, 34	30, 18, 20, 28, 29	30, 28, 14, 18, 20	30, 28, 21, 18, 29
$a_{20,14}$	r	13, 15, 17, 27, 18	13, 15, 18, 27, 17	15, 13, 27, 18, 12	18, 13, 15, 17, 2	15, 13, 27, 33, 18	27, 15, 13, 18, 20	13, 15, 27, 33, 18
	c	30, 28, 29, 17, 18	30, 23, 26, 29, 17	30, 28, 29, 26, 23	26, 30, 23, 29, 28	30, 23, 28, 26, 29	30, 28, 23, 27, 17	30, 26, 23, 29, 28

Table 21 Analysis of Changing Specific Elements of the IS

The first specific change is conducted on the coefficient $a_{7,28}$, which can be interpreted as the potential savings of 'paper, printing, publishing' for the financial intermediation industry. Considering the impacts e.g. for Austrian industries, shows a very exemplary structure: Less used paper reduces the inputs of wholesaling, retailing, energy consumption and diverse business activities. In turn wholesalers or retailers have to decrease their output, due to the decline in inter-industry demand of the financial industry and the cumulative effect. The second change covers the input of 'post and telecommunications' for the financial intermediation industry. Considering the impact visualization (see appendix 11.10) shows that an increased inter-industry demand would cause changes in almost all other industries. On the one hand the financial intermediation industry would profit of an increased efficiency of their ICT infrastructure and on the other hand this little boost would foster not only but also information sector related industries. The third change is conducted on the wholesale input for the 'electrical and optical equipment industry'. Effects on the 'supply-chain' can be conjectured, as inputs like financial services, transporting, machinery, construction and diverse business activities are affected most.

8.5. Multiplier Effects

8.5.1. Effects of the Output Multiplier

The following table (Table 22) contains output multipliers for industries (see chapter 4.8.3 for the full industry name) belonging to the defined information sector – for the year 2011 and each of the seven countries:

	AUT	ESP	FRA	GER	ITA	PRT	UK
c7	1.73	1.98	1.98	1.70	7.86	1.87	1.69
c14	1.45	1.95	2.07	1.56	1.84	1.64	1.58
c24	1.55	1.97	2.10	2.08	2.11	1.88	1.63
c25	1.71	1.97	1.64	1.75	2.04	1.91	1.54
c27	1.64	1.80	1.74	1.59	1.68	1.71	1.67
c28	1.68	1.50	1.72	1.82	1.56	1.45	1.68
c30	1.54	1.68	1.67	1.43	1.65	1.73	1.42
c31	1.37	1.47	1.31	1.39	1.39	1.39	1.57
c32	1.22	1.25	1.19	1.28	1.18	1.19	1.33
c33	1.37	1.57	1.24	1.31	1.48	1.54	1.78
c34	1.52	1.79	1.62	1.48	1.66	1.74	1.56

Table 22 Output Multipliers for the IS (2011)

Three industries of the information sector show a higher output multiplier than others: 'Pulp, Paper, Paper, Printing and Publishing', 'Water Transport' and 'Air Transport' (c7, c24, c25). Almost every country has its highest multiplier in these three industries. Also the 'Financial Intermediation' (c28) features a stronger effect of output, when there is a change in final demand, especially for Austria, Germany and the United Kingdom.

In appendix 11.10 output multipliers for all 35 industries of the year 2011 are provided to enable just in this case a more comprehensive evaluation base. Although the output multipliers of the industries within the information sector are of importance and have a big impact on the output of the whole economy, in the past years there was and there still is a lack of incentives to spend more money on these industries than some others e.g. 'Manufacturing, Nec; Recycling', 'Electricity, Gas and Water Supply' or 'Construction' (c16, c17, c18). The chapters 8.6.1 and 8.6.2 as well as the corresponding appendices 11.13 and 11.14 provide more comprehensive information to prove this point. From the perspective of the output multiplier and particularly the net backward- and forward linkages, it is pretty obvious that bigger financial investments were and are being made, because of the higher 'economic' results. When considering the employment multiplier, and thus the socio-economic context, this investment approach starts to crumble. Now we are in the situation where economic key figures are faced with more social focused coefficients. In a short-term view it seems more feasible to spend money on industries like manufacturing or construction, because of the higher economic output. But when applying a longer time span and extending the impact scope also on socio-economic issues, these industries do not seem that feasible any more, to spend most of the money for. Employment issues play a more and more important role in an economy, as they have impacts on income, capital investments and final demand, which again influences the whole economy due to the positive and cumulative effect. The problem which has to be overcome is that many governments operate in short-term perspectives (strong correlated to the election cycle), although structural changes in an economy require long-term policies.

8.5.2. Effects of the Employment Multiplier

The following table (Table 23) contains employment multipliers for the industries (see chapter 4.8.3 for the full industry name) belonging to the defined information sector – for the year 2011 and each of the seven countries. As previously mentioned the employment multipliers are very small and thus a change in final demand of 100 mill. is being applied, to make the multipliers more descriptive. See Table 24 for the original values. In appendix 11.12 employment multipliers for all 35 industries of the year 2011 are being provided.

	AUT	ESP	FRA	GER	ITA	PRT	UK
c7	538	897	719	824	2858	1282	856
c14	547	794	750	665	715	917	768
c24	517	689	436	569	642	861	1152
c25	490	580	603	506	512	920	1232
c27	608	607	753	827	631	807	1251
c28	618	376	580	668	518	826	865
c30	759	1004	831	934	851	2028	757
c31	983	1313	1034	1119	861	1567	1427
c32	1127	1420	1247	1443	1367	2229	1871
c33	1260	1412	1135	1310	972	2111	1252
c34	976	1904	922	946	943	1762	1049

Table 23 Employment Multipliers for the IS – FD Δ = 100 mill. (2011)

	AUT	ESP	FRA	GER	ITA	PRT	UK
c7	5.38E-06	8.98E-06	7.19E-06	8.24E-06	2.86E-05	1.28E-05	8.56E-06
c14	5.48E-06	7.94E-06	7.50E-06	6.66E-06	7.16E-06	9.18E-06	7.69E-06
c24	5.18E-06	6.89E-06	4.36E-06	5.70E-06	6.42E-06	8.62E-06	1.15E-05
c25	4.90E-06	5.80E-06	6.04E-06	5.06E-06	5.12E-06	9.20E-06	1.23E-05
c27	6.08E-06	6.07E-06	7.53E-06	8.27E-06	6.31E-06	8.08E-06	1.25E-05
c28	6.18E-06	3.77E-06	5.81E-06	6.68E-06	5.19E-06	8.26E-06	8.65E-06
c30	7.60E-06	1.00E-05	8.31E-06	9.35E-06	8.51E-06	2.03E-05	7.57E-06
c31	9.83E-06	1.31E-05	1.03E-05	1.12E-05	8.62E-06	1.57E-05	1.43E-05
c32	1.13E-05	1.42E-05	1.25E-05	1.44E-05	1.37E-05	2.23E-05	1.87E-05
c33	1.26E-05	1.41E-05	1.14E-05	1.31E-05	9.72E-06	2.11E-05	1.25E-05
c34	9.77E-06	1.90E-05	9.23E-06	9.46E-06	9.44E-06	1.76E-05	1.05E-05

Table 24 Employment Multiplier for the IS - FD Δ = 1 (2011)

As we know from the computation approach (see chapter 7.4.3), it does not change the multiplier itself, when final demand is different from one. Thus the disparity between Table 23 and Table 24 is just to make it clearer for the reader, for getting a feeling of how a change in final demand can affect employment in absolute terms. Before evaluating the differences of the employment multipliers across the countries of investigation, some restrictions and influences have to be considered:

- different ratios of employment in each industry across the countries influence the multipliers
- varying final demands – over time and between industries – across the countries have also great impact on the computation results
- heterogeneities between final demand and employment can distort the output slightly
- Stronger/weaker linkage of an industry within the economic system

The highest employment multipliers of each country are distributed over quite similar industries. Austria, France, Germany and the United Kingdom have their top three multipliers (only within information sector) in the industries 'Public Admin and Defence; Compulsory Social Security', 'Education' and 'Health and Social Work' (c31-c33). Italy and Portugal share the last two industries, as they have both others in 'Pulp, Paper, Paper, Printing and Publishing' (c7) and 'Renting of M&Eq and Other Business Activities' (c30). Spain also shares the last two industries, besides 'Other Community, Social and Personal Services'. Generally all countries show a higher employment multiplier in the industries c30-c34 compared to the rest of the information sector.
One common and important result is that the industries 'Education' and 'Health and Social Work' are shared by all the countries. Especially the former industry is very relevant to the information sector and its development, as it can be seen as the basis for knowledge generation and 'distribution'. An increase in final demand around 100 mill. monetary units causes and extraordinary growth of absolute employment between approx. 1100 and 2200. To make the development of absolute employment not conditional on absolute values in final demand and also provide a better and more expressive value than a change of absolute labour in an industry,

a relative change in final demand and the relative impact on employment is computed too – see therefore the following table.
Table 25 contains the percental change of employment, when there is a change of 1 % in final demand (increase or decrease) for the corresponding industry. This approach is some kind of sensitivity measure and makes the employment multiplier better comparable as it is based on relative values. Furthermore a relative change in employment is of greater importance and expressiveness for evaluation purposes, as it is hard to indicate if e.g. 1000 employees more/less in an industry constitute a substantial change or not.
Compared to the previous results, there is a slight change in the distribution of the top three industries, which are more sensitive to a change in final demand than others. One obvious disparity is the industry 'Air Transport'. Spain, Germany as well as Italy show here a higher impact in relative terms compared to the absolute approach before. Austria and the United Kingdom are the one and only country, which do not show a difference.
Already this small change of only 1 % in final demand indicates very clearly the reference points for exogenous interventions. Values around or greater than one are of high interest as here an effect of final demand change has the highest impact on employment. In particular the governmental final demand could provoke pointed positive stimuli for certain industries. Moreover a change or shift of final demand can be regulated easier by the government, as it represents a central point of decision. There is also the possibility of modifying the final demand of households, which could be accomplished through fiscal incentives or campaigns to foster consciousness for e.g. education issues.

