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The Role of the Austrian Service Sectors in Climate and Unemployment Mitigation Efforts

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Master of Science in Socio-Ecological Economics and Policy

Vienna, December 2021
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Abstract

This thesis analyzes the various Austrian sectors in terms of greenhouse gas emissions and employment to examine whether the job creation within specific service sectors could contribute towards climate mitigation efforts and an increase in employment. It uses an environmentally extended multi-regional input-output model based on data from EXIOBASE 3.8.1. The analysis considers greenhouse gas emissions, employment, and emission intensities per hour of employment, focusing on 2019, as well as decoupling tendencies, analyzing 1996 and 2019, of the Austrian sectors from a production and consumption perspective. It is being revealed that overall Austria displays a significant share of embodied emissions and embodied employment in international trade of total emissions and total employment. Furthermore, this thesis finds that from a production and consumption perspective the non-service sectors are responsible for a majority of the greenhouse gas emissions. In terms of employment, this thesis shows that from a production perspective the service sectors and from a consumption perspective the non-service sectors provide more employment. The analysis in terms of emission intensities reveals that from a production and consumption perspective the non-service sectors emit more greenhouse gas emissions per additional hour of employment than the service sectors. Additionally, the service sectors and the non-service sectors do not display decoupling tendencies from a production perspective. From a consumption perspective, the service sectors show absolute and the non-service sectors relative decoupling tendencies. Lastly, the analysis on a sectoral level shows that the health and public administration sectors, as well as other services are the most suitable when transitioning towards more labor intensive and less emission intensive sectors. The analysis has implications for the Austrian government, as it provides insights into how the government could reach both their objective concerning a reduction in terms of greenhouse gas emissions and an increase in employment.

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1.Introduction

The climate crisis is one of the biggest challenges humanity faces in the 21st century, which affects and will affect many people, for example in terms of their health or ability to work, if the current trend of global warming continues (IPCC, 2014). The IPCC report specifies that climate change results out of global warming and that the probability of global warming being due to human activity lies at more than 95% (IPCC, 2014). Therefore, governments are called upon to include strategies for the reduction of greenhouse gas (GHG) emissions in their governmental policy programs.

The Austrian government recognizes this responsibility in their recent governmental program, stating that the reduction of GHG emissions is at the core of the Austrian climate and energy strategy. Another objective of the Austrian government is to increase employment (BMNT and BMVIT, 2018; Die Neue Volkspartei and Die Grünen, 2020). This poses a challenge to the Austrian government as the factors which increase employment and emissions are mainly the same. For example, Kopidou et al. (2016) found that economic growth, increased consumption and resource intensity drive emissions and employment. An often proposed solution towards this challenge is the creation of jobs within service sectors, as they are considered to be less emission intensive and more labor intensive (Li et al., 2021; Minx et al., 2009; Sakai et al., 2017; Shao et al., 2019).

The term service sector generally refers to any economic sector that provides a service, such as health, care, or transport, and does not provide a tangible, physical good (Kutscher and Mark, 1983). While the existing literature often generalizes and summarizes the various service sectors in one broad service sector category, they should be analyzed in more detail as they each might have differing impacts in terms of GHG emissions and employment. Additionally, it is essential to not only focus on direct emissions and employment, but to consider the GHG emissions and employment associated with inputs along the supply chain which are necessary to provide this service. If the Austrian government were to create more jobs in the service sectors, this could cause for example an increase in GHG emissions in another sector as the service sectors might need inputs of this sector for the provision of their services. Therefore, the service sectors should be analyzed not only from a production perspective, i.e. GHG emissions released or jobs created directly by or in the sector, but also from a supply-chainwide consumption or 'footprint' perspective where all upstream inputs of GHG emissions and labor are accounted for as well.

This thesis uses an environmentally extended multi-regional input-output (MRIO) model to analyze the potential patterns of the various Austrian sectors in terms of GHG emissions and employment to examine whether the job creation within specific service sectors could contribute towards the solution of the conflict between the increase in employment and reduction of GHG emissions within Austria. MRIOs enable the calculation of consumption-based accounts (CBA), meaning all upstream factor inputs along the supply chain which are needed to satisfy final demand of for example a sector or country are quantified and attributed towards this sector or country. Although the production of the good or service itself may take place in another country or sector (Bastianoni et al., 2004; Piñero et al., 2019; Yuan et al., 2017). Thus, MRIOs enable the calculation of footprints, for example the carbon footprint which is defined as indirect or embodied emissions, measured in tons of carbon dioxide equivalents (CO_2eq), which are necessary to meet final demand (Minx et al., 2009). In contrast to this, the producer perspective, i.e. the production-based accounts (PBA), allocates all factor inputs to the country or sector where emissions are directly released. Compared to CBA, PBA are more frequently used by policy makers, since PBA for many different environmental stressors are part of the standard reporting scheme of many national statistics institutes. This thesis considers and analyses both direct (PBA) and indirect (CBA) flows of GHG emissions and employment.

This thesis investigates the following hypotheses from a production and consumption perspective:

H_1: The Austrian service economy emits less GHG emissions compared to the non-service part of the economy.

H_2: The Austrian service economy provides more employment compared to the non-service part of the economy.

H_3: The Austrian service economy is less emission intense, i.e. GHG emissions per hour of employment (kgCO_2/h), than the non-service part of the economy.

H_4: The Austrian service economy displays decoupling tendencies, i.e. absolute (GHG emissions are stable or decreasing while employment is increasing) or relative (employment increases at a faster rate than GHG emissions), between the years 1996 and 2019, while the non-service part of the economy does not.

In order to capture direct and indirect environmental impacts, a MRIO model with environmental extensions is being applied. The gross domestic product (GDP) is not considered in this thesis as it is not necessary in order to examine the relation between GHG emissions and employment[1]. Thus, this study contributes to the research on the role of the service sectors in climate mitigation efforts and an increase in employment.

This thesis is structured as follows. The second section presents the literature review. The third section introduces the method and data being used in this thesis. The fourth section presents the findings of the analysis. The fifth section covers the discussion, to lastly, conclude.

2.Literature Review

The literature review examines relevant existing literature for this thesis. Literature on (1) Austrian employment from a consumption and production perspective, (2) Austrian GHG emissions from a production and consumption perspective, (3) the interconnection between emissions and employment and (4) the emission dimension of the service sectors is being presented.

2.1 Austrian Employment

There is a variety of literature on Austrian employment form a production perspective, as well as several studies illustrating the development of Austrian employment over time. For example, Statistik Austria (2020) regularly publishes reports of various aspects of Austrian employment, such as statistics on unemployment or labor hours. In their most recent report, Statistik Austria (2020) states that in 2019 3.7% of the employed Austrians were working in the agriculture sector, 25.4% were working in the industrial sectors and 71% were working in the service sectors. Additionally, the academic literature examines research problems, such as the relation between higher education and graduate employment (Kellermann and Sagmeister, 2000), the influence of gender on low-wage employment (Fritsch et al., 2019) or the implementation of a job guarantee within Austria for the long-term unemployed (Picek, 2019a).

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[1] The GDP is often used as a measure of welfare or well-being, which is misleading as the GDP measures the market value of all final goods and services produced within a country in a given time period (Ivkovic, 2016). Therefore, the GDP actually excludes several welfare-enhancing activities, such as unpaid labor, volunteering, leisure time, ecosystem services and includes several welfare-reducing activities, such as car accidents, cigarettes or pollution (Costanza et al., 2009; Ivkovic, 2016; Kallis et al., 2018). Since this thesis is concerned with the conflict between the reduction of GHG emissions and the increase in employment, there is no need to consider the GDP.

There are only a few studies on Austrian employment measured based on CBA. For example, Koller and Stehrer (2010) study the employment effects of trade integration and outsourcing in Austria. While the authors do use an input-output model for their decomposition analysis, they do not focus on the labor footprint, but rather on the changes in employment effects over time. There are no studies so far on the Austrian employment footprint.

2.2 Austrian GHG Emissions

Generally, a variety of articles on Austria's emissions based on CBA have been published, including analyses of Austria's overall GHG emissions (e.g. Muñoz and Steininger (2010) and Steininger et al. (2018)), sectoral analyses of specific sectors (e.g. Neger et al. (2021)) or analyses of specific matters, for example an analysis of the carbon footprint of everyday activities in Austria (Smetschka et al., 2019) or the impact of urbanization on Austria's carbon footprint (Muñoz et al., 2020).

Overall, it has been found that a considerable part of Austrian consumption-based emissions are embodied emissions in trade (Muñoz and Steininger, 2010). Steininger et al. (2018) find that 62% of the consumption-based emissions occur outside of Austria (with 34% occurring outside of the EU), 35% occur in Austria and 3% are attributed to international transport. Additionally, the authors compare the results of GHG emissions measured based on CBA and PBA, showing that in 2011 GHG emissions are 54% higher measured based on CBA with 123.6 Mt of CO_2eq, compared to emissions measured based on PBA with 80.3 Mt CO_2eq. These findings are supported by Muñoz and Steininger (2010), who state that GHG emissions measured based on CBA are larger than PBA and that two thirds of the Austrian consumption-based emissions occur outside of Austria.

The study by Steininger et al. (2018) finds that in 2011 the top polluting sectors of Austria according to CBA are (1) construction, (2) public administration (including defense, health, and education), and (3) wholesale and retail, and the top polluting sectors according to PBA are (1) electricity, (2) iron and steel, and (3) non-metallic minerals. Muñoz and Steininger (2010) present similar results, stating that in 2004 the public administration, defense, education, and health sector, being aggregated to one sector, is the top polluting sector when analyzing emissions embodied in Austria's final consumption. However, the authors specify that this results out of the size of the sector, not because of the carbon intensity. Additionally, Steininger et al. (2018) investigate the emission intensities in kg of CO_2eq per 1000€ of the sectors, illustrating that the sectors with the highest emission intensities according to CBA are (1) iron and steel, (2) non-ferrous metals and (3) electricity and according to PBA (1) electricity, (2) iron and steel, and (3) non-metallic minerals.

There are no specific studies on the Austrian service sectors which analyze GHG emissions from a consumption and production perspective. However, Neger et al. (2021) study the carbon intensity of tourism in Austria, making some first estimates of the CO_2 emissions of the tourism sector for the year 2016. The findings include that the Austrian tourism sector has a large carbon footprint and that one of the most important factors are tourist transport by car and aircraft, especially considering Asian and US-American tourists. However, the study exhibits several limitations, such as data accuracy.

2.3 The Interconnection between GHG Emissions and Employment

The existing literature investigates the interconnection between employment and emissions mostly from a production perspective, for example by analyzing the impact of climate policies on employment (e.g. Bailie et al. (2001), Fankhaeser et al. (2008), Krause et al. (2003)), studying the link between CO_2 emissions and employment status (Vardopoulos and Konstantinou, 2017), or investigating the relation between working hours and environmental pressures (e.g. Antal et al. (2020), Knight et al. (2013), Pullinger, (2014)).

There are few studies analyzing emissions and employment from a consumption perspective. Yet, these are not specific to Austria. For example, Sakai et al. (2017) examine the emissions and employment footprints of the UK and the main findings of the paper are that (1) the UK is an importer of embodied emissions, as well as embodied employment, and that (2) the drivers of employment and emissions are similar, for example final demand. Shao et al. (2019) study the interregional spillovers in eight major regions in China from 2007 to 2012, focusing on carbon emissions and employment and state that while the sectors with the highest carbon emissions are (1) electricity and gas and (2) raw material manufacturing, the sectors with the highest employment were (1) services and (2) construction and equipment manufacturing.

2.4 The Emission Dimension of the Service Sector

There is literature suggesting the creation of jobs within the service sector, especially as the service sectors are perceived to be labor-intense, while not being emission-intense (Li et al., 2021; Sakai et al., 2017; Shao et al., 2019). However, the existing research on the service sector shows that they are not as environmentally-friendly as suggested when taking the upstream inputs of sectors into account (Alcántara and Padilla, 2009; Butnar and Llop, 2011; Ge and Lei, 2014; Suh, 2006; Yuan et al., 2017; Zhang et al., 2020).

Alcántara and Padilla (2009) studied the CO_2 emissions associated with the Spanish service sectors in the year 2000. The authors find that based on CBA, the sectors rank the following from most to least emitting: (1) transport, (2) wholesale and retail trade, (3) hotels and restaurants, (4) real estate, renting and business activities, (5) public administration and defense, (6) other community, social and personal service activities (7) health and social work, (8) education, (9) post and telecommunications and (10) financial intermediation[2]. Ge and Lei (2014) study the carbon emissions of Beijing's service sector for the years 2010 and 2011. They find that considering only direct emissions (PBA) the transportation, storage, mail and telecommunications and real estate trade subsectors stand out. When accounting for both direct and indirect emissions (CBA), scientific studies and technical services gain in importance. The sectors with the least influence are water, environment and municipal engineering, resident services and other services and culture, sports, art and recreation. Yuan et al. (2017) support these results, by highlighting that the transportation sector and the scientific studies technical services sector have emitted the most.

Additionally, the authors find that the service sectors exhibit a strong pull effect on other sectors, meaning the service sectors induce other economic sectors to emit GHG emissions by demanding intermediate inputs, which makes them more emission intensive than suggested (Alcántara and Padilla, 2009; Butnar and Llop, 2011; Ge and Lei, 2014; Yuan et al., 2017). Alcántara and Padilla (2009) find that in the year 2000 35.2% of the emissions generated by the industrial sectors were generated to satisfy the demand of the Spanish service sectors. The authors specifically highlight that the (1) wholesale and retail trade, (2) hotels and restaurants, (3) real estate, renting and business activities and (4) public administration sectors have a strong

[2] For a comprehensive overview of the subsectors of the Spanish service sectors in terms of their direct and indirect emissions please refer to Table 2 on page 911 in the original paper (Alcántara and Padilla, 2009).

pull effect. This has been confirmed by Butnar and Llop (2011) who have studied the CO_2 emissions of the Spanish service sectors as well, focusing on the changes in the CO_2 emissions between 2000 and 2005. They find that the sectors with the strongest pull effect are (1) commerce and reparations, (2) transport, and (3) post and telecommunications. Additionally, Ge and Lei (2014) and Yuan et al. (2017) state that the service sectors in China exhibit a pull effect as well. Ge and Lei (2014) highlight the scientific studies and technical services, hotels and restaurants, and the health care, social security, and social welfare subsectors, and Yuan et al. (2017) point towards the wholesale and retail trade and hotels and restaurants sectors.

2.5 Summary

Overall, the literature review shows that there is a variety of studies on Austrian GHG emissions from a consumption and production perspective. However, the study of Muñoz and Steininger (2010) for example only considers carbon emissions and not GHG emissions overall. The existing studies on GHG emissions show the importance of considering both PBA, as well as CBA. Additionally, there are no studies on the Austrian employment footprint, especially not in relation to GHG emissions.

Depending on the study, several sectors were identified to be hotspot sectors in terms of GHG emissions. Generally, there is a body of literature which suggests the industrial sectors to be more emission intense than the service sectors. However, there are existing studies which suggest that there "is the false perception that the service sector is an environment friendly sector" (Alcántara and Padilla, 2009: p. 906), because the service sectors seem to exhibit a pull effect. Since there are no studies done on the Austrian service sectors, besides a study on the carbon intensity of the Austrian tourism sector, it is important to investigate the Austrian sectors in terms of GHG emissions and employment from both a production and a consumption perspective.

3.Methodology

3.1 Method

This section serves to introduce the basics of environmentally extended input-output analysis (EEIOA) and the mathematics behind it. For a more elaborate explanation of the method and its background, please refer to Kitzes (2013) and Miller and Blair (2009).

Generally, input-output analysis (IOA) was developed in the 1930s by Wassily Leontief and can be used to analyze the interdependence between different sectors of an economy (Miller and Blair, 2009). It is employed in a variety of research areas, including trade, energy, economy, labor, resource use, industrial ecology or social issues, and its uses include, inter alia, the calculation of a variety of footprints, such as carbon, water or energy (Wiedmann and Lenzen, 2018).

EEIOA is an extension of IOA with environmental accounts, which is used to evaluate the linkages of environmental impacts, such as GHG emissions, for all economic sectors of the economy and consumption (Kitzes, 2013; Miller and Blair, 2009; Minx et al., 2009). The linkages are explored via the analysis of the financial transaction between the economic sectors of the model (intermediate demands). Generally, EEIOA is used to (1) calculate the upstream, embodied and/or indirect environmental impacts in downstream consumption activities and to (2) calculate the embodied environmental impacts associated with goods which are being traded between nations (Kitzes, 2013). Therefore, EEIOA reallocates the responsibility of environmental impacts from producers to consumers. The advantages of the method include that it accounts for various layers of production, addresses loops, avoids double counting, captures the trade in services and captures the trade in secondary processed products as well (Kitzes, 2013).

IOA models represent linear equations in the form of matrices. These matrices are termed input-output tables (IOT), which show the interindustry transactions of all economic sectors of an economy. The transactions within the matrix are displayed in monetary units. Hence, the matrices contain information about the inputs a specific economic sector receives from another economic sector for their production. Table 1 displays a simplified IOT.

	Industry or Goods (Destination)	Final Demand	Total Output
Industry or Goods (Source)	$Z = \begin{pmatrix} z_{11} & \cdots & z_{1j} \\ \vdots & \ddots & \vdots \\ z_{i1} & \cdots & z_{ij} \end{pmatrix}$	$y = \begin{pmatrix} y_1 \\ \vdots \\ y_i \end{pmatrix}$	$x = \begin{pmatrix} x_1 \\ \vdots \\ i \end{pmatrix}$
Value Added	$v = (v_1 \cdots v_j)$		
Total Input	$x = (x_1 \cdots x_j)$		

Table 1: Simplified Graphical Display of an IOT (adapted from Miller and Blair (2009))

The Z matrix displays the inter-industry flows between the economic sectors and each element z_{ij} illustrates the flows of inputs from one economic sector i to another economic sector j. Thus, the rows contain information about the distribution of outputs of economic sectors and the columns provide information about the inputs needed from other economic sectors. The y vector displays the final demand for each economic sector and can also be a matrix if the final demand is split into different consumer groups, such as households, government, or capital formation. Hence, based on Z (intermediate demand) and y (final demand) x (total output) can be calculated by summing up the elements of the rows of the vectors.

$$x_i = z_{i1} + \cdots + z_{ij} + y_i$$

The vector v represents value-added of each economic sector. As y, v can also be a matrix if split up into different categories, such as labor, capital income or taxes. The total inputs (x) can be calculated when summing up the elements in the columns of Z and v. The total inputs and total outputs (elements in the rows) must be equal, i.e. balanced, which is the most important accounting identity of any IOT.

The calculus is as follows. The first step is to estimate the direct intensity vector (f), which provides information on the emissions associated with one monetary unit of output. It is calculated by dividing the emissions per element (e) by total output.

$$f = e/x_i$$

The second step is to calculate the technical coefficient matrix (A), which is estimated by dividing intermediate inputs by total output. Hence, the technical coefficient matrix provides information about the inputs that are needed to produce one unit of output. $\hat{x}$ is the diagonalized x vector.

$$A = Z\hat{x}^{-1}$$

$$a_{ij} = z_{ij}/x_i$$

The third step is to calculate the Leontief inverse matrix (L).

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

The fourth step encompasses the calculation of the total intensity vector (F), also called the upstream multiplier. The total intensity vector entails information on the emission intensity, i.e. the total upstream emissions released anywhere in the economy which are necessary to produce one unit of output for final demand.

$$F = fL = f * (I - A)^{-1}$$

Lastly, the consumption-based inventory (CBA) can be calculated, which displays the total indirect emissions to produce goods and services for final consumers. This is also called the footprint.

$$CBA = F * y$$

3.2 Model and Data

This thesis uses a MRIO database. The advantage of MRIOs is that they include tables for multiple regions in the model, meaning the trade between nations is captured in the model and hence, embodied emissions in ex- and imports (Miller and Blair, 2009; Schaffartzik et al., 2014). As has been shown in the literature review, a large portion of Austria's emissions consist of embodied emissions in traded goods and services, and hence, an MRIO should be used to take these trade-related emissions into account (Muñoz and Steininger, 2010).

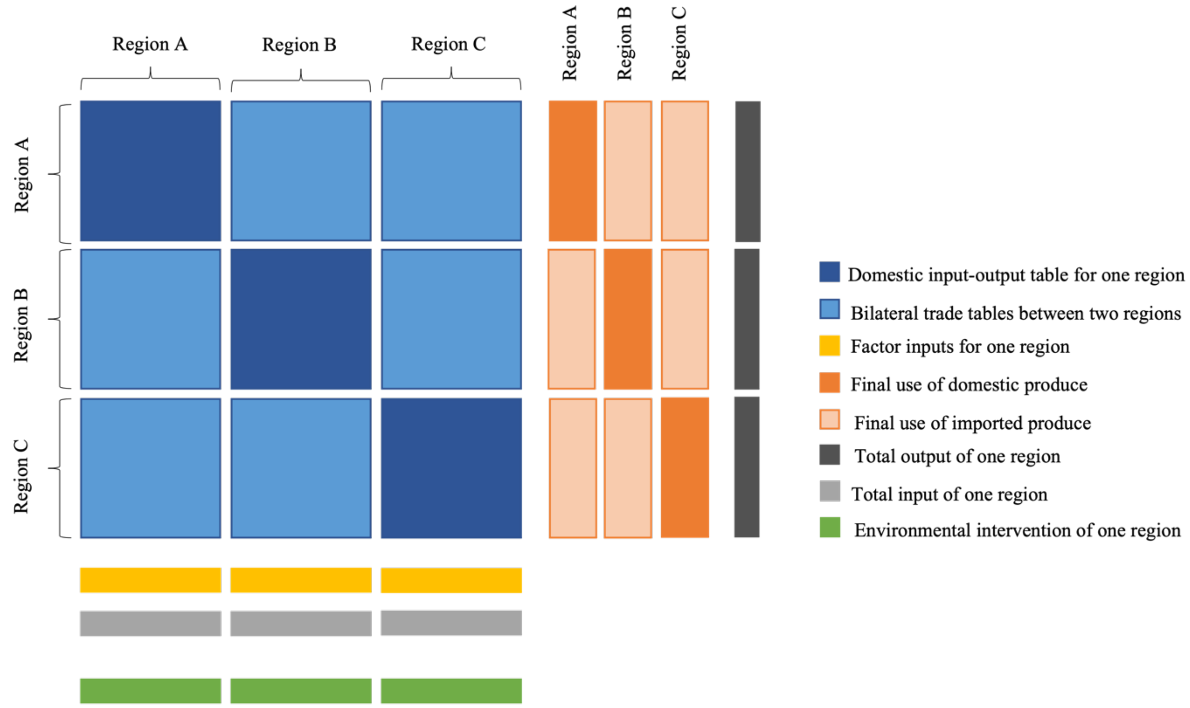

Figure 1: General Structure of a 3 Region MRIO System with Environmental Data (Giljum et al., 2017)

The data which was used for this model is provided by EXIOBASE. EXIOBASE provides detailed, global multi-regional environmentally extended supply-use tables (EE-MRSUT) and input-output tables (EE-MRIOT). This study uses the monetary tables of EXIOBASE 3.8.1 (Stadler et al., 2021). The tables encompass 44 countries and 5 aggregated world regions, 200 products, 163 industries, 3 employment skill levels per gender, 417 emission categories, and 662 material and resource categories. The model is used to analyze GHG emissions, measured in Mt CO_2eq, and employment, measured in hours.

For the present study, all regions are aggregated into three main categories, namely Austria, the EU and the rest of the world. The rest of the world aggregates all countries that are not part of the EU. Furthermore, the sectors of EXIOBASE are aggregated to match the ÖNACE classification of Statistics Austria, which can be found in Appendix A. Generally, the analyzed sectors of this thesis are the agriculture, mining, manufacturing, electricity, water, construction, trade, transportation, accommodation, post, financial, real estate, R&D, public administration, education, health, and entertainment sectors, as well as other services. A detailed list of the sectors with their short and long names can be found in Appendix B.

For part of the analysis, the sectors are grouped into the service economy and the non-service economy. The term service economy refers to all service sectors, namely the trade, transportation, accommodation, post, financial, real estate, R&D, public administration, education, health, and entertainment sectors, as well as other services. The non-service economy entails all other sectors, namely the agriculture, mining, manufacturing, electricity, water, and construction sectors.

This thesis considers 1995 until 2019 as the overall time period. However, as the results concerning employment display a steep drop from 1995 to 1996, both according to PBA and CBA, there seems to be an error in the data, and hence, 1995 will not be considered in the analysis. It is being analyzed whether a single data point can be identified which may have distorted the data, however no sector or region could be identified to be the main cause.
The findings presented in the next section are based on the year 2019, as it is the most recent year, as well as 1996 and 2019, when analyzing trends over time. The results do not change drastically over time and hence, 2019 can be used as an exemplary year. The exact developments over time for the different indicators can be found in Appendix C.