	AUT	**ESP**	**FRA**	**GER**	**ITA**	**PRT**	**UK**
c7	0.23	0.42	0.50	0.52	2.40	0.37	0.50
c14	0.07	0.15	0.28	0.09	0.18	0.22	0.12
c24	0.10	0.53	0.54	0.84	1.17	0.17	0.01
c25	0.71	1.16	0.49	1.28	1.63	0.78	0.55
c27	0.54	0.83	0.67	0.73	0.66	1.01	0.40
c28	0.48	0.67	0.63	0.84	0.54	0.75	0.65
c30	0.08	0.11	0.09	0.08	0.12	0.12	0.06
c31	1.10	1.07	1.09	1.10	1.21	1.11	1.19
c32	1.01	1.03	0.98	0.97	0.96	1.03	0.93
c33	1.10	1.15	1.07	1.13	1.17	1.22	1.31
c34	0.77	0.87	0.99	0.77	0.82	1.07	0.85

Table 25 Change of Employment in % for the IS (2011)

8.6. Resulting Linkages

8.6.1. Net Backward-Linkages

Linkages are also an important indicator for an industry's position and correlation within an economy. When an industry shows a substantial backward-linkage, it is an indicator that its output requires a lot of intermediate inputs from other industries. Thus a stimulus for an

industry with a higher backward-linkage affects all other correlated industries. As already described before, the net backward-linkage is an adjusted value, to avoid self-distortions. Thus it provides a clearer indicator on how much an industry is related to all the residual industries.
Having a closer look on the net backward-linkages of the information sector, two bigger groups can be distinguished. The industries c7, c14, c24, c25 rather show higher values than the rest. An important reason is that these industries are more production focused in physical terms and thus more linked to other industries, as they require real inputs e.g. raw materials, goods, information, etc. On the other hand industries like 'Education' (c32) or 'Public Admin and Defence; Compulsory Social Security' (c31) have a lower linkage, as their outputs cannot be used that easily as inputs for other industries.
The net backward-linkage is also an essential indicator for investment decisions, because a higher linked industry distributes positive effects to more other industries than the ones with a lower linkage. As mentioned in chapter 8.5.1 not only the generated output and the spread of its positive effects is important, but moreover the socio-economic context as well.

	AUT	ESP	FRA	GER	ITA	PRT	UK
c7	0.62	0.83	0.79	0.59	6.19	0.79	0.54
c14	0.41	0.85	0.99	0.48	0.73	0.45	0.55
c24	0.55	0.97	0.83	1.05	1.10	0.83	0.63
c25	0.67	0.94	0.62	0.74	1.04	0.90	0.53
c27	0.40	0.66	0.57	0.42	0.64	0.46	0.52
c28	0.43	0.23	0.43	0.45	0.28	0.37	0.60
c30	0.30	0.52	0.34	0.19	0.42	0.45	0.18
c31	0.37	0.46	0.30	0.37	0.39	0.38	0.56
c32	0.21	0.25	0.19	0.19	0.15	0.18	0.28
c33	0.36	0.50	0.23	0.29	0.40	0.46	0.53
c34	0.42	0.63	0.52	0.33	0.53	0.64	0.42

Table 26 Net Backward-Linkages for the IS (2011)

8.6.2. Forward-Linkage

As mentioned previously the forward-linkages are not based on the Gosh-Inverse but rather on Leontief-Inverse matrices. Nevertheless the computed results provide expressive information and allow drawing conclusions on the inter-industrial linkage, especially for the information sector and its relationships. The two industries 'Financial Intermediation' and 'Renting of M&Eq and Other Business Activities' (c28, c30) show the highest forward-linkages within the information sector. This is because their products and services play an essential part in the whole supply chain as they basically provide financing and procure capital flows.
Comparing forward-linkages of the information sector with the residual industries, there is another big group, which plays an important part in the supply chain (see appendix 11.14), namely 'Electricity, Gas and Water Supply', 'Construction', 'Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles' and 'Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods' (c17, c18, c20, c21). It is quite obvious that the

products and services of these industries indicate also a key role in the supply chain, as they provide the essential basics for even being enabled to produce/process goods and distribute them to the customers.

	AUT	ESP	FRA	GER	ITA	PRT	UK
c7	1.49	1.70	1.64	1.33	1.97	1.36	1.56
c14	1.22	1.36	1.29	1.39	1.57	1.43	1.13
c24	1.00	1.05	1.31	1.09	1.05	1.07	1.00
c25	1.11	1.14	1.04	1.12	1.09	1.02	1.06
c27	1.55	1.80	1.70	1.48	1.69	1.85	1.86
c28	2.15	3.19	3.10	2.52	2.77	2.82	2.36
c30	3.89	4.74	7.41	5.58	5.80	4.26	5.52
c31	1.08	1.27	1.14	1.23	1.02	1.32	1.17
c32	1.07	1.10	1.17	1.24	1.13	1.08	1.24
c33	1.06	1.19	1.08	1.05	1.10	1.12	1.36
c34	1.57	1.69	1.52	1.88	1.81	1.37	1.64

Table 27 Forward Linkages for the IS (2011)

9. Conclusion

9.1. Concluding Summary

Primarily it was necessary to evaluate the aims of the thesis in detail and come upon the most appropriate data source. Due to the availability of input-output tables for a longer time span and every single year, as well as additional data on social indicators and the free access, it was decided to use mainly the sources of WIOD. During further steps in the thesis it emerged, that for some countries data was missing or that the existing time span 1995-2009 should be extended up to 2011. For this purposes it was again necessary to allocate compensation data from a different source, where Eurostat was picked.

The formal definition of the information sector and the corresponding industry classification represents also a basic step for the aimed research goals. The definition followed a hybrid-approach, due to the existence of partly definitions of the information sector as well as the underlying data basis. The researches by the OECD and findings of Porat were most important for the definition assignment. The industries were strictly classified taking account of their main business activity, where there was such information available. In case of an information lack, they were not incorporated to the information sector. Moreover the R&D density and also the percental ratio of high-skilled labour represented an essential decision base for the industry classification. The final 11 information sector industries are as follows: 'Pulp, Paper, Paper, Printing and Publishing', 'Electrical and Optical Equipment', 'Water Transport', 'Air Transport', 'Post and Telecommunications', 'Financial Intermediation', 'Renting of M&Eq and Other Business Activities', 'Public Admin and Defence; Compulsory Social Security', 'Education', 'Health and Social Work' and 'Other Community, Social and Personal Services'.

Especially for the time series analysis of the information sector it was required to prolong the time span up to 2011. In the first step it was necessary for the missing values, to map the industry classification of Eurostat to the one used by WIOD (ISIC Rev. 2). Furthermore the AGR was computed to be able to apply relative growth rates instead of absolute values and also use it in some cases as a measurement for prolonging data. Two key tasks were the preparation issues and final conduction of the GRAS-algorithm for determining the Z-matrix of an input-output table, through two residual sum vectors and a 35x35 base matrix of the year 2009. All these operations well may have caused most of the effort in this thesis, due to many emerged barriers and problems, which mostly manifested in the very last moment. After all these assignments a final data basis of input-output tables as well as additional measurements for the years 1995-2011 and the countries Austria, France, Germany, Italy, Portugal, Spain, and the United Kingdom was accomplished. The subsequent time series analysis focused on diverse economic aspects like output, percental share of the information sector, net-exports and also socio-economic issues e.g. absolute/relative employment within the information sector and high-skilled labour compensation. Particularly the financial crisis in the year 2008 revealed several interesting economic behaviours of the information sector and enabled drawing comprehensive conclusions or also prove obvious characteristics with bare figures. To summarize some findings: more high-skilled labour in general, makes an economy less vulnerable to exogenous threats; the ratio of high-skilled labour is much higher within the information sector; the output/final demand volatility of South-European countries, especially Portugal, is higher than in Central European

countries; continuous increase of the information sector's relative share (aiming for 50 % and more). Some of these findings allow conclusions on a country's economy like drawbacks from missed structural reforms or obsolete development of economic sectors.
The construction of technical coefficient matrices, better known as Leontief-Inverse matrices, and multiplier effects as well as inter-industry linkages represents the main basis for conducting the bottom-up impact analysis. The computation of multipliers and linkages is built on these technical coefficient matrices, which in turn require standardized values for their construction. Therefore it is necessary to compute from the absolute values of the Z-matrix, input coefficients which then constitute the A-matrix. All mathematical models and methodologies are explained in detail also with regard to replicability.
From all these previous construction and computation steps it is obvious that it exceeds the scope of manual treatment. Thus it was necessary to evaluate all steps, if they are automatable effectively. Matlab scripts represent the major implementation efforts, to be able to read, process and export data en masses. Excel functionalities and macros complete the picture of automation tasks. All self-written/used source codes are provided in the appendix for comprehensive understanding issues on the one hand and to enable interested readers of re-computing several results on their own on the other hand.
The main results of the thesis' impact analysis are the following objects: evaluation/visualization of changed input coefficients ('ceteris paribus') and their effects on technical coefficients as well as the inter-industry correlations; output and employment multipliers; net backward- and forward-linkages. A highly essential industry of the information sector, which can be used exemplary, is the 'Financial Intermediation'. When changing only a single coefficient of it e.g. due to efficiency savings or output increases, almost all other industries react positively correlated. To make these inter-industry relations more obvious, a 3D-model was computed (see visualizations in the appendix). The calculated output multipliers of information sector industries are compared to the residual industries pretty high. Though industries like 'Construction' feature a greater one, which might be a reason, that there the investment incentives are higher. To consider also the socio-economic context, the employment multiplier was computed too. It is an important indicator for absolute and relative changes in the labour force, when there is an increase/decrease in final demand. Information sector industries feature averaging high multipliers, which should be used to foster these industries and the benefiting rest of the economy. Net backward-linkages as well as forward linkages indicate the impact of a single industry in two directions. Information sector industries feature again a very high forward- and backward-linkage, which makes them very important as crucial points for exogenous control tasks. This economic behaviour can be reconstructed not only when considering the linkages but also when looking at the 3D visualizations of changed input coefficients.
Furthermore many differences between the investigated countries were found e.g. South European countries tend to have a lower relative share of the information sector, compared to their whole economy, as well as there is a deficiency of high-skilled labour. Germany and the UK are better placed due to their strong information sector industries e.g. high output, high inter-industry correlation or larger positive employment effects. Portugal is one of the weakest countries regarding its information sector, as many basic structural policies were not carried out and also the shift of its economy from primary and secondary activities to tertiary and especially quaternary activities is still in its early stage. Austria's information sector features good

economic results, but there is still a need for improvement concerning the socio-economic stimuli e.g. high-skilled labour within the information sector and the residual industries.

9.2. Discussion of Limitations

The industry classification is partly based on existing approaches e.g. from the OECD. As there was generally not enough information available, to decide whether and industry's main business activity is information sector related or not, a very strict approach had to be conducted. The industry 'Renting of M&Eq and Other Business Activities' is a good example: It incorporates diverse business activities, where it is not exactly clear if all of them are information sector related. Thus the little information available by some definition approaches was used, to be able to make a distinction decision. This shows that the classification cannot be fully correct, but as the required information is hardly available, this limitation has to be accepted. The distinction approach by Karlics[178] follows a similar approach, where such information was missing too.

The data prolongation for the years 2010 and 2011 is delicate because of two reasons: On the one hand it is only a projection of values and on the other hand the effects of the financial crisis still distort a 'normal' development of an economy, which makes it even harder to determine the right growth for all industries. Although data from Eurostat was used, the industry classification mapping incorporates a risk. The computation of final demand, exports and imports was based on the assumption of non-structural changes over time. Thus inter-industrial changes cannot be described. The AGR has some limitations e.g. how to determine the time span for retrieving appropriate growth rates? The GRAS-algorithm provides very robust results, but as it does also not describe structural changes, it is only a projection of values. These limitations of national input-output tables for the last two years have to be considered carefully. The time series analysis is the one and only part in the thesis, which is using these approximated values. The impact analysis was conducted on the data set of the year 2009, which is fully provided by WIOD.

9.3. Future Work

One key issue for a bottom-up future work is the implementation of a forecast for the development of the information sector as a whole and its related industries. This requires a lot of econometric know-how, to be able to retrieve robust and sophisticated results. Moreover the raised time and cost expenses have to be compensated somehow too. Therefore it seems feasible to outsource this task to a statistical institute e.g. Statistik Austria, which gets paid for conducting this forecast. When aiming to keep the project 'in-house' a good possibility is also to allocate some budget/manpower and especially use the present knowledge of the 'Institute for Mathematical Methods in Economics' at the Vienna University of Technology. This approach has the advantage, that the built up knowledge and stronger commitment to the project facilitates the resumption and could also gain more experience in the fields of input-output analysis.

Besides the implementation of a forecast there is also the possibility of using this thesis as a basis for lectures in the fields of input-output analysis at the Vienna University of Technology. In former times there were many of such courses, but due to structural changes in several study plans, there are none of them hold anymore. This thesis could be used to bring the materials up

[178] **Karlics** (2010), p. 95-102.

to date and also establish or reactivate contacts to professors, who are willing to lecture on these topics.

Another field of application, which was already mentioned in previous chapters, is the usage of the thesis' results and methodologies for external agents like economists or researchers regarding input-output analysis. Used approaches like the GRAS-algorithm, AGR or different types of impact analyses provide a wide range of feasibilities. In addition the main outcome represents a rich data as well as methodical basis for current and upcoming projects at the Institute for Mathematical Methods in Economics.

9.4. Epilogue

The correspondence, particularly at the beginning of the thesis, with diverse organizations like the OECD in New York, Eurostat in Berlin and Statistik Austria in Vienna or professors from Universities of Lisbon, Porto, Groningen and Vienna, was of special interest to me. Establishing contacts and introducing the aims of my thesis sometimes led to interesting exchanges of ideas, especially my chosen methodology. Most of the time the piece of advice was very small, as some used approaches in my thesis like applying the GRAS-algorithm for prolonging the data of an input-output table was quite new for some, but still I was satisfied with it, as my understanding for present or upcoming challenges has widened through these discussions. Sometimes mathematical problems or issues with the quality of the provided data seemed unsolvable. In several cases a comprehensive change of thinking was necessary and in others it was more a matter of time input to overcome an obstacle. It was always quite clear to me that I have to aim for several interim results, as most of the thesis follows a bottom-up approach. Through the whole origination process, I can state now at the very end that I would not have been able at the beginning to predict the exact structure but rather concerning the solution methodologies than the final outcome. In fact this made the thesis' creative work an interesting experience for me as also the domain of input-output analysis was new to me.

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10.2. List of Web Resources

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10.3. List of Figures

10.4. List of Tables

10.5. List of Acronyms

AGR	average growth rate
DIKW	data information knowledge wisdom
EC	European Commission
ESA	European System of National and Regional Accounts
EU	European Union
FD	Final Demand
GDP	gross domestic product
GNP	gross national product
GRAS	Generalized RAS-Algorithm (also Bi-Proportional Fitting)
ICT	information communication technology
IPF	iterative proportional fitting
IS	information sector
ISIC	International Standard Industrial Classification
KAM	knowledge assessment methodology
KBE	knowledge-based economy
KEI	Knowledge Economy Index
KI	Knowledge Index
KPI	key performance indicator
NACE	Statistical classification of economic activities in the European Community
NAICS	North American Industry Classification System
NIPA	National Income and Product Accounts
OECD	Organisation for Economic Co-operation and Development
R&D	Research & Development
SIC	Standard Industrial Classification
SNA	System of National Accounts
STAN	Structural Analysis
SUT	Supply and Use Table
WIIW	Wiener Institut für international Wirtschaftsvergleiche
WIOD	World Input Output Database

11. Appendix

11.1. 'Tableau Economique'

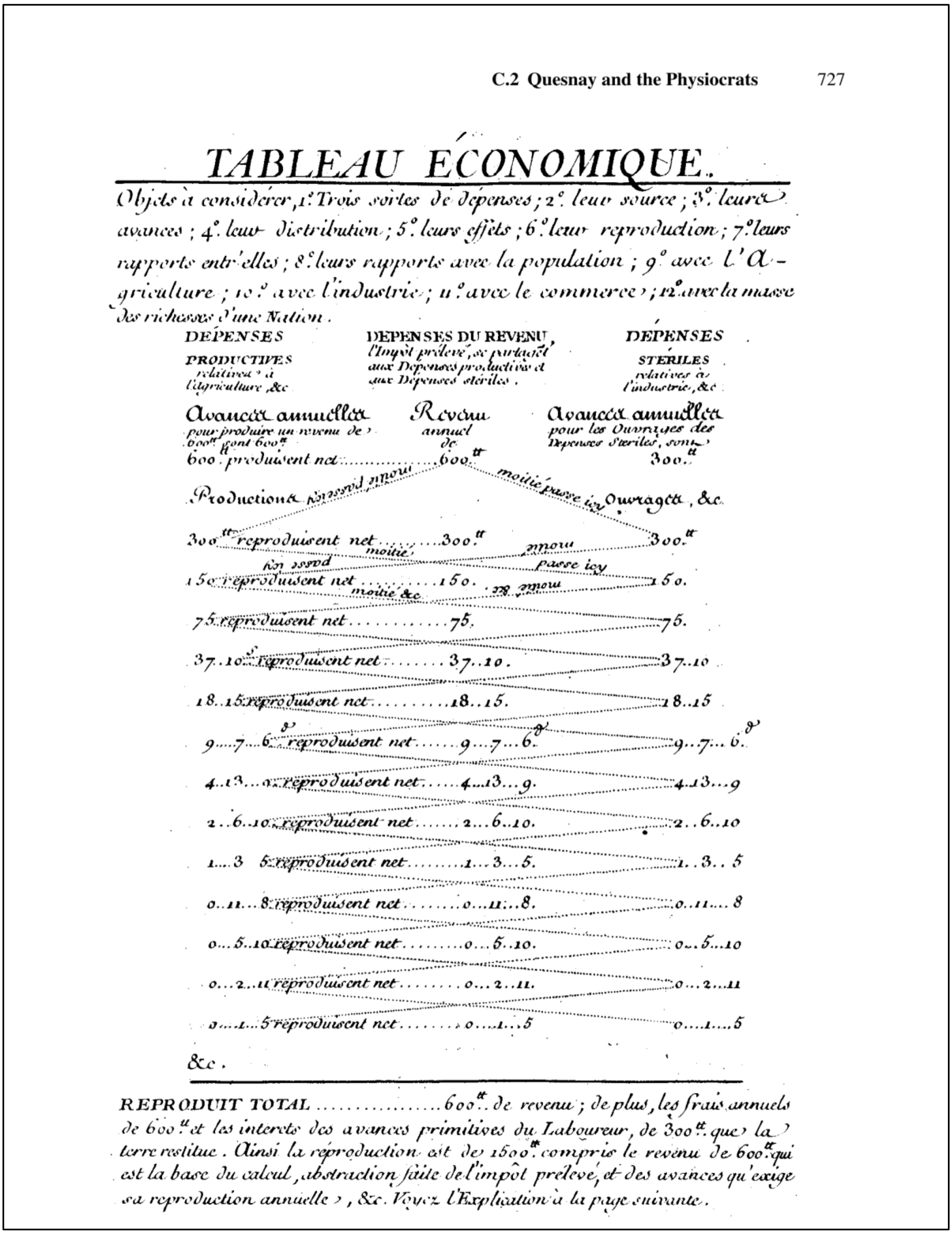

C.2 Quesnay and the Physiocrats 727

TABLEAU ÉCONOMIQUE.

Objets à considérer, 1°. Trois sortes de dépenses; 2°. leur source; 3°. leurs avances; 4°. leur distribution; 5°. leurs effets; 6°. leur reproduction; 7°. leurs rapports entr'elles; 8°. leurs rapports avec la population; 9°. avec l'Agriculture; 10°. avec l'industrie; 11°. avec le commerce; 12°. avec la masse des richesses d'une Nation.