The analysis considers various aspects. Austrian GHG emissions and employment are analyzed from both a consumption and a production perspective. The CBA of GHG emissions and employment are analyzed for their regional and sectoral origin. The emission intensity, i.e. GHG emissions per hour of employment, in $kgCO_2/h$ is calculated, and decoupling trends, i.e. absolute (GHG emissions are stable or decreasing while employment is increasing) or relative (employment increases at a faster rate than GHG emissions), between the years 1996 and 2019 are being analyzed. The following section presents the findings of the analysis.

4.Findings

This section serves to provide an overview of the main findings. It is structured as follows. Firstly, the results in terms of total CBA and PBA, for the entire economy of Austria, are presented. Secondly, all service sectors grouped together, termed service economy, are compared to all other sectors, coined non-service economy. Thirdly, the results concerning the analysis of single sectors are presented, with a strong focus on service sectors. Note that the results are mainly presented in relative terms, as this makes it easier to compare the results for GHG emissions and employment. If not otherwise stated, numbers refer to the year 2019.

4.1 Total GHG Emissions and Employment

Embodied emissions and embodied employment in trade play a significant role in Austria. The Austrian GHG emissions are higher when measured from a consumption perspective (111.96 Mt CO_2eq) compared to the production perspective (80.81 Mt CO_2eq), with a difference of 38.55% , calculated with PBA as a base. The same applies to total employment, where the CBA for employment are 77.63% higher (13.78 billion hours) than the PBA (7.76 billion hours). Thus, embodied emissions and embodied employment in trade, i.e. imports, are of high relevance for the footprint of the Austrian economy. For both stressors (GHG emissions and employment), Austria is a net-importer. The relative difference between CBA and PBA is much larger for employment (77.63%) than for GHG emissions (38.55%).

4.2 Service Economy and Non-Service Economy

The assessment of the service economy and the non-service economy comprises of the analysis of GHG emissions and employment from a production and consumption perspective (Figure 2), as well as the examination of the regional and sectoral origin of the flows of the CBA (Figure 3) and lastly, the calculation of emission intensities in kgCO_2/h from a production and consumption perspective (Figure 4).

4.2.1 GHG Emissions and Employment

From a consumption and production perspective, the non-service economy is responsible for the majority of GHG emissions (Figure 2). Based on PBA, the non-service economy emitted 80.38% (52.26 Mt CO_2eq), compared to 19.62% (12.76 Mt CO_2eq) which was emitted by the service economy. Similarly, based on CBA, the non-service economy emitted 70.44% (67.74 Mt CO_2eq) and the service economy emitted 29.56% (28.43 Mt CO_2eq) of Austrian GHG emissions.

In terms of the PBA of employment, it was found that the service economy has a larger share than the non-service economy. Contrary to that, the employment footprint of the non-service economy is larger than the footprint of the service economy. From a production perspective, the non-service economy provided 28.73% (2.23 billion hours) and the service economy 71.27% (5.53 billion hours) of the employment within Austria. From a consumption perspective, the non-service economy accounted for 55.83% (7.7 billion hours) and the service economy for 44.17% (6.09 billion hours) of the employment footprint (Figure 2).

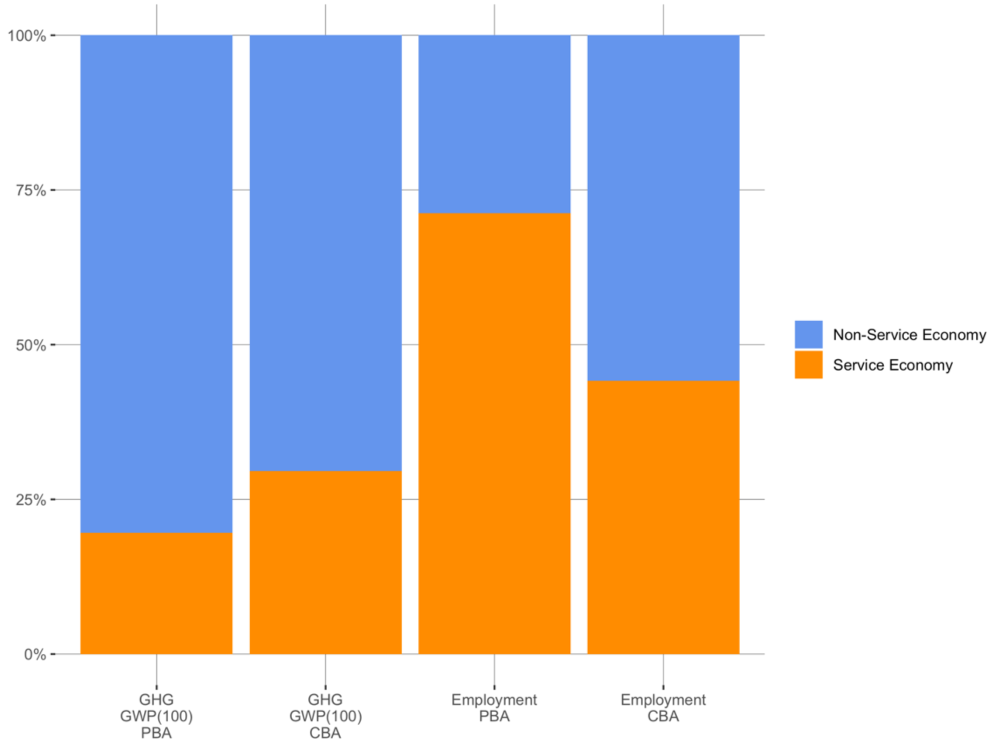

Figure 2: Austrian GHG Emissions and Employment of the Service Economy and the Non-Service Economy in 2019 in %

The majority of upstream GHG emissions in the carbon footprint of Austria can be traced back to inputs from the non-service economy (83.55% or 80.35 $MtCO_2eq$). This also applies to the results in terms of the carbon footprint of the service economy (58.78% or 16.71 $MtCO_2eq$) and the non-service economy (93.95% or 63.64 $MtCO_2eq$). Additionally, the majority of embodied GHG emissions are sourced within Austria (42.33% or 40.71 $MtCO_2eq$), followed by the rest of the world (34.13% or 32.82 $MtCO_2eq$) and the European Union (23.55% or 22.64 $MtCO_2eq$). These results are roughly mirrored when analyzing the service economy and the non-service economy separately, as it was revealed that the GHG emissions associated with the demand for services are mainly affiliated with inputs from Austria (53.73% or 15.27 $MtCO_2eq$), and the GHG emissions linked to the non-services stem to almost equal shares from inputs of Austria (37.54% or 25.43 $MtCO_2eq$) and the rest of the world (37.21% or 25.21 $MtCO_2eq$), and to a smaller share of the European Union (25.25% or 17.1 $MtCO_2eq$) (Figure 3).

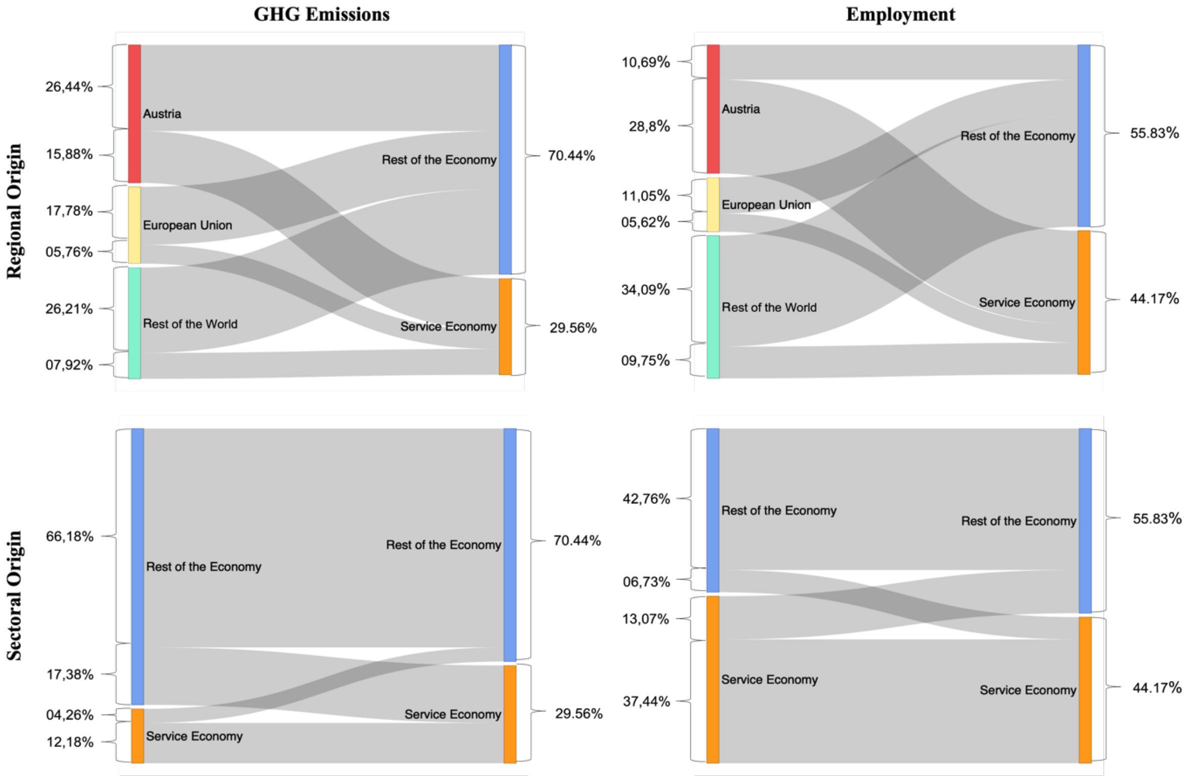

Figure 3: Regional and Sectoral Origin of the CBA GHG Emissions and Employment Flows of the Service Economy and the Non-Service Economy for the year 2019 in % in Austria

The upstream employment of the employment footprint originates to almost equal shares from inputs of the non-service economy (49.49% or 6.82 billion hours) and the service economy (50.51% or 6.96 billion hours). When analyzing the upstream employment associated with the service economy and non-service economy separately, it becomes apparent that the upstream employment linked to the service economy is mainly affiliated with inputs from the service sectors (84.76% or 5.16 billion hours). On the contrary, most of the employment needed to satisfy the final demand of the non-service economy can be traced back to inputs from the non-service sectors (76.59% or 5.89 billion hours). Furthermore, the majority of embodied employment in the Austrian footprint originates from the rest of the world (43.84% or 6.04 billion hours), closely followed by Austria (39.49% or 5.44 billion hours) and a smaller portion of the European Union (16.67% or 2.3 billion hours). Yet, the employment footprints of the service economy and the non-service economy show larger differences. The majority of embodied employment in the employment footprint of the service economy originates in Austria (65.21% or 3.97 billion hours), whereas the embodied employment associated with non-services mainly originates in the rest of the world (61.06% or 4.7 billion hours).

4.2.2 Emission Intensity of the Service Economy and the Non-Service Economy

For both PBA and CBA, it was found that the non-service economy exhibits a higher emission intensity per hour of employment than the service economy (Figure 4).

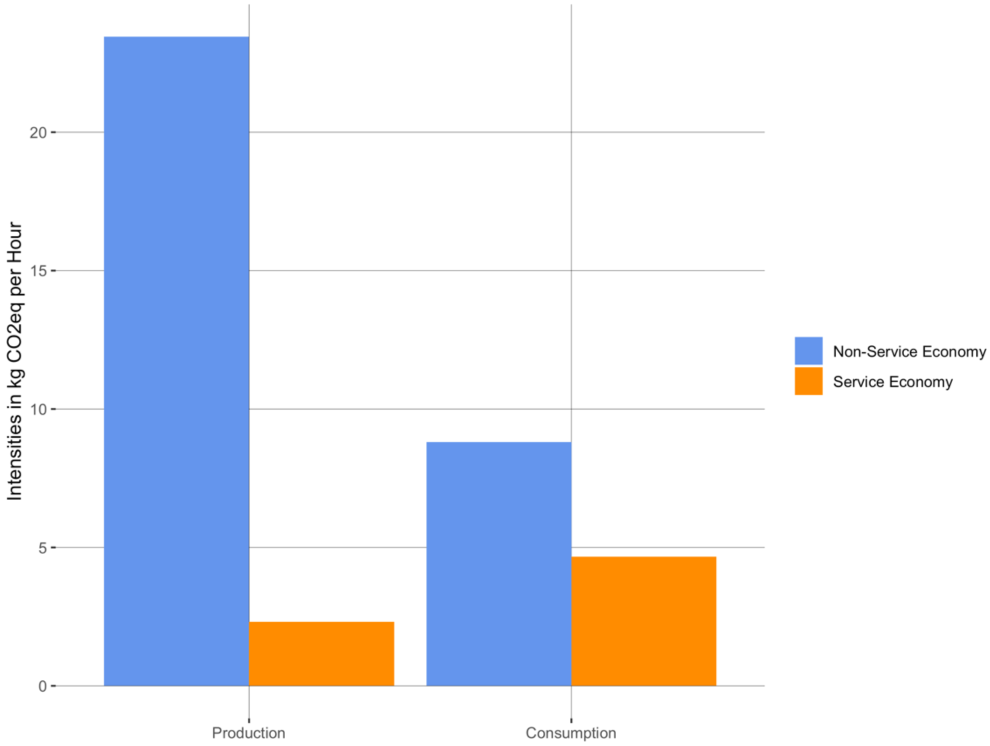

Figure 4: PBA and CBA Emission Intensities of Working Hours for the Service Economy and the Non-Service Economy of Austria in 2019 in Kg of CO_2eq per Hour of Employment

From a production perspective, the non-service economy exhibits an emission intensity of 23.45 kgCO_2/h, while the emission intensity of the service economy lies at 2.31 kgCO_2/h. In comparison, the emission intensities from a consumption perspective of the non-service economy and the service economy are 8.81 and 4.67 kgCO_2/h respectively.

Thus, for both CBA and PBA, the non-service economy emits more GHG emissions per additional hour of employment than the service economy.

4.3 Sectoral Analysis

The analysis on the sectoral level groups all sectors into four groups to investigate flows of GHG emissions and employment from a production and consumption perspective (Figure 5&6). Moreover, the emission intensities in kgCO_2/h (Table 2), and the decoupling trends between 1996 and 2019 are being analyzed (Figure 7&8).

4.3.1 GHG Emissions and Employment

In order to identify patterns and potential sectors for a structural transformation, the sectors are divided into four categories, namely (1) sectors with high GHG emissions and high employment shares, (2) sectors with high GHG emissions and low employment shares, (3) sectors with low GHG emissions and high employment shares and (4) sectors with low GHG emissions and low employment shares. The shares refer to the proportion that the sectors account for of the total Austrian GHG emissions and employment in %. The analysis revealed that the average share of GHG emissions from a production perspective is 4.47% and 4.77% from a consumption perspective. And based on PBA and CBA the average share of employment is 5.56%. Thus, 5% is a sensible cut-off point to classify the sectors, meaning all sectors displaying shares above 5% are classified as high and all sectors displaying shares below 5% are classified as low. The exact absolute and relative numbers for each sector from a consumption and production perspective can be found in Appendix D.

The most important category for this study concerns the sectors being low in GHG emissions and high in employment, as these sectors may be suitable for a structural transformation towards labor-intensive and not emission-intensive sectors. Based on PBA, the accommodation (0.26% of GHG emissions and 6.76% of employment), construction (1.85% and 6.76% respectively), education (0.44% and 5.58% respectively), health (0.74% and 9.97% respectively), public administration (0.24% and 6.67% respectively) and trade (3.22% and 13.36% respectively) sectors as well as other services (0.54% and 16.78% respectively) fall into this category, as Figure 5 shows. Additionally, the sectors being low in terms of GHG emissions and employment could constitute another relevant category. The real estate, R&D, post and entertainment sectors each emitted below 0.12% of Austrian GHG emissions and provided up to 1.6% of the employment opportunities, and thus, fall into this category. Furthermore, the financial sector (0.14% and 3.58%) and the water sector (4.93% and 0.67%) also fall in this category. The sectors being high in GHG emissions should not be considered for a structural transformation. The manufacturing (20.25% and 15.23% respectively), agriculture (11.68% and 5.39% respectively) and transportation (9.91% and 5.14% respectively) sectors are hotspot sectors in terms of GHG emissions and employment. And lastly, the electricity (20.33% and 0.55% respectively) and mining (5.64% and 0.13% respectively) sectors exhibit high GHG emissions and low employment shares.

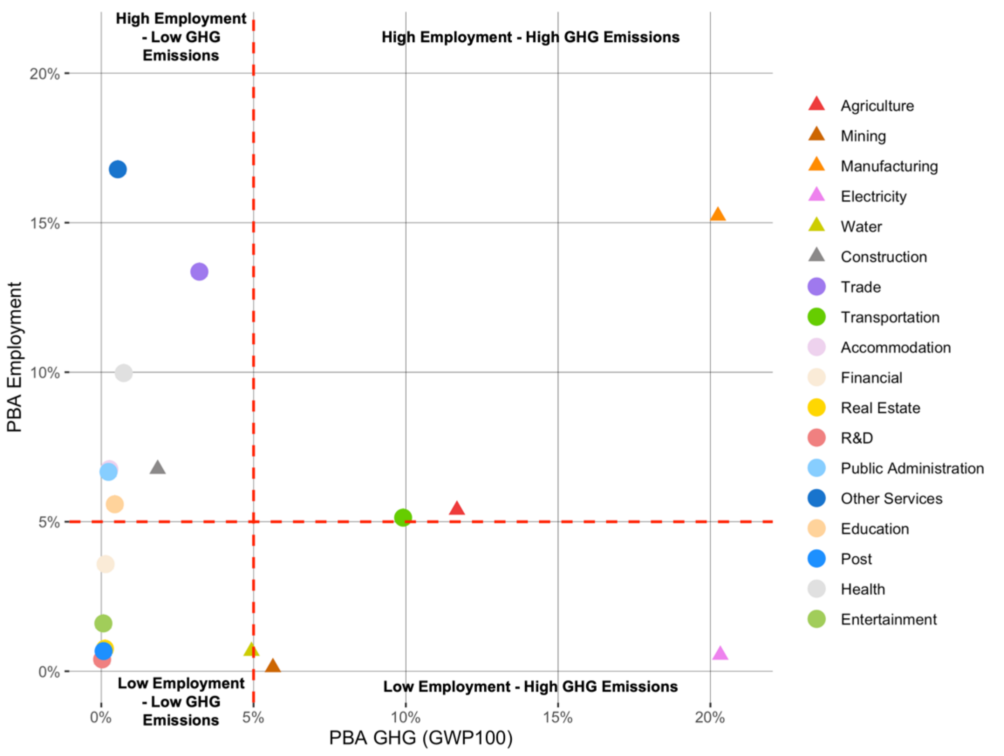

Figure 5: PBA GHG Emissions and Employment of the Austrian Sectors in 2019 in % with Service Sectors marked as Circles and Non-Service Sectors as Triangles

Based on CBA, it appears that the manufacturing sector (38.65% and 37.93% respectively) is extraordinary high in GHG emissions and employment compared to all other sectors. Therefore, Figure 6 shows all sectors besides the manufacturing sector. Aside from the manufacturing sector, the construction and transportation sectors exhibit high shares in terms of GHG emissions and employment compared to the rest of the sectors, as the GHG emissions and employment shares of the construction sector, as well as the GHG emissions of the transportation sector lie between 8 and 9%, and the employment share of the transportation sector is 5.42%. The electricity sector exhibits a high share in terms of GHG emissions with 8.81% and a low share in terms of employment with 1.06%. The rest of the sectors exhibit shares below 3.7% in terms of GHG emissions and hence, may be considered as rather low in emissions. In terms of employment, the sectors span from 0.05% (water sector) to 7.86% (agriculture sector), with the agriculture, health, accommodation, and public administration sectors and other services exhibiting higher shares than 5%.

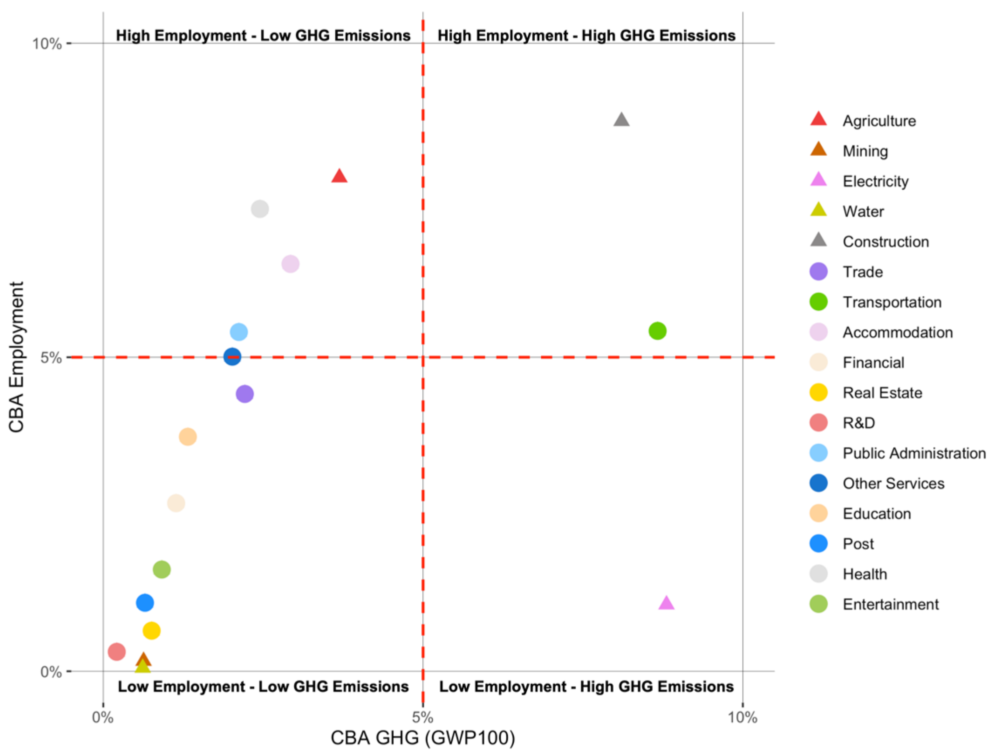

Figure 6: CBA GHG Emissions and Employment of the Austrian Sectors, excluding the Manufacturing Sector, in 2019 in % with Service Sectors as Circles and Non-Service Sectors as Triangles

It was found that the hotspot sector in terms of GHG emissions is mainly the manufacturing sector, as well as the electricity and transportation sectors according to PBA and CBA. Additionally, based on CBA, the construction sector and based on PBA, the agriculture and mining sectors can be considered as hotspot sectors. Based on CBA and PBA, the hotspot sectors in terms of employment are the accommodation, agriculture, construction, health, manufacturing, public administration, and transportation sectors, as well as other services. Based on PBA, the education and trade sectors also exhibit high employment footprints. Lastly, it can be noted that based on PBA there appears to be a pattern that the non-service sectors tend to be more emitting, however this does not apply to the results based on CBA. In terms of employment there does not seem to appear any patterns as the service sectors and non-service sectors span a range of labor intensities.

Overall, it can be inferred that the accommodation, health, and public administration sectors, as well as other services should be considered when discussing a structural transformation towards labor intensive and non-emission intensive sectors, as these are the sectors with low emissions and high employment according to both PBA and CBA. Additionally, one may consider the sectors emitting the least (below 1%) based on CBA and PBA, namely the real estate, R&D, post, and entertainment sectors.

4.3.2 Emission Intensities of the Sectors

According to PBA as well as CBA, the sectors with the highest emission intensities of employment are the electricity with 388.22 kgCO_2/h (PBA) and 67.44 kgCO_2/h (CBA) respectively, followed by mining (453.75 and 31.49 kgCO_2/h respectively), and water sectors (76.18 and 94.87 kgCO_2/h respectively). The emission intensities of all sectors can be found in Table 2.

Based on PBA, the sectors with the lowest emission intensities are other services, as well as the public administration, accommodation, financial, and entertainment sectors, which all exhibit intensities below 0.45 kgCO_2/h. Additionally, the education, health, and R&D sectors exhibit intensities below 1 kgCO_2/h. Based on CBA, the emission intensities are generally higher. The following sectors exhibit emission intensities below 4 kgCO_2/h, namely the health, education, public administration, financial, accommodation and agriculture sectors, as well as other services. Furthermore, there seems to appear the pattern that based on PBA and CBA the service sectors have lower emission intensities compared to non-service sectors.

Therefore, potential leverage points could be the financial, health, education, public administration and accommodation sectors, as well as other services, as they exhibit some of the lowest emission intensities according to both PBA and CBA.