DÉPENSES PRODUCTIVES relatives à l'Agriculture, &c.	DÉPENSES DU REVENU, l'Impôt prélevé, se partagent aux Dépenses productives et aux Dépenses stériles.	DÉPENSES STÉRILES relatives à l'industrie, &c.
Avances annuelles pour produire un revenu de 600tt sont 600tt	Revenu annuel de	Avances annuelles pour les Ouvrages des Dépenses Stériles, sont
600 produisent net	600tt	300tt
Productions	moitié passe ici	Ouvrages, &c.
300tt reproduisent net	300tt	300tt
150 reproduisent net	150	150
75 reproduisent net	75	75
37..10 reproduisent net	37..10	37..10
18..15 reproduisent net	18..15	18..15
9...7...6 reproduisent net	9...7...6	9...7...6
4..13...9 reproduisent net	4...13...9	4..13...9
2..6..10 reproduisent net	2...6..10	2..6..10
1...3...5 reproduisent net	1...3...5	1..3..5
0..11...8 reproduisent net	0...11...8	0...11...8
0...5..10 reproduisent net	0...5..10	0...5...10
0...2..11 reproduisent net	0...2..11	0...2...11
0...1...5 reproduisent net	0...1...5	0....1....5
&c.		

REPRODUIT TOTAL .... 600tt. de revenu; de plus, les frais annuels de 600tt et les interets des avances primitives du Laboureur, de 300tt. que la terre restitue. Ainsi la reproduction est de 1500tt. compris le revenu de 600tt qui est la base du calcul, abstraction faite de l'impôt prélevé, et des avances qu'exige sa reproduction annuelle, &c. Voyez l'Explication à la page suivante.

Figure 17 Francois Quesnay: 'Tableau Economique'[179]

[179] Source: **Kenessey** (2009), p. 360.

11.2. ISIC Rev.2

1 Agriculture, Hunting, Forestry and Fishing
- 11 Agriculture and Hunting
- 12 Forestry and logging
- 13 Fishing

2 Mining and Quarrying
- 21 Coal Mining
- 22 Crude Petroleum and Natural Gas Production
- 23 Metal Ore Mining
- 29 Other Mining

3 Manufacturing
- 31 Manufacture of Food, Beverages and Tobacco
- 32 Textile, Wearing Apparel and Leather Industries
- 33 Manufacture of Wood and Wood Products, Including Furniture
- 34 Manufacture of Paper and Paper Products, Printing and Publishing
- 35 Manufacture of Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products
- 36 Manufacture of Non-Metallic Mineral Products, except Products of Petroleum and Coal
- 37 Basic Metal Industries
- 38 Manufacture of Fabricated Metal Products, Machinery and Equipment
- 39 Other Manufacturing Industries

4 Electricity, Gas and Water
- 41 Electricity, Gas and Steam
- 42 Water Works and Supply

5 Construction
- 50 Construction

6 Wholesale and Retail Trade and Restaurants and Hotels
- 61 Wholesale Trade
- 62 Retail Trade
- 63 Restaurants and Hotels

7 Transport, Storage and Communication
- 71 Transport and Storage
- 72 Communication

8 Financing, Insurance, Real Estate and Business Services
- 81 Financial Institutions
- 82 Insurance
- 83 Real estate and Business Services

9 Community, Social and Personal Services
- 91 Public Administration and Defence
- 92 Sanitary and Similar Services
- 93 Social and Related Community Services
- 94 Recreational and Cultural Services
- 95 Personal and Household Services
- 96 International and Other Extra-Territorial Bodies

0 Activities not Adequately Defined
- 00 Activities not adequately defined

Source: United Nations Statistics Division ISIC Rev.2 <http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=8&Lg=1> (accessed August 2013).

11.3. Matlab Function ‘eurostat_to_wiod()’

```
%written by Anton Paukner, October 2013
function eurostat_to_wiod()
%path and range variables
inputfilename = 'path to input-file';
outfilename = 'path to output-file';
wiodfilename = 'path to wiod-file';
xlRange2009 = 'B13:B76';
xlRange2010 = 'C13:C76';
xlRange2011 = 'D13:D76';
country_indic_range = 'B8:B9';
years_range = 'D4:F4';
name_range = 'A1:A2';
wiod_range = 'A5:C39';
years = [2009, 2010, 2011];
[a, b, wiod_structure] = xlsread(wiodfilename, 1, 'A1:C35');
sheet = 1;

%check if output-file already exists
if exist(outfilename)
    delete(outfilename);
    disp('Existing file deleted!');
end

%preparing structure of excel file: country names, indic_na, years, tables
i=1;
while i <= 14
    [c, d, name]=xlsread(inputfilename, i, country_indic_range);
    xlswrite(outfilename, name, i, name_range);
    xlswrite(outfilename, years, i, years_range);
    xlswrite(outfilename, wiod_structure, i, wiod_range);
    i=i+1;
end
disp('Creation of Excel-file structure was successful!');

%reading values from Eurostat
while sheet <= 14
    v2009 = xlsread(inputfilename, sheet, xlRange2009);
    v2010 = xlsread(inputfilename, sheet, xlRange2010);
    v2011 = xlsread(inputfilename, sheet, xlRange2011);

    %harmonizing classification structure of Eurostat
    hv2009 = harmonize(v2009,2009);
    hv2010 = harmonize(v2010,2010);
    hv2011 = harmonize(v2011,2011);

    %writing harmonized and USD to EUR converted values into new excel file
    xlswrite(outfilename,hv2009, sheet, 'D5:D39');
    xlswrite(outfilename,hv2010, sheet, 'E5:E39');
    xlswrite(outfilename,hv2011, sheet, 'F5:F39');

sheet = sheet + 1;
%Spain has to be calculated manually
if sheet == 3
   sheet = sheet + 2;
```

```
end
end

%auxiliary function used for harmonizing the industry classification
function [hV] = harmonize(V, year)
eur2009=1.3948;
eur2010=1.3257;
eur2011=1.3920;

c1=sum(V([1 2 3]));
c2=V(4);
c3=V(5);
c4=V(6);
c5=V(6);
c6=V(7);
c7=sum(V([8 9 37]));
c8=V(10);
c9=sum(V([11 12]));
c10=V(13);
c11=V(14);
c12=sum(V([15 16]));
c13=V(19);
c14=sum(V([17 18]));
c15=sum(V([20 21]));
c16=sum(V([22 23]));
c17=sum(V([24 25 26]));
c18=V(27);
c19=V(28);
c20=V(29);
c21=V(30);
c22=V(36);
c23=V(31);
c24=V(32);
c25=V(33);
c26=sum(V([34 53]));
c27=sum(V([35 38 39]));
c28=sum(V([41 42 43]));
c29=V(44);
c30=sum(V([40 46 47 48 49 50 51 52 54]));
c31=V(55);
c32=V(56);
c33=V(57);
c34=sum(V([58 59 60 61 62]));
c35=V(63);

x=[c1, c2, c3, c4, c5, c6, c7, c8, c9, c10, c11, c12, c13, c14, c15, c16,
    c17, c18, c19, c20, c21, c22, c23, c24, c25, c26, c27, c28, c29, c30,
    c31, c32, c33, c34, c35]';

%additional conversion from EUR to USD
if year == 2009
    hV = x*eur2009;
elseif year == 2010
    hV = x*eur2010;
elseif year == 2011
    hV = x*eur2011;
end
```

11.4. GRAS-Algorithm – Matlab Sourcecode

```
function [X,r,s] = gras(X0,u,v,eps)
% PURPOSE: estimate a new matrix X with exogenously given row and column
% totals that is a close as possible to a given original matrix X0 using
% the Generalized RAS (GRAS) approach
% -------------------------------------------------------------------------
% USAGE: X = gras(X0,u,v) OR [X,r,s] = gras(X0,u,v) with or without eps
% included as the fourth argument, where
% INPUT:
% -> X0 = benchmark (base) matrix, not necessarily square
% -> u = column vector of (new) row totals
% -> v = column vector of (new) column totals
% -> eps = convergence tolerance level; if empty, the default threshold
% is 0.1e-5 (=0.000001)
% OUTPUT:
% -> X = estimated/adjusted/updated matrix
% -> r = substitution effects (row multipliers)
% -> s = fabrication effects (column multipliers)
% -------------------------------------------------------------------------
% REFERENCES: 1) Junius T. and J. Oosterhaven (2003), The solution of
% updating or regionalizing a matrix with both positive and negative
% entries, Economic Systems Research, 15, pp. 87-96.
% 2) Lenzen M., R. Wood and B. Gallego (2007), Some comments on the GRAS
% method, Economic Systems Research, 19, pp. 461-465.
% 3) Temurshoev, U., R.E. Miller and M.C. Bouwmeester (2013), A note on the
% GRAS method, Economic Systems Research, 25, pp. 361-367.
% -------------------------------------------------------------------------
% NOTE FROM THE AUTHOR: If you use this program and publish the results in
% the form of working/discussion papers, journal articles etc., you are
% kindly asked to cite the third paper mentioned above (as this code is the
% online Appendix to that paper).
% -------------------------------------------------------------------------
% Written by:   Umed Temurshoev, 07/10/2010 with later adjustments
%               Current e-mail: umed.temurshoev@ec.europa.eu

[m,n] = size(X0);
N = zeros(m,n);
N(X0<0) = -X0(X0<0);
N = sparse(N);      %could save memory with large-scale matrices
P = X0+N;
P = sparse(P);

r = ones(m,1);      %initial guess for r (suggested by J&O, 2003)
pr = P'*r;
nr = N'*invd(r)*ones(m,1);
s1 = invd(2*pr)*(v+sqrt(v.^2+4*pr.*nr));    %first step s
ss = -invd(v)*nr;
s1(pr==0) = ss(pr==0);
ps = P*s1;
ns = N*invd(s1)*ones(n,1);
r = invd(2*ps)*(u+sqrt(u.^2+4*ps.*ns));     %first step r
rr = invd(u)*ns;
r(ps==0) = rr(ps==0);

pr = P'*r;
```

```
nr = N'*invd(r)*ones(m,1);
s2 = invd(2*pr)*(v+sqrt(v.^2+4*pr.*nr));    %second step s
ss = -invd(v)*nr;
s2(pr==0) = ss(pr==0);
dif = s2-s1;
iter = 1                  %first iteration
if  nargin < 4 || isempty(eps)
    eps = 0.1e-5;         %default tolerance level
end
M = max(abs(dif));
while (M > eps)
    s1 = s2;
    ps = P*s1;
    ns = N*invd(s1)*ones(n,1);
    r = invd(2*ps)*(u+sqrt(u.^2+4*ps.*ns));   %previous step r
    rr = -invd(u)*ns;
    r(ps==0) = rr(ps==0);
    pr = P'*r;
    nr = N'*invd(r)*ones(m,1);
    s2 = invd(2*pr)*(v+sqrt(v.^2+4*pr.*nr));  %current step s
    ss = -invd(v)*nr;
    s2(pr==0) = ss(pr==0);
    dif = s2-s1;
    iter = iter+1
    M = max(abs(dif));
end
s = s2;                                        %final step s
ps = P*s;
ns = N*invd(s)*ones(n,1);
r = invd(2*ps)*(u+sqrt(u.^2+4*ps.*ns));        %final step r
rr = -invd(u)*ns;
r(ps==0) = rr(ps==0);
X = diag(r)*P*diag(s)-invd(r)*N*invd(s);       %updated matrix

function invd = invd(x)         %auxiliary function used above
invd = 1./x;
invd(x==0) = 1;
invd = diag(invd);
```

Source: Temurshoev, U., R.E. Miller and M.C. Bouwmeester (2013), A note on the GRAS method, Economic Systems Research, 25, pp. 361-367.

11.5. Excel Macro 'Add_NetExports'

```
'written by Anton Paukner, October 2013
Attribute VB_Name = "Modul1"
Sub Add_NetExports()
Attribute Add_NetExports.VB_ProcData.VB_Invoke_Func = "X\n14"
'
' Add_NetExports Makro
'
' Tastenkombination: Strg+Umschalt+X
'
    Range("AU4").Select
    With Selection.Interior
        .Pattern = xlSolid
        .PatternColorIndex = xlAutomatic
        .ThemeColor = xlThemeColorLight2
        .TintAndShade = 0.799981688894314
        .PatternTintAndShade = 0
    End With
    With Selection
        .HorizontalAlignment = xlCenter
        .VerticalAlignment = xlBottom
        .WrapText = True
        .Orientation = 0
        .AddIndent = False
        .ShrinkToFit = False
        .ReadingOrder = xlContext
        .MergeCells = False
    End With
    ActiveCell.FormulaR1C1 = "Net_Exports"
    Range("AU6").Select
    ActiveCell.FormulaR1C1 = "c45"
    Range("AU7").Select
    ActiveCell.FormulaR1C1 = "=RC[-2]-SUM(R[35]C[-42]:R[35]C[-8])"
    Range("AU8").Select
    ActiveWindow.SmallScroll Down:=-12
    Range("AU7").Select
    Selection.AutoFill Destination:=Range("AU7:AU41"),
Type:=xlFillDefault
    Range("AU7:AU41").Select
    Range("AU42").Select
    ActiveCell.FormulaR1C1 = "=SUM(R[-35]C:R[-1]C)"
    Range("AU43").Select
End Sub
```

11.6. Matlab Function 'computeTechnCoeffMatr()'

```
%written by Anton Paukner, October 2013
function computeTechnCoeffMatr()
inputfilePath= '...\Master Thesis\Sourcen\Technical Coeffcient Matrices\';
outfilePath = '...\Master Thesis\Sourcen\Technical Coeffcient Matrices\Output\';
rangeInnerMatrix = 'E7:AM41';
rangeOutputTotals = 'E84:AM84';
rangeOutput = 'A1:AI35';
countries = {'AUT.xlsm', 'GER.xlsm', 'ESP.xlsm', 'FRA.xlsm', 'GBR.xlsm',
'ITA.xlsm', 'PRT.xlsm'};
outputTables = {'AUT_LI.xlsm', 'GER_LI.xlsm', 'ESP_LI.xlsm', 'FRA_LI.xlsm',
'GBR_LI.xlsm', 'ITA_LI.xlsm', 'PRT_LI.xlsm'};
sheet=2;
i=1;

while i <= length(countries)
    while sheet <= 18
         %import values of Z-matrix
         M = xlsread(strcat(inputfilePath, countries{i}), sheet, rangeInnerMatrix);

         %import column totals
         colTot = xlsread(strcat(inputfilePath, countries{i}), sheet,
rangeOutputTotals)';

         %compute input coefficient matrix
         ICM = computeICM(M, colTot);

         %compute Leontief-Inverse: (IdentityMatrix-ICM)^(-1)
         LI = inv(eye(35,35)-ICM);

         xlswrite(strcat(outfilePath, outputTables{i}), LI, sheet-1, rangeOutput);
         sheet=sheet + 1;
         clearvars colTot ICM LI;
    end
    sheet=2;
    i=i+1;
end

function [ICM] = computeICM(M, colTot)
k=1;
l=1;

while k <= 35
    while l <=35        %avoid div by 0, because of colTot = 0
        if l==35
            ICM(k, l) = 0;
            l=l+1;
        else
            ICM(k, l) = M(k,l)/colTot(l);
            l=l+1;
        end
    end
    l=1;
    k=k+1;
end
```

11.7. Matlab Function 'compute_Multiplier()'

```
function compute_Multiplier()
%written by Anton Paukner, November 2013
inputfilePathLI= '...\Master Thesis\Sourcen\IMPACT  ANALYSIS\2
multipliers\Input_Leontief\';
inputfilePathIOT= '...\Master Thesis\Sourcen\IMPACT  ANALYSIS\2
multipliers\IOT_with_netexports\';
inputfilePathEmplCoeff = ...\Master Thesis\Sourcen\IMPACT  ANALYSIS\2
multipliers\IOT_with_netexports_and_social_coeff\';
outfilePath = ...\Master Thesis\Sourcen\IMPACT  ANALYSIS\2
multipliers\OutputMultiplier\';
rangeLI = 'B2:AJ36';
rangeEmplCoeff = 'B39:R73';
rangeAbsEmpl = 'B2:R36';
rangeFD = 'AN7:AP41';
firstRow='B1:R1';
firstCol='A2:A36';
outputRange = 'B2:R36';
countries = {'AUT.xlsm', 'GER.xlsm', 'ESP.xlsm', 'FRA.xlsm', 'GBR.xlsm',
'ITA.xlsm', 'PRT.xlsm'};
outputTables = {'AUT_Mult.xlsm', 'GER_Mult.xlsm', 'ESP_Mult.xlsm', 'FRA_Mult.xlsm',
'GBR_Mult.xlsm', 'ITA_Mult.xlsm', 'PRT_Mult.xlsm'};
country_acron =
{'c1','c2','c3','c4','c5','c6','c7','c8','c9','c10','c11','c12','c13','c14','c15','
c16','c17','c18','c19','c20','c21','c22','c23','c24','c25','c26','c27','c28','c29',
'c30','c31','c32','c33','c34','c35'};
years = {'1995', '1996', '1997', '1998', '1999', '2000', '2001', '2002', '2003',
'2004', '2005', '2006', '2007', '2008', '2009', '2010','2011'};
sheet=1;
i=1;
j=1;
diagonal=1;

while i <= length(countries)
    %imports
    EmplCoeffM = xlsread(strcat(inputfilePathEmplCoeff, countries{i}), 19,
rangeEmplCoeff);
    absEmpl = xlsread(strcat(inputfilePathEmplCoeff, countries{i}), 19,
rangeAbsEmpl);

    %prepare structure
    xlswrite(strcat(outfilePath, outputTables{i}), country_acron', 1, firstCol);
    xlswrite(strcat(outfilePath, outputTables{i}), years, 1, firstRow);
    xlswrite(strcat(outfilePath, outputTables{i}), country_acron', 2, firstCol);
    xlswrite(strcat(outfilePath, outputTables{i}), years, 2, firstRow);
    xlswrite(strcat(outfilePath, outputTables{i}), country_acron', 3, firstCol);
    xlswrite(strcat(outfilePath, outputTables{i}), years, 3, firstRow);
    xlswrite(strcat(outfilePath, outputTables{i}), country_acron', 4, firstCol);
    xlswrite(strcat(outfilePath, outputTables{i}), years, 4, firstRow);
    xlswrite(strcat(outfilePath, outputTables{i}), country_acron', 5, firstCol);
    xlswrite(strcat(outfilePath, outputTables{i}), years, 5, firstRow);

    while sheet <= 17
        %import Leontief-Inverse matrix and final demand
        LI = xlsread(strcat(inputfilePathLI, countries{i}), sheet, rangeLI);
```

```
        FD = xlsread(strcat(inputfilePathIOT, countries{i}), sheet+1, rangeFD);

        while j <=35
            %compute employment multiplier
            emplMultM(j,sheet) = EmplCoeffM(:,sheet)'*LI(:,j);

            %compute relative change of employment with 1% change in FD
            DeltaFD(j, sheet) = (emplMultM(j,sheet) *
(sum(FD(j,:))*1000000*0.01))*100/(absEmpl(j, sheet)*1000);

            %compute output multiplier
            outputMultM(j, sheet) = sum(LI(:, j));

            %compute net backward linkage
            netBLM(j, sheet) = sum(LI(:, j))-LI(diagonal,j);
            diagonal=diagonal + 1;

            %compute forward linkage matrix
            FLM(j, sheet) = sum(LI(j,:));
            j=j+1;
        end
        j=1;
        diagonal=1;
        sheet=sheet + 1;
        clearvars LI FD;
    end
    sheet=1;
    xlswrite(strcat(outfilePath, outputTables{i}), emplMultM, 1, outputRange);
    xlswrite(strcat(outfilePath, outputTables{i}), DeltaFD, 2, outputRange);
    xlswrite(strcat(outfilePath, outputTables{i}), outputMultM, 3, outputRange);
    xlswrite(strcat(outfilePath, outputTables{i}), netBLM, 4, outputRange);
    xlswrite(strcat(outfilePath, outputTables{i}), FLM, 5, outputRange);
    clearvars emplMult EmplCoeffM DeltaFD outputMultM netBLM FLM;
    i=i+1;
end
```