Production-Based Accounts		Consumption-Based Accounts	
Sector	**Intensity ($kgCO_2/h$)**	**Sector**	**Intensity ($kgCO_2/h$)**
Mining	453.75	Water	94.87
Electricity	388.22	Electricity	67.44
Water	76.18	Mining	31.49
Agriculture	22.56	Transportation	13.00
Transportation	20.10	Real Estate	9.53
Manufacturing	13.85	Manufacturing	8.28
Construction	2.85	Construction	7.52
Trade	2.51	R&D	5.53
Real Estate	1.65	Post	4.86
Post	1.16	Entertainment	4.59
Education	0.83	Trade	4.07
Health	0.77	Agriculture	3.82
R&D	0.73	Accommodation	3.67
Entertainment	0.45	Financial	3.46
Financial	0.41	Other Services	3.27
Accommodation	0.41	Public Administration	3.19
Public Administration	0.37	Education	2.88
Other Services	0.34	Health	2.70

Table 2: PBA and CBA Emission Intensities of Working Hours of the Austrian Sectors ranked from Most to Least Emission Intense in 2019 in kg of CO2eq per Hour of Employment (Service Sectors being Marked in Orange)

4.3.3 Decoupling

Based on PBA, the public administration (-45.52% GHG growth rate and 19.94% employment growth rate), accommodation (-25.19% and 28.55% respectively), water (-17.25% and 26.07% respectively), and health (-5.97% and 63.69% respectively) sectors, as well as other services (-8.94% and 451.84% respectively) display absolute decoupling tendencies and the entertainment (3.64% and 75.65% respectively), financial (11.57% and 56.53% respectively) and education (12.81% and 50.65% respectively) sectors illustrate relative decoupling tendencies (Figure 7). Thus, these sectors should be considered when discussing a structural transformation. In contrast, the manufacturing (5.78% and 3.93% respectively), transportation (100.26% and 25.81% respectively), construction (152.16% and 9.25% respectively), and trade (155.5% and 9.98% respectively) sectors do not show any decoupling tendencies. Furthermore, the post (11.41% and -17.17% respectively), electricity (15.08% and -20% respectively) and mining (9.62% and -36% respectively) sectors display positive growth rates for GHG emissions and negative growth rates for employment, and the real estate (-56% and -12.66% respectively) and agriculture (-5.27% and -41.03% respectively) sectors exhibit negative growth rates for both indicators. Hence, these sectors should not be considered.

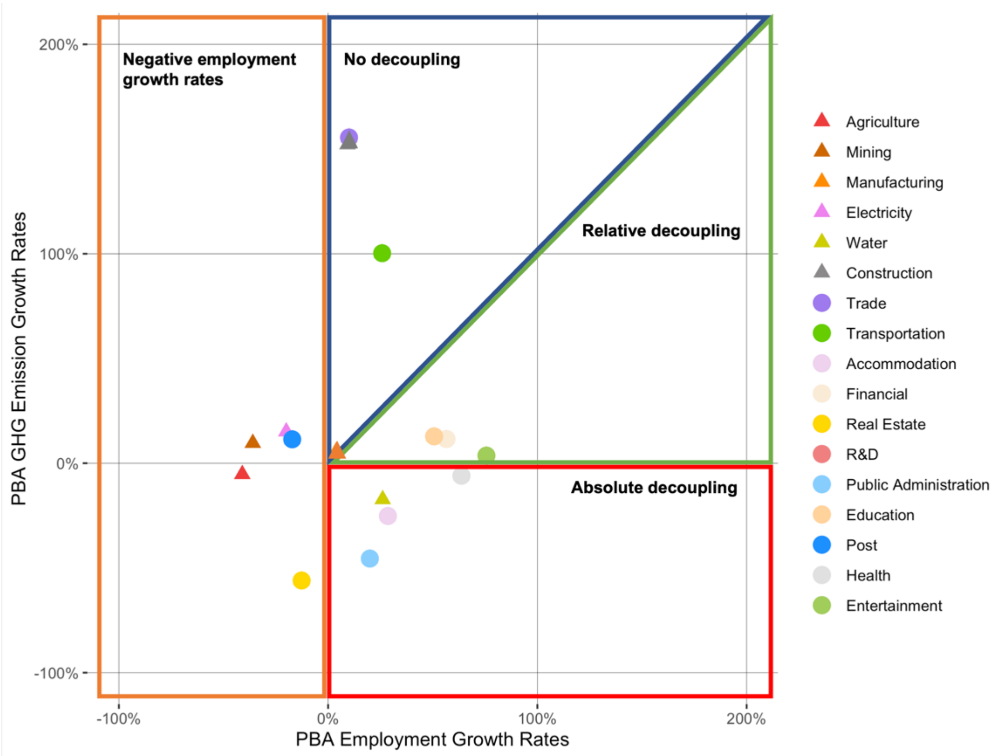

Figure 7: PBA GHG Emissions and Employment Growth Rates of the Austrian Sectors, excluding Other Services, for the years 1996 and 2019 in % with Service Sectors as Circles and Non-Service Sectors as Triangles

Based on CBA, the agriculture (-24.12% GHG growth rate and 0.33% employment growth rate), construction (-0.82% and 8.05% respectively), health (-21.7% and 40.52% respectively), mining (-31.46% and 24.61% respectively), and public administration (-21.17% and 0.67% respectively) sectors display absolute decoupling tendencies, and the education (13.92% and 41.52% respectively), electricity (2.04% and 26.56% respectively), entertainment (62.65% and

101% respectively), financial (83.4% and 146.72% respectively), manufacturing (8.86% and 22.57% respectively) and R&D (40.9% and 132.15% respectively) sectors, as well as other services (15.95% and 143.54% respectively) display relative decoupling tendencies (Figure 8). Therefore, they should be considered as potential sectors for a structural transformation. While the post (136.75% and 129.05% respectively) sector does not display any decoupling tendencies, the water (54.27% and -9.94% respectively) and transportation (24.87% and -23.22% respectively) sectors show positive growth rates for GHG emissions and negative growth rates for employment. Lastly, the accommodation (-34.03% and -39.07% respectively), trade (-4.73% and -29.36% respectively), and real estate (-77.6% and -69.18% respectively) sectors exhibit negative growth rates for both indicators.

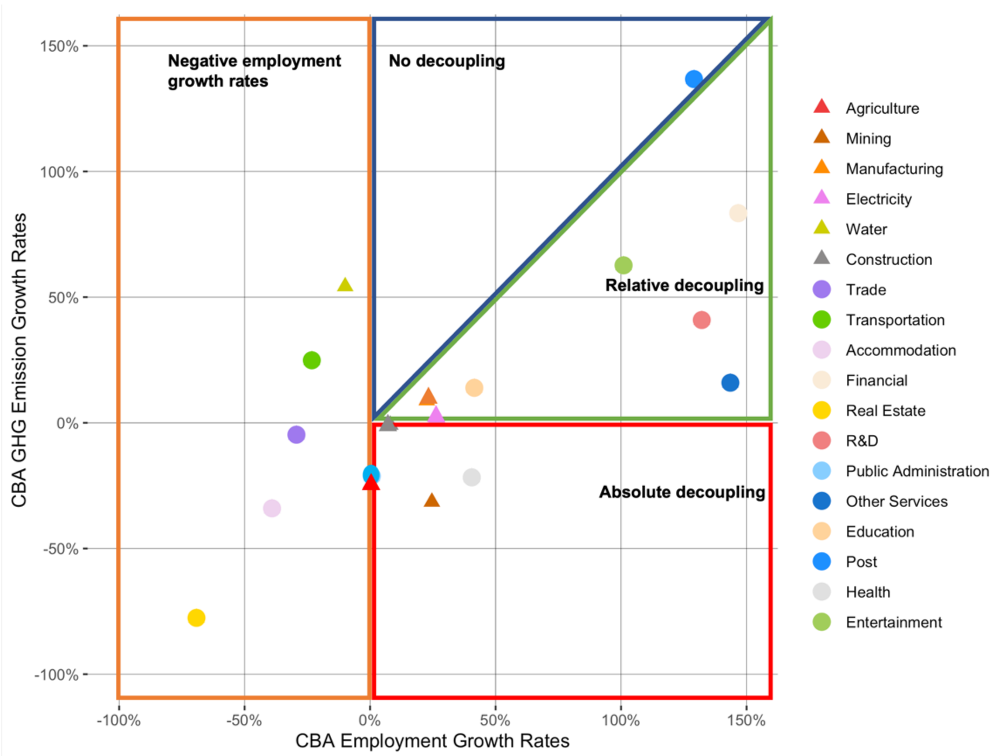

Figure 8: CBA GHG Emissions and Employment Growth Rates of the Austrian Sectors in % for the years 1996 and 2019 with Service Sectors as Circles and Non-Service Sectors as Triangles

The sectors which should be considered for a structural transformation display absolute or relative decoupling tendencies, meaning they display either (1) stable or negative growth rates for GHG emissions while employment is increasing (absolute) or (2) employment is increasing at a faster rate than GHG emissions (relative). Therefore, considering both PBA and CBA, the public administration, health, entertainment, financial, and education sectors, as well as other services are the most suitable sectors for a structural transformation.

4.4 Summary of the Findings

Overall, it was shown that embodied emissions and embodied employment have a considerable share in Austria. Furthermore, it was shown that based on PBA and CBA the non-service economy is responsible for a majority of the GHG emissions and that most of the GHG emissions needed to satisfy Austrian final demand can be traced back to inputs from the non-service sectors. However, most of the GHG emissions associated with the service economy are affiliated with inputs from Austria, while the GHG emissions linked to the non-service economy are associated to almost equal shares with inputs from Austria and the rest of the world. In terms of employment, based on PBA the service economy and based on CBA the non-service economy provided more employment. While the employment linked to the service economy is mainly affiliated with inputs from the service sectors and Austria, most of the employment needed to satisfy the final demand of the non-service economy can be traced back to inputs from the non-service sectors and the rest of the world. The analysis in terms of emission intensities revealed that based on PBA and CBA the non-service economy emitted more GHG emissions per additional hour of employment than the service economy.

The analysis on a sectoral level has provided insights in terms of which sectors should be considered for a structural transformation when wanting to transition towards labor intensive and less emission intensive sectors. Based on the analysis of GHG emissions and employment, it can be inferred that the accommodation, health, public administration, real estate, R&D, post, and entertainment sectors, as well as other services should be considered. Considering the findings on emission intensities, other services, the financial, health, education, public administration and accommodation sectors could be potential leverage points. Lastly, based on the analysis of decoupling tendencies, the public administration, health, entertainment, financial, and education sectors, as well as other services are the most suitable. Therefore, considering all findings, the health and public administration sectors, as well as other services seem the most suitable sectors for a structural transformation towards labor intensive and less emission intensive sectors.

5.Discussion

5.1 Discussion of Findings

Overall, this thesis found that Austria is a net-importer of GHG emissions and employment, which supports the findings of previous studies of Muñoz and Steininger (2010) and Steininger et al. (2018). While PBA are frequently used by policy makers as they are part of the standard reporting scheme of many national statistics institutes, the consumption perspective is not being considered as often. But it has been shown that the consumption perspective can contribute to gaining a holistic picture of the factor inputs along the supply chain and the interdependence between sectors, as well as providing insights to combat the outsourcing of GHG emissions. Therefore, it is essential to consider CBA and PBA to achieve an overall reduction in GHG emissions and an increase in employment.

5.1.1 Austrian GHG Emissions

The first hypothesis (H_1), stating that the Austrian service economy emits less GHG emissions compared to the non-service part of the economy, is being supported by the evidence of this thesis. Based on CBA and PBA, it was shown that the non-service economy emits more GHG emissions than the service economy.

On a sectoral level, the CBA and PBA have shown that the manufacturing sector, as well as the electricity and transportation sector are hotspot sectors in terms of GHG emissions. This confirms the results of previous studies, which found that the manufacturing and the electricity sectors emit the most GHG emissions (Shao et al., 2019; Steininger et al., 2018) and that the transportation sector is the top polluting sector among the service sectors (Alcántara and Padilla, 2009; Ge and Lei, 2014; Yuan et al., 2017). In terms of the individual service sectors, Alcántara and Padilla (2009) have provided a ranking of the Spanish service sectors in terms of their CBA GHG emissions, namely (1) transport, (2) wholesale and retail trade, (3) hotels and restaurants, (4) real estate, renting and business activities, (5) public administration and defense, (6) other community, social and personal service activities (7) health and social work, (8) education, (9) post and telecommunications and (10) financial intermediation from most to least emitting. This ranking is similar compared to the results of this study with two minor exemptions, namely (1) the real estate sector being of less importance and (2) the health sector being of more importance.