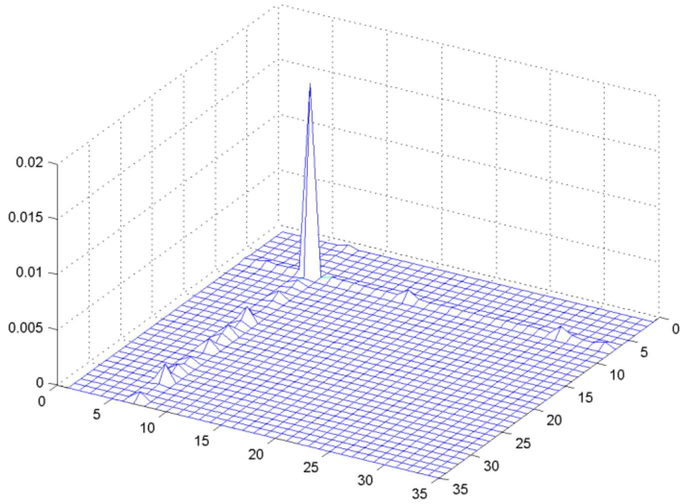
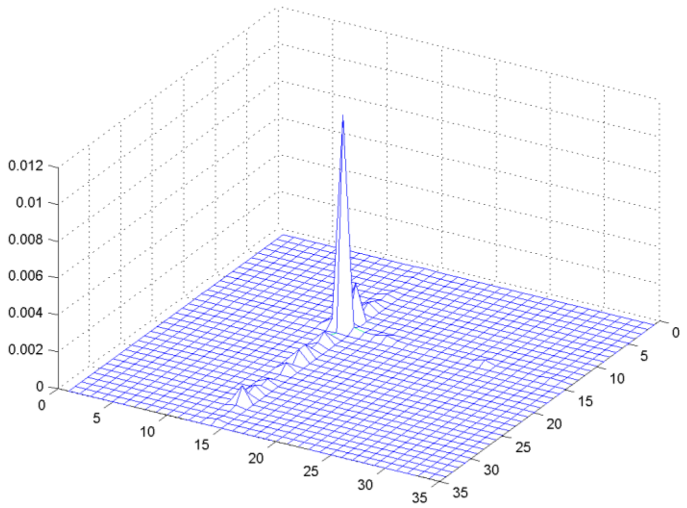
11.8. Matlab Function 'delta_input_coeff()'

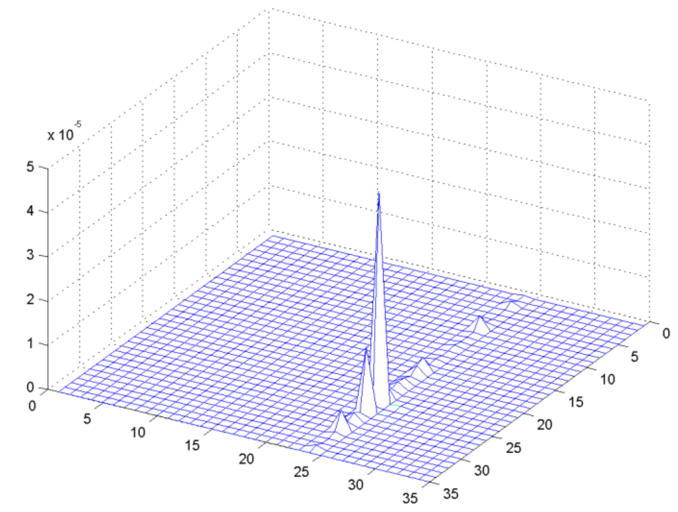
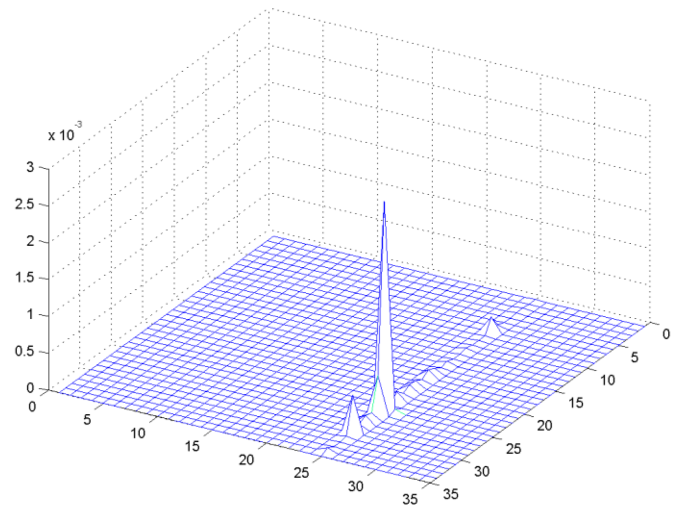
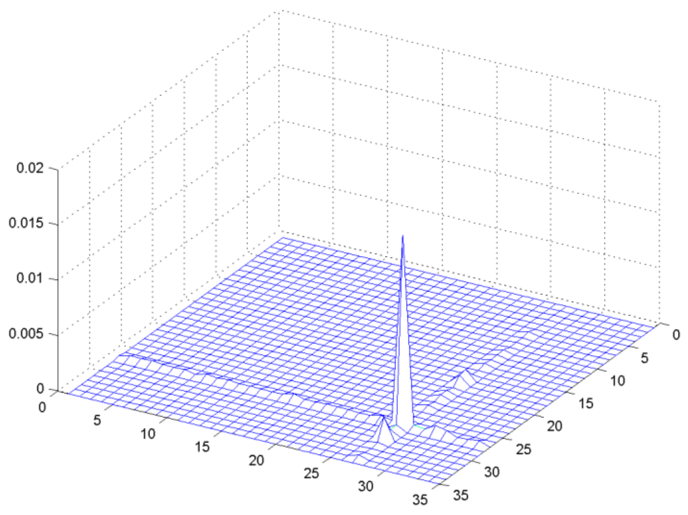
```
function delta_input_coeff()
%written by Anton Paukner, November 2013
inputfilePathTM= '...\Master Thesis\Sourcen\IMPACT  ANALYSIS\1 changing
coefficients\inputTM\';
inputfilePathLIold=...\Master Thesis\Sourcen\IMPACT  ANALYSIS\1 changing
coefficients\inputLI\';
outfilePathNewLI = ...\Master Thesis\Sourcen\IMPACT  ANALYSIS\1 changing
coefficients\output_LI\';
outfilePathPix = '...\Master Thesis\Sourcen\IMPACT  ANALYSIS\1 changing
coefficients\output_Pix\';
rangeTM = 'B2:AJ36';
outputRange = 'A1:AI35';
inputLIold = {'AUT_LI.xlsm', 'GER_LI.xlsm', 'ESP_LI.xlsm', 'FRA_LI.xlsm',
'GBR_LI.xlsm', 'ITA_LI.xlsm', 'PRT_LI.xlsm'};
countriesTM = {'AUT_TM.xlsm', 'GER_TM.xlsm', 'ESP_TM.xlsm', 'FRA_TM.xlsm',
'GBR_TM.xlsm', 'ITA_TM.xlsm', 'PRT_TM.xlsm'};
outputTables = {'AUT_LInew.xlsm', 'GER_LInew.xlsm', 'ESP_LInew.xlsm',
'FRA_LInew.xlsm', 'GBR_LInew.xlsm', 'ITA_LInew.xlsm', 'PRT_LInew.xlsm'};
outputPix = {'AUT.png', 'GER.png', 'ESP.png', 'FRA.png', 'GBR.png', 'ITA.png',
'PRT.png'};
i=1;
deltaLI=-0.1;
deltaLIcol=0;
deltaLIrow=0;
S=0;
T=0;

%change input coefficient
delta=-0.1;
row = 7;
col = 28;

while i <= length(countriesTM)
    %imports TM and LIold from the year 2009
    deltaTM = xlsread(strcat(inputfilePathTM, countriesTM{i}), 1, rangeTM);
    LIold = xlsread(strcat(inputfilePathLIold, inputLIold{i}), 15, rangeTM);

    %change specific input coefficient in TM
    deltaTM(row, col) =  deltaTM(row, col)* (1+delta);

    %compute Leontief-Inverse matrix
    LInew = inv(eye(35,35)-deltaTM);
    xlswrite(strcat(outfilePathNewLI, outputTables{i}), LInew, 1, outputRange);

    %compute deltaLI - always positive application
    if delta <=0
        deltaLI=LIold-LInew;
    else
        deltaLI=LInew-LIold;
    end

    pix=mesh(deltaLI);
    colormap winter
    set(gca,'XDir','reverse');
```