Furthermore, it has been shown that most of the GHG emissions needed to satisfy final demand for services can be traced back to inputs from the non-service economy. Thus, a structural shift towards the service sectors may induce some sectors of the non-service economy to emit more GHG emissions. Therefore, the government needs to account for the individual interdependencies between the sectors. The results reveal that the mining, electricity, water, trade, transportation, and financial sectors can be considered as suppliers, as their GHG emissions are associated with supplying inputs to other sectors to satisfy the demand of the other sectors rather than satisfying their own demand. Contrarily, all other sectors are not suppliers and they carry embodied emissions of other sectors, needed to satisfy the demand for their final goods and services. This pattern can be observed when comparing PBA and CBA GHG emissions. In 2019, the PBA GHG emissions, compared to CBA, are higher for 3 out of 12 Austrian service sectors and 3 out of 6 non-service sectors, namely the mining, electricity, water, trade, transportation, and financial sectors. However, since the GHG emissions footprint of the health and public administration sectors, as well as other services are rather small, one may assume an overall reduction of GHG emissions when shifting towards these specific service sectors.

5.1.2 Austrian Employment

The second hypothesis (H_2), arguing that the Austrian service economy provides more employment compared to the non-service sectors of the Austrian economy, has partly been confirmed by this thesis. Based on PBA, the service economy does provide more employment. However, based on CBA, the non-service economy displays a larger labor footprint.

Moreover, the analysis of the individual sectors does not illustrate a pattern such as service sectors being more labor intensive than non-service sectors. Based on CBA and PBA, the sectors providing the most employment are the accommodation, agriculture, construction, health, manufacturing, public administration and transportation sectors, as well as other services. Thus, the analysis of the aggregated CBA, as well as the analysis of the individual sectors illustrate that the service sectors might not be as labor intensive as suggested compared to the non-service sectors of the Austrian economy.

Furthermore, the results suggest that if demand would increase in the service economy, there are stronger employment effects on the service economy than the non-service economy as there are relatively few indirect flows between the service economy and the non-service economy. The employment linked to the service economy is mainly affiliated with inputs from the service sectors. On the contrary, most of the employment needed to satisfy the final demand of the non-service economy can be traced back to inputs from the non-service sectors. Thus, a structural shift towards service sectors, i.e. the increase of demand for services, could induce other service sectors to provide more employment, and a shift towards or from the sectors of the non-service economy would lead to an induced increase or reduction of employment in the non-service sectors respectively.

Additionally, a structural shift towards service sectors would lead to an increase in Austrian employment, as the employment linked to inputs for the service economy mainly lies in Austria. However, the employment bound to inputs for the non-service economy mainly lies in the rest of the world and thus an investment into the sectors of the non-service economy would most likely lead to an increase of employment opportunities outside of Austria.

5.1.3 Emission Intensity and Decoupling

The third hypothesis (H_3), arguing that the Austrian service economy is less emission intense than the non-service economy, has been supported by this study. Based on CBA and PBA, the non-service economy displays higher emission intensities than the service economy. In addition, it was found that based on CBA and PBA the individual service sectors tend to have lower emission intensities compared to non-service sectors.

The fourth hypothesis (H_4) stating that the Austrian service economy displays decoupling tendencies between GHG emissions and employment between the years 1996 and 2019, while the non-service economy does not, has not been confirmed. Based on PBA, the service economy and the non-service economy do not display decoupling tendencies. Contrarily, based on CBA, the non-service economy displays relative decoupling and the service economy absolute decoupling tendencies.

On a sectoral level, based on PBA solemnly service sectors display absolute or relative decoupling tendencies, and based on CBA, service sectors as well as non-service sectors display absolute and relative decoupling tendencies and there is no pattern apparent.

5.2 Policy Discourse

Overall, one may argue that Austria is on a good path to reduce GHG emissions, as their GHG emissions strategies target the hotspot sectors, such as the electricity, mining, or transportation sectors (BMNT and BMVIT, 2018; Die Neue Volkspartei and Die Grünen, 2020). However, in order to decrease GHG emissions further while increasing employment, the governmental program should include new policy programs which target the restructuring of the Austrian economy towards service sectors. More specifically, this thesis has shown that a structural transformation towards the health and public administration sectors, as well as other services[3] could contribute towards climate mitigation efforts and an increase in employment because the GHG emissions footprint is relatively small, and the labor requirements are high compared to other economic activities. This section presents concepts which could provide input to form a new policy program for the restructuring of the Austrian economy. It briefly presents three different concepts, namely the foundational economy, a job guarantee, and green jobs.

The concept of the foundational economy could be an important building block in a new policy program to restructure the Austrian economy towards service sectors, especially the health and public administration sectors. The foundational economy focuses on the collective and long-term social well-being by providing essential goods and services such as health, care, education, housing, and utility supply (Engelen et al., 2017; Foundational Economy Collective, 2020). The foundational economy especially prioritizes health and care, as health and care will become more important with time since societies are facing more health-related issues, such as bad air quality, mental health issues, health issues related to poor diets and needed care for an aging society (Foundational Economy Collective, 2020). The Foundational Economy Collective (2020) presents concrete aspects which should be considered when strengthening the health sector, such as the expansion of community-based health services or the raise of health funding. Thus, the foundational economy could provide input for a new policy program on the implementation of a structural shift of the Austrian economy towards the health sector.

Another possibility would be to implement a job guarantee in the health or public administration sectors, or in one of the sub-sectors of other services (see Appendix A). A job guarantee entails publicly funded jobs which could reduce unemployment, especially long-term unemployment (Picek, 2019a). There are proposals of job guarantees suggesting the

[3] As can be seen in Appendix A, other services include (1) the renting of machinery and equipment without operator and personal and household goods, (2) computer and related activities, (3) other business activities, (4) activities of membership organizations, (5) other service activities, (6) private households with employed persons and (7) extra-territorial organizations and bodies.

creation of jobs focusing on the care for society and the environment (Picek, 2019b; Tcherneva, 2017). The "Aktion 20.000" (translated: Action 20.000) program, an employment project in Austria, provides an example of such a policy program. It can provide specific insights for a new policy program as the program entailed the creation of publicly funded jobs in the sectors which were identified to be suitable in this thesis. Half of the jobs of the "Aktion 20.000" were created in the health sector, a quarter in the public administration sector and another quarter were classified as other services. The evaluation of the "Aktion 20.000" showed that the unemployment rates decreased and life satisfaction increased (Picek, 2019b). Overall, a job guarantee in the health and public administration sectors, as well as other services, similar to the "Aktion 20.000", provides a possibility to restructure the Austrian economy towards labor intensive and less emitting service sectors.

Lastly, Austria could implement a new plan concerning the creation of green jobs in the health or public administration sector, as well as in one of the sectors belonging to other services (see Appendix A). Austria has implemented a master plan concerning the creation of 100.000 additional green jobs until the year 2020 (Leitner et al., 2012). According to the ILO (2016) green jobs are "jobs that contribute to preserve or restore the environment, be they traditional sectors such as manufacturing and construction, or in new, emerging green sectors such as renewable energy and energy efficiency". Austria has planned to create new jobs within the following sectors, (1) renewable energies, (2) ground, water and surface protection, (3) waste management, (4) trade, (5) construction, and (6) architecture and engineering (Leitner et al., 2012). However, as the main aim of green jobs are to preserve the environment and increase social-wellbeing, the government may consider to design a new policy program entailing the creation of green jobs in the health or public administration sectors, as well as in one of the sectors belonging to other services (see Appendix A) to restructure the Austrian economy towards less emitting and labor intensive service sectors.

5.3 Limitations

There are several limitations to this study, mainly concerning the method. Firstly, some of the assumptions of IOA may lead to less accurate results, such as the assumption of homogeneity, the assumption that fixed proportions of inputs are needed to produce outputs, assumptions about the treatment of the capital stock, or the assumption about the relation between physical and monetary data (Kitzes, 2013; Schaffartzik et al., 2014). Secondly, the accuracy of the data and IOT may be impeded by various factors, such as that IOT do not capture all economic activities (for example unpaid work) or that IOT do not exist for all nations (Kitzes, 2013; Schaffartzik et al., 2014). Additionally, to integrate the data of various regions into a MRIO while meeting the requirements of IOA, such as total inputs equaling total outputs, some of the data must be adjusted and harmonized. Hence, for some countries the estimates and resulting recommendations based on MRIOs might not be as accurate anymore. Thirdly, the assessment and the assignment of environmental impacts is difficult, and the data used in the model is only an estimation (Schaffartzik et al., 2014). Fourthly, different data sets may lead to differing results on the sector level.

This thesis tried to limit the extent of the limitations and ensure the validity of the results by comparing the data to several other studies. The emission and employment data of the PBA analysis was compared to data by Statistik Austria (2021), and the emission data of the analysis based on CBA was compared to results based on the databases Eora, WIOD, Exiobase 3.7, and Exiobase 3.4.1 ("Environmental Footprint Explorers," 2020). The results based on Exiobase 3.7 show larger differences to the results of this thesis. However, the deviation of the results of this study compared to the results of all other databases are under 20% and thus, can be considered as fluctuations due to the data. The results of employment based on CBA could not be compared to existing data as there was none.

5.4 Recommendations for Future Research

Based on the findings and limitations of this study, there are several recommendations for future research. Firstly, future researchers may consider performing a structural decomposition analysis and input-output subsystem analysis in order to analyze how strong the potential pull-effect of the Austrian service sectors is, and which sectors the pull-effect of the service sectors affect. Secondly, future research may create a different model which addresses the data accuracy issues. For example, researchers may consider an analysis on the basis of a system of national account consistent MRIO (SNAC-MRIO) (Edens et al., 2015; Tukker et al., 2018). A SNAC-MRIO exchanges the data of a country found in a database, such as EXIOBASE, with the data from the national statistics institute of the country. Therefore, the model allows for more robust estimates concerning this specific country (Edens et al., 2015; Tukker et al., 2018). Thirdly, future research may replicate the results of this study with data from other databases to confirm or refute the results of this study. Lastly, future research may analyze one of the presented policy concepts in more detail, such as analyzing the foundational economy based on IOA.

6.Conclusion

This thesis used an environmentally extended MRIO model to analyze the various Austrian sectors in terms of GHG emissions and employment to examine whether the job creation within specific service sectors could contribute towards climate mitigation efforts and an increase in employment. The analysis considered GHG emissions, employment, and emission intensities per hour of employment, focusing on 2019, and analyzed decoupling tendencies, between 1996 and 2019, from a production and consumption perspective.

This thesis revealed several insights. Firstly, Austria is generally on a promising path concerning GHG reduction, as the corresponding hotspot sectors, such as electricity, mining or transportation, are addressed in their GHG emissions reduction strategy. However, the component of a potential structural shift is missing which could solve the conflict between the policy objectives of the Austrian government to reduce GHG emissions and increase employment. Secondly, the most suitable sectors for a structural shift are the health and public administration sectors, as well as other services. Thirdly, new policy programs to implement such a structural shift could include the foundational economy, a job guarantee, or green jobs. Lastly, further research could investigate the potential of concepts such as the foundational economy in more detail from a quantitative perspective, and the Austrian service sectors could be analyzed for the strength of their pull effect, as well as analyzing them with a SNAC-MRIO.

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Appendix A: Classification of Sectors of MRIO EXIOBASE 3.8.1 with Service Sectors marked in Orange

Industry in MRIO EXIOBASE 3.8.1	Classification
Cultivation of paddy rice	Agriculture, Forestry and Fishery (A)
Cultivation of wheat	Agriculture, Forestry and Fishery (A)
Cultivation of cereal grains nec	Agriculture, Forestry and Fishery (A)
Cultivation of vegetables, fruit, nuts	Agriculture, Forestry and Fishery (A)
Cultivation of oil seeds	Agriculture, Forestry and Fishery (A)
Cultivation of sugar cane, sugar beet	Agriculture, Forestry and Fishery (A)
Cultivation of plant-based fibers	Agriculture, Forestry and Fishery (A)
Cultivation of crops nec	Agriculture, Forestry and Fishery (A)
Cattle farming	Agriculture, Forestry and Fishery (A)
Pigs farming	Agriculture, Forestry and Fishery (A)
Poultry farming	Agriculture, Forestry and Fishery (A)
Meat animals nec	Agriculture, Forestry and Fishery (A)
Animal products nec	Agriculture, Forestry and Fishery (A)
Raw milk	Agriculture, Forestry and Fishery (A)
Wool, silk-worm cocoons	Agriculture, Forestry and Fishery (A)
Manure treatment (conventional), storage and land application	Agriculture, Forestry and Fishery (A)
Manure treatment (biogas), storage and land application	Agriculture, Forestry and Fishery (A)
Forestry, logging and related service activities (02)	Agriculture, Forestry and Fishery (A)
Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing (05)	Agriculture, Forestry and Fishery (A)
Mining of coal and lignite; extraction of peat (10)	Mining and Quarrying (B)
Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	Mining and Quarrying (B)
Extraction of natural gas and services related to natural gas extraction, excluding surveying	Mining and Quarrying (B)
Extraction, liquefaction, and regasification of other petroleum and gaseous materials	Mining and Quarrying (B)

Mining of uranium and thorium ores (12)	Mining and Quarrying (B)
Mining of iron ores	Mining and Quarrying (B)
Mining of copper ores and concentrates	Mining and Quarrying (B)
Mining of nickel ores and concentrates	Mining and Quarrying (B)
Mining of aluminium ores and concentrates	Mining and Quarrying (B)
Mining of precious metal ores and concentrates	Mining and Quarrying (B)
Mining of lead, zinc and tin ores and concentrates	Mining and Quarrying (B)
Mining of other non-ferrous metal ores and concentrates	Mining and Quarrying (B)
Quarrying of stone	Mining and Quarrying (B)
Quarrying of sand and clay	Mining and Quarrying (B)
Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	Mining and Quarrying (B)
Processing of meat cattle	Manufacturing (C)
Processing of meat pigs	Manufacturing (C)
Processing of meat poultry	Manufacturing (C)
Production of meat products nec	Manufacturing (C)
Processing vegetable oils and fats	Manufacturing (C)
Processing of dairy products	Manufacturing (C)
Processed rice	Manufacturing (C)
Sugar refining	Manufacturing (C)
Processing of Food products nec	Manufacturing (C)
Manufacture of beverages	Manufacturing (C)
Manufacture of fish products	Manufacturing (C)
Manufacture of tobacco products (16)	Manufacturing (C)
Manufacture of textiles (17)	Manufacturing (C)
Manufacture of wearing apparel; dressing and dyeing of fur (18)	Manufacturing (C)
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear (19)	Manufacturing (C)
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (20)	Manufacturing (C)
Re-processing of secondary wood material into new wood material	Manufacturing (C)
Pulp	Manufacturing (C)
Re-processing of secondary paper into new pulp	Manufacturing (C)
Paper	Manufacturing (C)
Publishing, printing and reproduction of recorded media (22)	Manufacturing (C)
Manufacture of coke oven products	Manufacturing (C)
Petroleum Refinery	Manufacturing (C)
Processing of nuclear fuel	Manufacturing (C)
Plastics, basic	Manufacturing (C)
Re-processing of secondary plastic into new plastic	Manufacturing (C)
N-fertiliser	Manufacturing (C)
P- and other fertiliser	Manufacturing (C)

Chemicals nec	Manufacturing (C)
Manufacture of rubber and plastic products (25)	Manufacturing (C)
Manufacture of glass and glass products	Manufacturing (C)
Re-processing of secondary glass into new glass	Manufacturing (C)
Manufacture of ceramic goods	Manufacturing (C)
Manufacture of bricks, tiles and construction products, in baked clay	Manufacturing (C)
Manufacture of cement, lime and plaster	Manufacturing (C)
Re-processing of ash into clinker	Manufacturing (C)
Manufacture of other non-metallic mineral products n.e.c.	Manufacturing (C)
Manufacture of basic iron and steel and of ferro-alloys and first products thereof	Manufacturing (C)
Re-processing of secondary steel into new steel	Manufacturing (C)
Precious metals production	Manufacturing (C)
Re-processing of secondary preciuos metals into new preciuos metals	Manufacturing (C)
Aluminium production	Manufacturing (C)
Re-processing of secondary aluminium into new aluminium	Manufacturing (C)
Lead, zinc and tin production	Manufacturing (C)
Re-processing of secondary lead into new lead, zinc and tin	Manufacturing (C)
Copper production	Manufacturing (C)
Re-processing of secondary copper into new copper	Manufacturing (C)
Other non-ferrous metal production	Manufacturing (C)
Re-processing of secondary other non-ferrous metals into new other non-ferrous metals	Manufacturing (C)
Casting of metals	Manufacturing (C)
Manufacture of fabricated metal products, except machinery and equipment (28)	Manufacturing (C)
Manufacture of machinery and equipment n.e.c. (29)	Manufacturing (C)
Manufacture of office machinery and computers (30)	Manufacturing (C)
Manufacture of electrical machinery and apparatus n.e.c. (31)	Manufacturing (C)
Manufacture of radio, television and communication equipment and apparatus (32)	Manufacturing (C)
Manufacture of medical, precision and optical instruments, watches and clocks (33)	Manufacturing (C)
Manufacture of motor vehicles, trailers and semi-trailers (34)	Manufacturing (C)
Manufacture of other transport equipment (35)	Manufacturing (C)
Manufacture of furniture; manufacturing n.e.c. (36)	Manufacturing (C)
Recycling of waste and scrap	Manufacturing (C)
Recycling of bottles by direct reuse	Manufacturing (C)
Production of electricity by coal	Electricity, Gas, Steam, and Air Conditioning Supply (D)

Production of electricity by gas	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by nuclear	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by hydro	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by wind	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by petroleum and other oil derivatives	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by biomass and waste	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by solar photovoltaic	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by solar thermal	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by tide, wave, ocean	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity by Geothermal	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Production of electricity nec	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Transmission of electricity	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Distribution and trade of electricity	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Manufacture of gas; distribution of gaseous fuels through mains	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Steam and hot water supply	Electricity, Gas, Steam, and Air Conditioning Supply (D)
Collection, purification and distribution of water (41)	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Construction (45)	Construction (F)
Re-processing of secondary construction material into aggregates	Construction (F)
Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries	**Wholesale and Retail Trade: Repair of Motorvehicles and Motorcycles (G)**
Retail sale of automotive fuel	**Wholesale and Retail Trade: Repair of Motorvehicles and Motorcycles (G)**
Wholesale trade and commission trade, except of motor vehicles and motorcycles (51)	**Wholesale and Retail Trade: Repair of Motorvehicles and Motorcycles (G)**
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52)	**Wholesale and Retail Trade: Repair of Motorvehicles and Motorcycles (G)**

Hotels and restaurants (55)	**Accommodation and Food Service Activities (I)**
Transport via railways	**Transportation and Storage (H)**
Other land transport	**Transportation and Storage (H)**
Transport via pipelines	**Transportation and Storage (H)**
Sea and coastal water transport	**Transportation and Storage (H)**
Inland water transport	**Transportation and Storage (H)**
Air transport (62)	**Transportation and Storage (H)**
Supporting and auxiliary transport activities; activities of travel agencies (63)	**Transportation and Storage (H)**
Post and telecommunications (64)	**Post and Telecommunication (PTK)**
Financial intermediation, except insurance and pension funding (65)	**Financial and Insurance Activities (K)**
Insurance and pension funding, except compulsory social security (66)	**Financial and Insurance Activities (K)**
Activities auxiliary to financial intermediation (67)	**Financial and Insurance Activities (K)**
Real estate activities (70)	**Real Estate Activities (L)**
Renting of machinery and equipment without operator and of personal and household goods (71)	**Other Services (OS)**
Computer and related activities (72)	**Other Services (OS)**
Research and development (73)	**Professional, Scientific and Technical Activities (M)**
Other business activities (74)	**Other Services (OS)**
Public administration and defence; compulsory social security (75)	**Public Administration and Defence: Compulsory Social Security (O)**
Education (80)	**Education (P)**
Health and social work (85)	**Human Health and Social Work Activities (Q)**
Incineration of waste: Food	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Incineration of waste: Paper	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Incineration of waste: Plastic	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Incineration of waste: Metals and Inert materials	Water Supply: Sewerage, Waste Management and Remediation Activities (E)

Incineration of waste: Textiles	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Incineration of waste: Wood	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Incineration of waste: Oil/Hazardous waste	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Biogasification of food waste, incl. land application	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Biogasification of paper, incl. land application	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Biogasification of sewage slugde, incl. land application	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Composting of food waste, incl. land application	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Composting of paper and wood, incl. land application	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Waste water treatment, food	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Waste water treatment, other	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Landfill of waste: Food	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Landfill of waste: Paper	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Landfill of waste: Plastic	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Landfill of waste: Inert/metal/hazardous	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Landfill of waste: Textiles	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Landfill of waste: Wood	Water Supply: Sewerage, Waste Management and Remediation Activities (E)
Activities of membership organisation n.e.c. (91)	**Other Services (OS)**

Recreational, cultural and sporting activities (92)	**Arts, Entertainment and Recreation (R)**
Other service activities (93)	**Other Services (OS)**
Private households with employed persons (95)	**Other Services (OS)**
Extra-territorial organizations and bodies	**Other Services (OS)**

Appendix B: Sectors with Long and Short Names with Service Sectors marked in Orange

Long Name	**Short Name**
Agriculture, Forestry and Fishery (A)	Agriculture
Mining and Quarrying (B)	Mining
Manufacturing (C)	Manufacturing
Electricity, Gas, Steam, and Air Conditioning Supply (D)	Electricity
Water Supply: Sewerage, Waste Management and Remediation Activities (E)	Water
Construction (F)	Construction
Wholesale and Retail Trade: Repair of Motorvehicles and Motorcycles (G)	Trade
Transportation and Storage (H)	Transportation
Accommodation and Food Service Activities (I)	Accommodation
Financial and Insurance Activities (K)	Financial
Real Estate Activities (L)	Real Estate
Professional, Scientific and Technical Activities (M)	R&D
Public Administration and Defence: Compulsory Social Security (O)	Public Administration
Other Services (OS)	Other Services
Education (P)	Education
Post and Telecommunication (PTK)	Post
Human Health and Social Work Activities (Q)	Health
Arts, Entertainment and Recreation (R)	Entertainment

Appendix C: Figures over Time

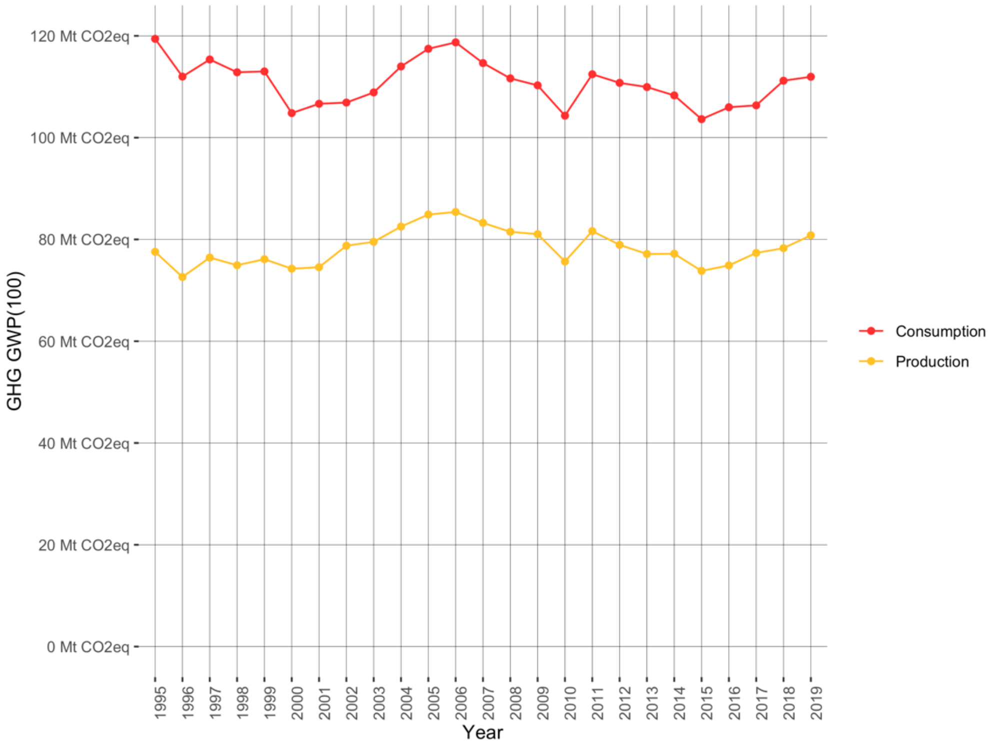

Figure 9: Total PBA and CBA Austrian GHG Emissions from 1995 until 2019 in Mt CO_2eq