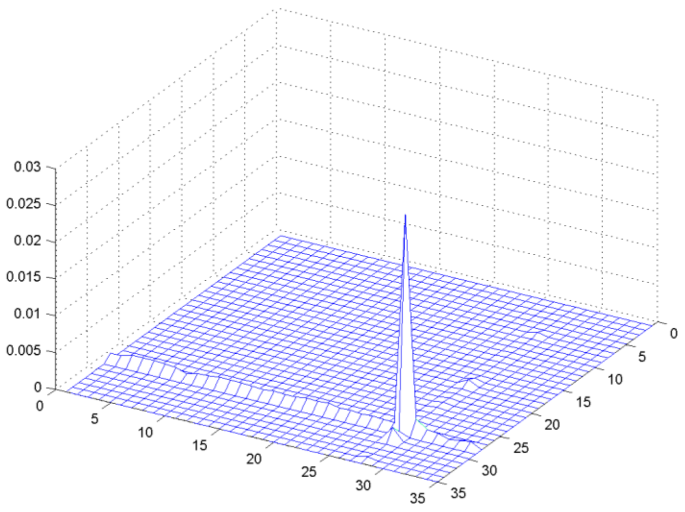
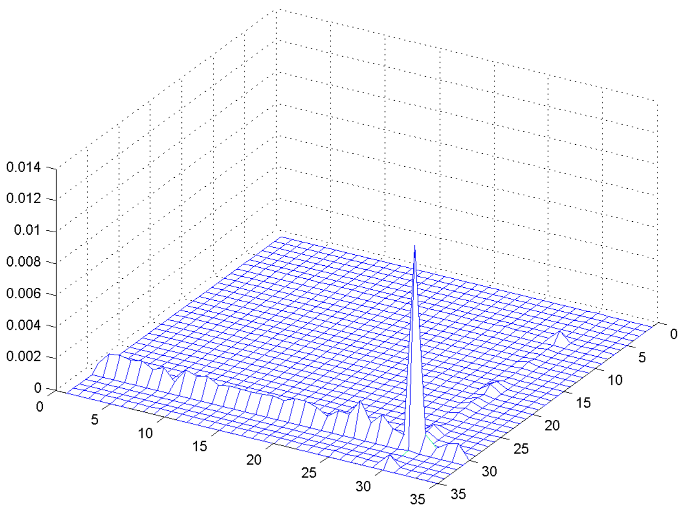
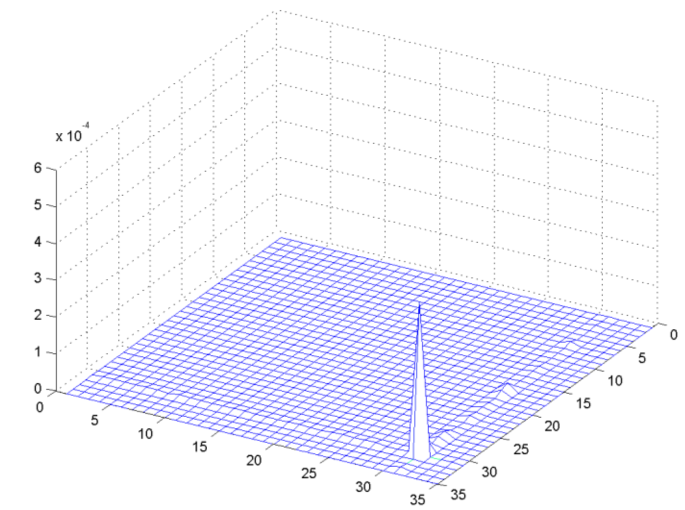
```
    view(210,40);

    %find coords of top 5 delta
    deltaLIrow=deltaLI(row,:);
    deltaLIcol=deltaLI(:,col);

    [I, J]=sort(deltaLIcol, 'descend');
    S=[I, J];
    [I, J]=sort(deltaLIrow, 'descend');
    T=[I, J];

    %display impacts on other industries
    disp(countriesTM{i});
    disp('column:');
    disp(S(37:41));
    disp(S(2:6));
    disp('row:');
    disp(T(37:41));
    disp(T(2:6));

    %export 3D picture of LInew-LIold
    saveas(pix, strcat(outfilePathPix, outputPix{i}));
    clearvars deltaTM LIold LInew pix
    i=i+1;
end
```

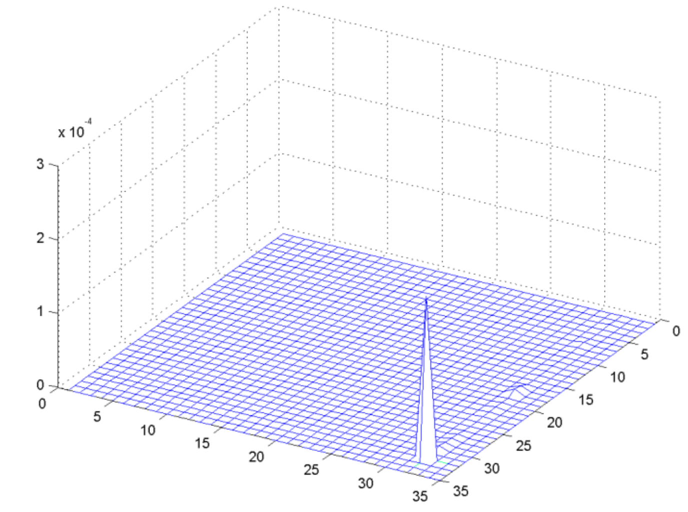
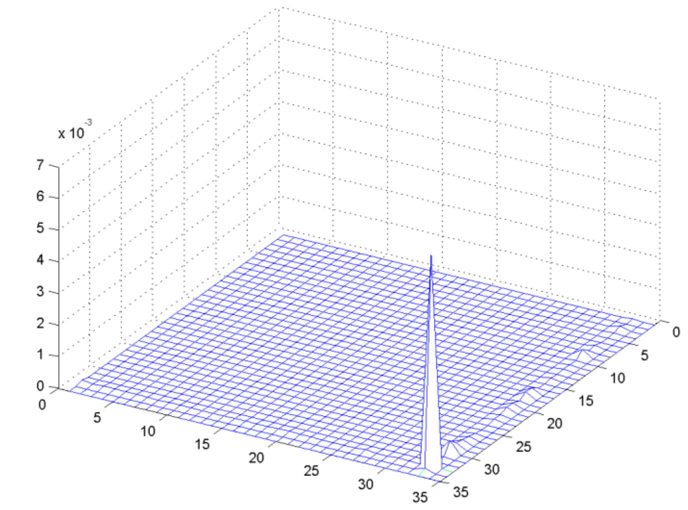
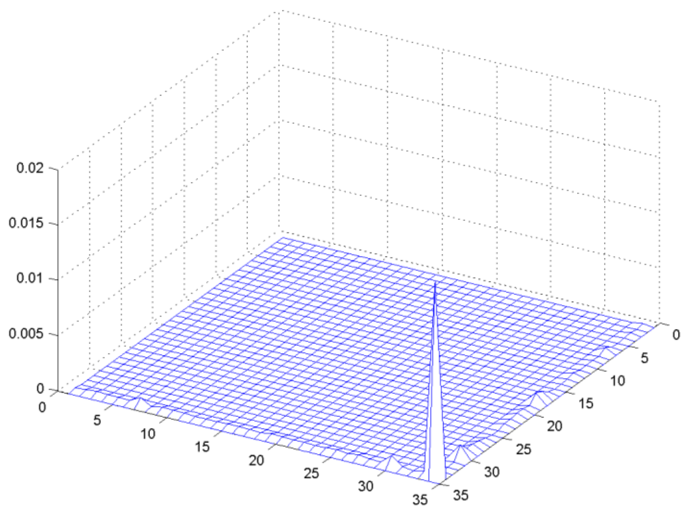
11.9. Effects of Changed Input Coefficients based on Spain

Table 28 Effects of Changed Diagonal Input Coeff. of the IS on the Techn. Coeff. (ESP)

$\mathbf{a_{7,7}}$	
$\mathbf{a_{14,14}}$	

$\mathbf{a}_{24,24}$	
$\mathbf{a}_{25,25}$	
$\mathbf{a}_{27,27}$	

$\mathbf{a_{28,28}}$	
$\mathbf{a_{30,30}}$	
$\mathbf{a_{31,31}}$	

$\mathbf{a_{32,32}}$	
$\mathbf{a_{33,33}}$	
$\mathbf{a_{34,34}}$	

11.10. Effects of Changed Input Coefficients based on Austria

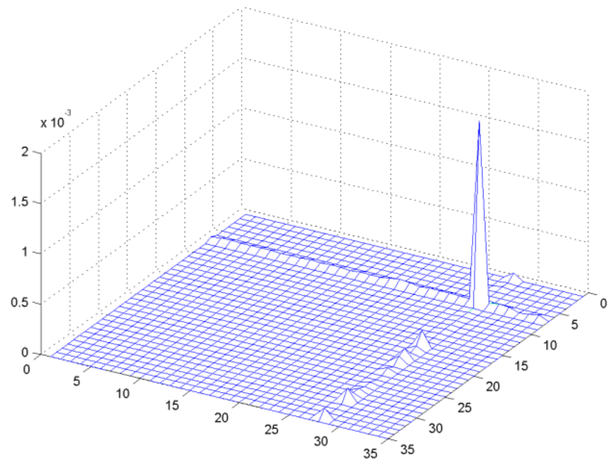
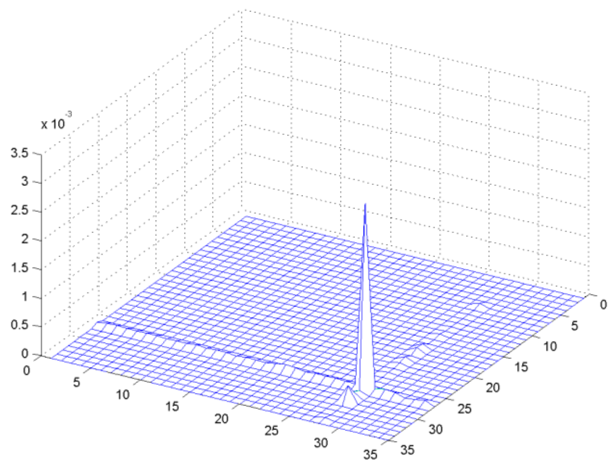
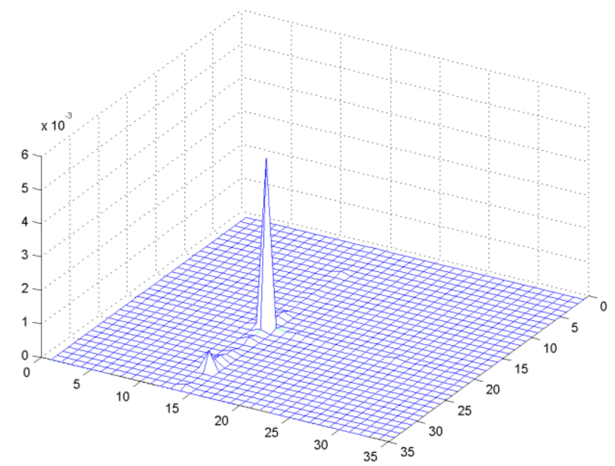
$\mathbf{a}_{7,28}$	
$\mathbf{a}_{27,28}$	
$\mathbf{a}_{20,14}$	

Table 29 Effects of Changed Input Coeff. of the IS on the Techn. Coeff. (AUT)

11.11. Output Multipliers – All Industries (2011)

	AUT	ESP	FRA	GER	ITA	PRT	UK
c1	1.70	1.74	1.88	1.71	1.64	1.81	1.60
c2	1.48	2.01	1.82	1.67	1.50	1.66	1.32
c3	1.88	2.44	2.37	1.92	2.18	2.15	1.88
c4	1.53	2.03	1.96	1.54	2.02	1.87	1.70
c5	1.72	2.11	1.73	1.49	2.12	1.79	1.67
c6	1.87	2.15	2.26	1.78	1.25	2.20	1.78
c7	1.73	1.98	1.98	1.70	7.86	1.87	1.69
c8	1.24	1.41	1.60	1.78	1.15	1.24	1.75
c9	1.49	1.96	2.00	1.61	1.94	1.90	1.66
c10	1.52	2.01	2.01	1.59	1.96	1.79	1.72
c11	1.63	2.18	2.05	1.73	1.94	1.94	1.72
c12	1.54	2.11	2.10	1.71	1.94	1.86	1.71
c13	1.54	2.16	2.03	1.66	1.98	1.64	1.66
c14	1.45	1.95	2.07	1.56	1.84	1.64	1.58
c15	1.43	1.99	2.07	1.76	2.04	1.61	1.71
c16	1.54	2.14	2.01	1.69	1.93	1.95	1.71
c17	2.41	2.23	1.89	1.66	1.41	2.17	1.80
c18	1.63	2.38	1.85	1.66	1.79	2.08	1.90
c19	1.40	1.76	1.53	1.41	1.86	1.38	1.55
c20	1.50	1.71	1.80	1.57	1.89	1.63	1.65
c21	1.46	1.58	1.57	1.57	1.74	1.52	1.56
c22	1.52	1.76	1.81	1.57	1.80	1.71	1.80
c23	1.55	1.85	1.64	1.63	1.70	1.73	1.69
c24	1.55	1.97	2.10	2.08	2.11	1.88	1.63
c25	1.71	1.97	1.63	1.75	2.04	1.91	1.54
c26	1.62	2.11	1.80	1.81	2.01	1.66	1.75
c27	1.64	1.80	1.74	1.59	1.68	1.71	1.67
c28	1.68	1.50	1.72	1.82	1.56	1.45	1.68
c29	1.47	1.34	1.19	1.23	1.11	1.23	1.40
c30	1.54	1.68	1.67	1.43	1.65	1.73	1.42
c31	1.38	1.47	1.31	1.39	1.39	1.39	1.57
c32	1.22	1.25	1.19	1.29	1.18	1.19	1.33
c33	1.37	1.57	1.24	1.31	1.48	1.54	1.78
c34	1.52	1.79	1.62	1.48	1.66	1.74	1.56
c35	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 30 Output Multipliers for all Industries FD Δ = 1 (2011)

11.12. Employment Multipliers – All Industries (2011)

	AUT	ESP	FRA	GER	ITA	PRT	UK
c1	502	1001	562	991	1035	1594	821
c2	369	987	593	790	436	1368	233
c3	631	989	756	946	690	1619	788
c4	660	1027	794	767	836	2387	866
c5	742	1063	871	902	799	2112	757
c6	593	1145	878	835	591	1891	710
c7	538	898	719	824	2859	1283	856
c8	134	178	223	473	73	187	291
c9	358	594	475	546	493	939	683
c10	573	861	744	747	672	1135	834
c11	590	860	715	810	800	1571	812
c12	493	788	708	625	714	1467	772
c13	556	990	702	664	711	1481	708
c14	548	794	750	666	716	918	769
c15	368	796	507	508	680	853	648
c16	542	1073	750	809	720	2121	756
c17	254	526	411	446	218	581	265
c18	695	1102	795	826	805	2521	802
c19	760	925	889	1386	744	1511	1159
c20	665	985	682	837	604	1989	1247
c21	1282	1386	1167	1748	853	2793	1190
c22	976	1011	1013	1877	825	2069	1192
c23	877	972	836	1248	512	1581	1248
c24	518	689	436	570	642	862	1153
c25	490	580	604	506	512	920	1232
c26	707	831	707	859	827	1238	1341
c27	608	607	753	827	631	808	1252
c28	618	377	581	668	519	826	865
c29	282	240	139	182	66	267	678
c30	760	1004	831	935	851	2028	757
c31	983	1314	1035	1119	862	1567	1427
c32	1127	1420	1248	1443	1368	2229	1871
c33	1261	1412	1135	1310	972	2112	1252
c34	977	1904	923	946	944	1762	1050
c35	7939	0	3103	7034	7536	6943	2173

Table 31 Employment Multipliers for all Industries FD Δ = 100 mill. (2011)

11.13. Net Backward-Linkages – All Industries (2011)

	AUT	ESP	FRA	GER	ITA	PRT	UK
c1	0.45	0.68	0.67	0.67	0.55	0.68	0.52
c2	0.46	1.00	0.79	0.66	0.47	0.61	0.27
c3	0.76	1.20	1.20	0.82	1.01	0.99	0.76
c4	0.50	0.90	0.81	0.54	0.78	0.61	0.66
c5	0.72	1.02	0.73	0.49	0.93	0.62	0.67
c6	0.69	0.90	1.07	0.63	0.19	0.76	0.56
c7	0.62	0.83	0.79	0.59	6.19	0.79	0.54
c8	0.23	0.29	0.47	0.71	0.13	0.18	0.74
c9	0.49	0.83	0.92	0.60	0.77	0.73	0.64
c10	0.50	0.86	0.93	0.55	0.89	0.76	0.65
c11	0.55	1.06	0.92	0.65	0.83	0.85	0.66
c12	0.41	0.80	0.74	0.45	0.67	0.57	0.58
c13	0.47	1.09	0.93	0.55	0.91	0.56	0.61
c14	0.41	0.85	0.99	0.48	0.73	0.45	0.55
c15	0.42	0.90	0.85	0.56	0.97	0.54	0.64
c16	0.50	1.09	0.98	0.65	0.88	0.89	0.69
c17	0.26	0.80	0.57	0.48	0.29	0.42	0.45
c18	0.50	0.86	0.69	0.61	0.69	0.70	0.54
c19	0.37	0.72	0.52	0.40	0.84	0.36	0.52
c20	0.45	0.67	0.71	0.53	0.76	0.61	0.64
c21	0.45	0.57	0.56	0.57	0.71	0.51	0.54
c22	0.51	0.76	0.78	0.57	0.78	0.70	0.80
c23	0.51	0.78	0.56	0.58	0.61	0.60	0.65
c24	0.55	0.97	0.83	1.05	1.10	0.83	0.63
c25	0.67	0.94	0.62	0.74	1.04	0.90	0.53
c26	0.55	0.84	0.53	0.59	0.90	0.59	0.49
c27	0.40	0.66	0.57	0.42	0.64	0.46	0.52
c28	0.43	0.23	0.43	0.45	0.28	0.37	0.60
c29	0.41	0.33	0.15	0.20	0.10	0.22	0.38
c30	0.30	0.52	0.34	0.19	0.42	0.45	0.18
c31	0.37	0.46	0.30	0.37	0.39	0.38	0.56
c32	0.21	0.25	0.19	0.19	0.15	0.18	0.28
c33	0.36	0.50	0.23	0.29	0.40	0.46	0.53
c34	0.42	0.63	0.52	0.33	0.53	0.64	0.42
c35	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 32 Net Backward-Linkages - All Industries (2011)

11.14. Forward-Linkages – All Industries (2011)

	AUT	ESP	FRA	GER	ITA	PRT	UK
c1	1.87	1.58	2.09	1.38	1.48	1.88	1.36
c2	1.13	1.12	1.15	1.09	1.28	1.32	1.98
c3	1.51	1.86	1.61	1.32	1.86	1.61	1.56
c4	1.05	1.24	1.22	1.01	1.50	1.41	1.05
c5	1.00	1.10	1.00	1.00	1.29	1.18	1.00
c6	1.38	1.46	1.38	1.26	1.31	1.87	1.33
c7	1.49	1.70	1.64	1.33	1.97	1.36	1.56
c8	1.18	1.89	1.96	1.66	1.71	2.14	1.17
c9	1.16	1.78	1.39	1.14	1.87	1.74	1.14
c10	1.16	1.61	1.45	1.26	1.45	1.30	1.32
c11	1.33	1.50	1.39	1.24	1.49	1.45	1.20
c12	1.53	3.03	2.58	2.11	2.69	2.12	1.72
c13	1.27	1.45	1.53	1.46	1.50	1.20	1.24
c14	1.22	1.36	1.29	1.39	1.57	1.43	1.13
c15	1.04	1.28	1.49	1.46	1.41	1.11	1.25
c16	1.16	1.42	1.15	1.11	1.34	1.20	1.09
c17	3.75	3.13	2.12	2.00	2.65	3.45	2.32
c18	2.23	2.64	1.67	1.52	2.05	2.25	1.98
c19	1.41	1.72	1.31	1.31	1.63	1.57	1.62
c20	2.55	2.57	3.08	2.16	3.91	2.41	2.13
c21	2.02	2.53	2.07	1.89	2.68	2.07	2.38
c22	1.26	1.32	1.35	1.03	1.61	1.45	1.04
c23	1.41	2.70	1.63	1.79	2.91	1.85	2.00
c24	1.00	1.05	1.31	1.09	1.05	1.07	1.00
c25	1.11	1.14	1.04	1.12	1.09	1.02	1.06
c26	1.72	2.98	2.30	2.73	2.26	1.83	2.37
c27	1.55	1.80	1.70	1.48	1.69	1.85	1.86
c28	2.15	3.19	3.10	2.52	2.77	2.82	2.36
c29	2.15	1.96	1.89	2.32	2.42	1.48	2.04
c30	3.89	4.74	7.41	5.58	5.80	4.26	5.52
c31	1.08	1.27	1.14	1.23	1.02	1.32	1.17
c32	1.07	1.10	1.17	1.24	1.13	1.08	1.24
c33	1.06	1.19	1.08	1.05	1.10	1.12	1.36
c34	1.57	1.69	1.52	1.88	1.81	1.37	1.64
c35	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 33 Forward-Linkages - All Industries (2011)