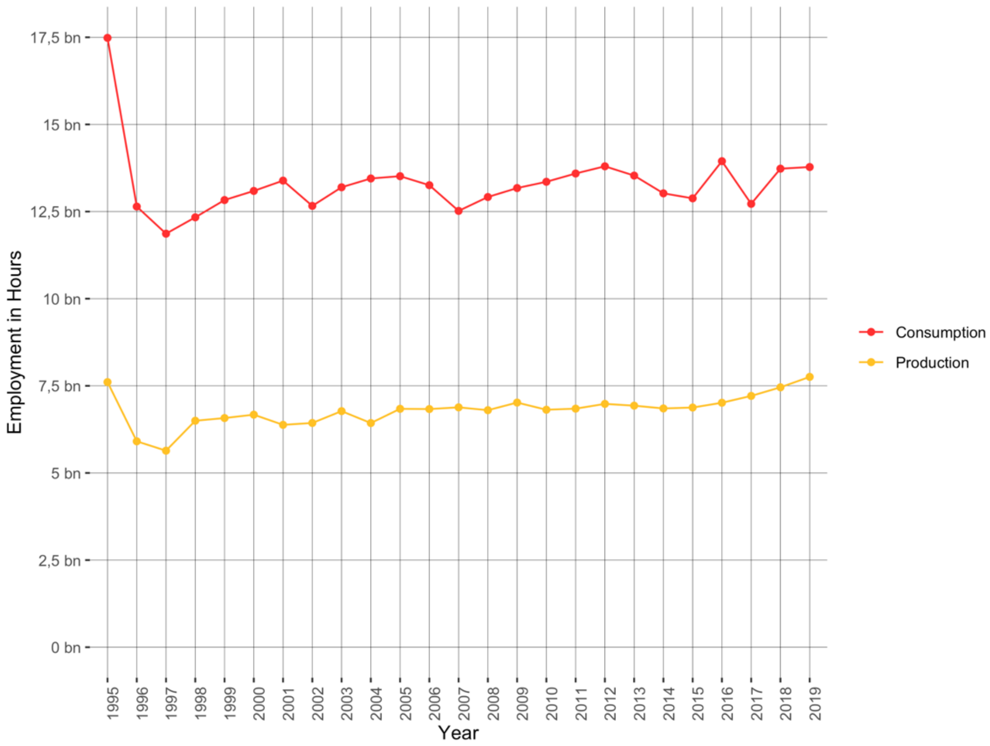

Figure 10: Total PBA and CBA Austrian Employment from 1995 until 2019 in Billion Hours

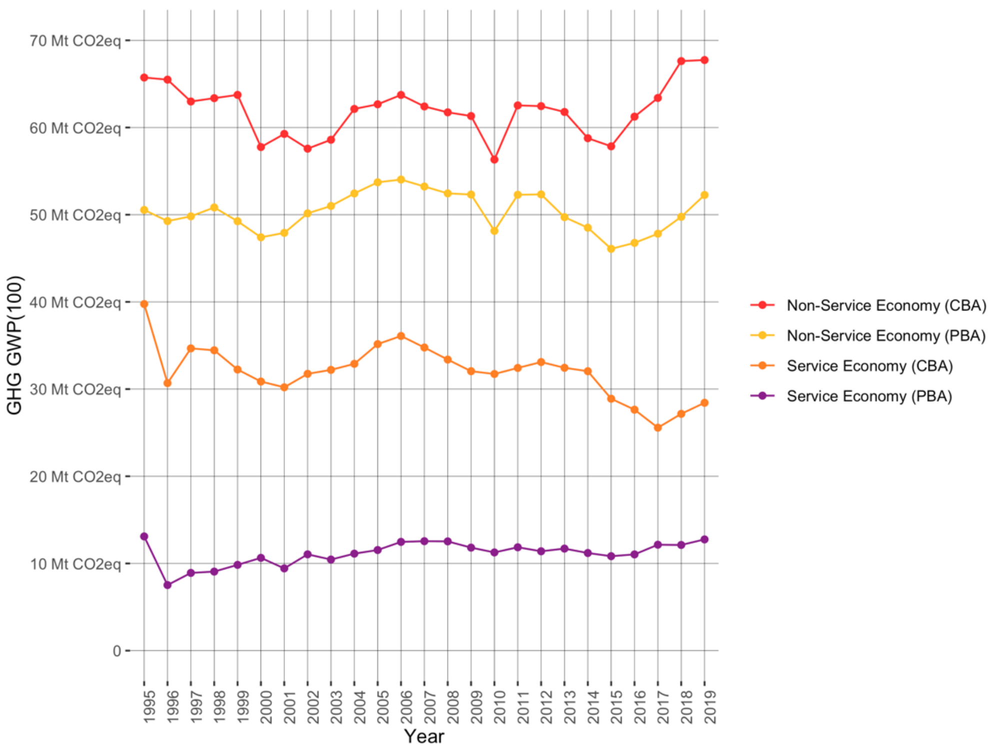

Figure 11: Austrian PBA and CBA GHG Emissions of the Service Economy and the Non-Service Economy from 1995 until 2019 in Mt CO_2eq

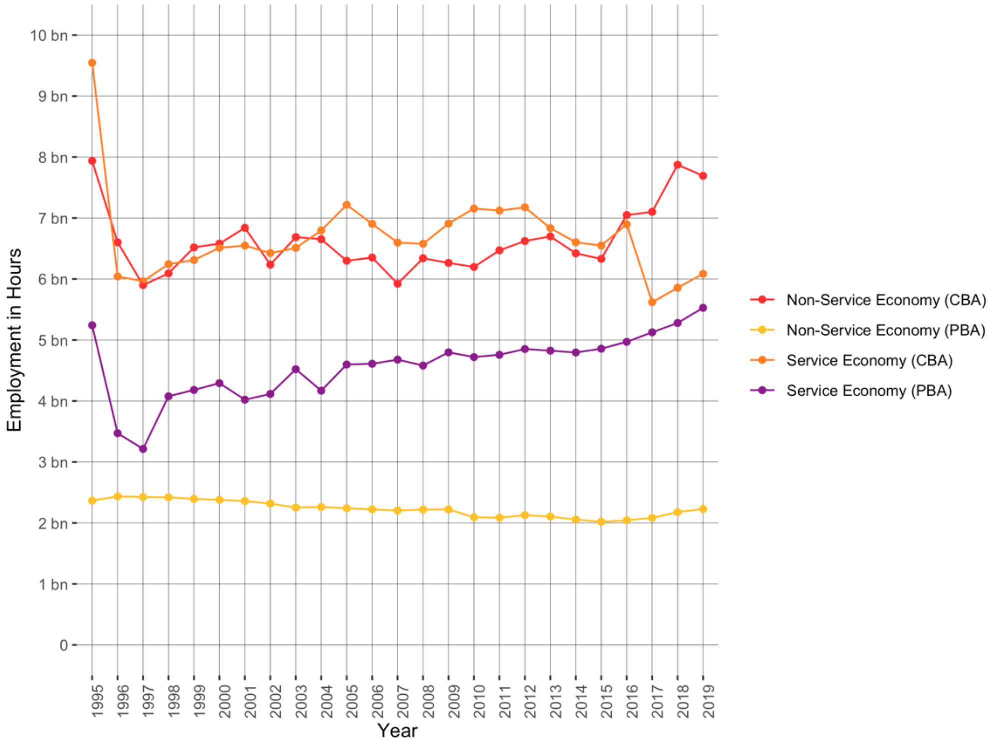

Figure 12: Austrian PBA and CBA Employment of the Service Economy and Non-Service Economy from 1995 until 2019 in Billion Hours

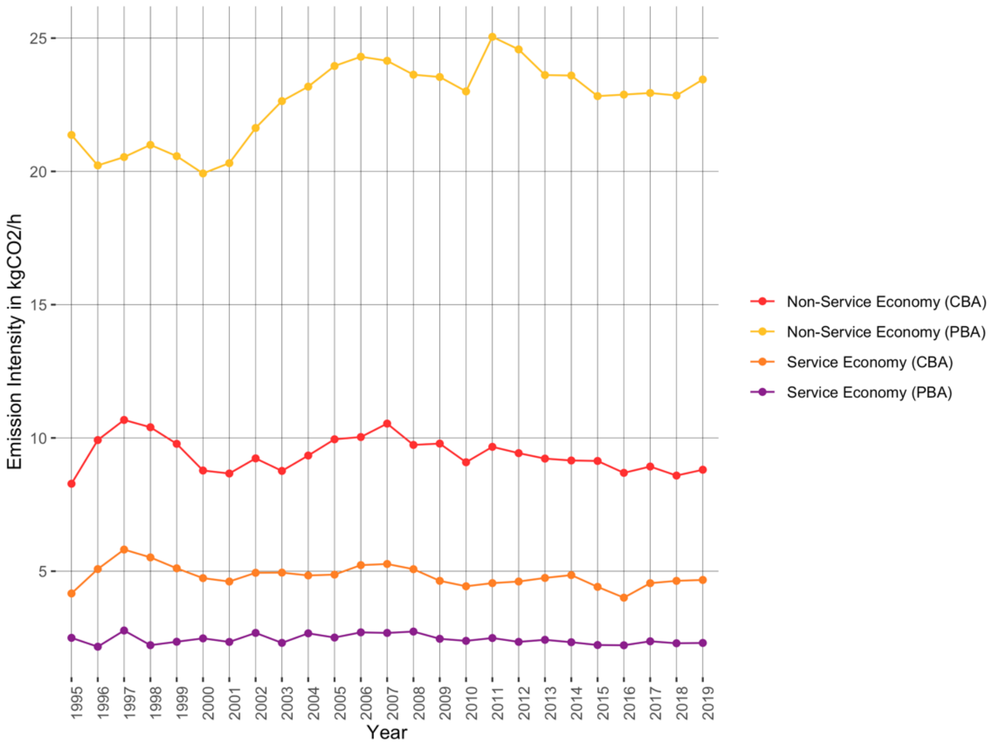

Figure 13: PBA and CBA Emission Intensity of the Service Economy and the Non-Service Economy from 1995 until 2019 in Austria in kg of CO_2eq per Hour of Employment

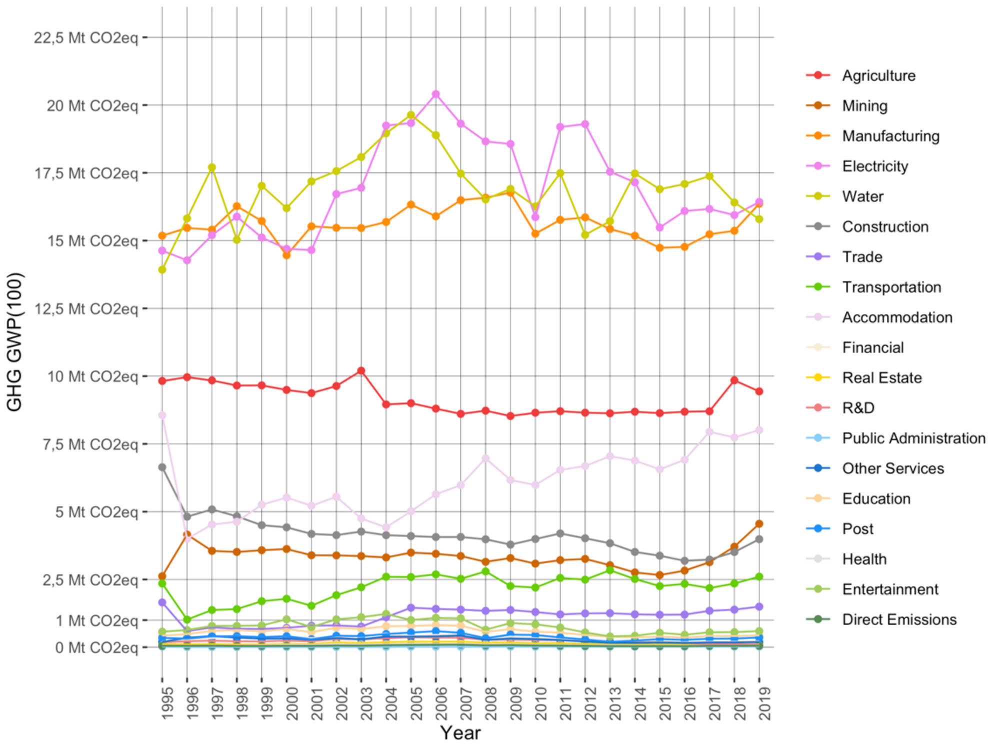

Figure 14: Austrian PBA GHG Emissions of Sectors from 1995 until 2019 in Mt CO_2eq

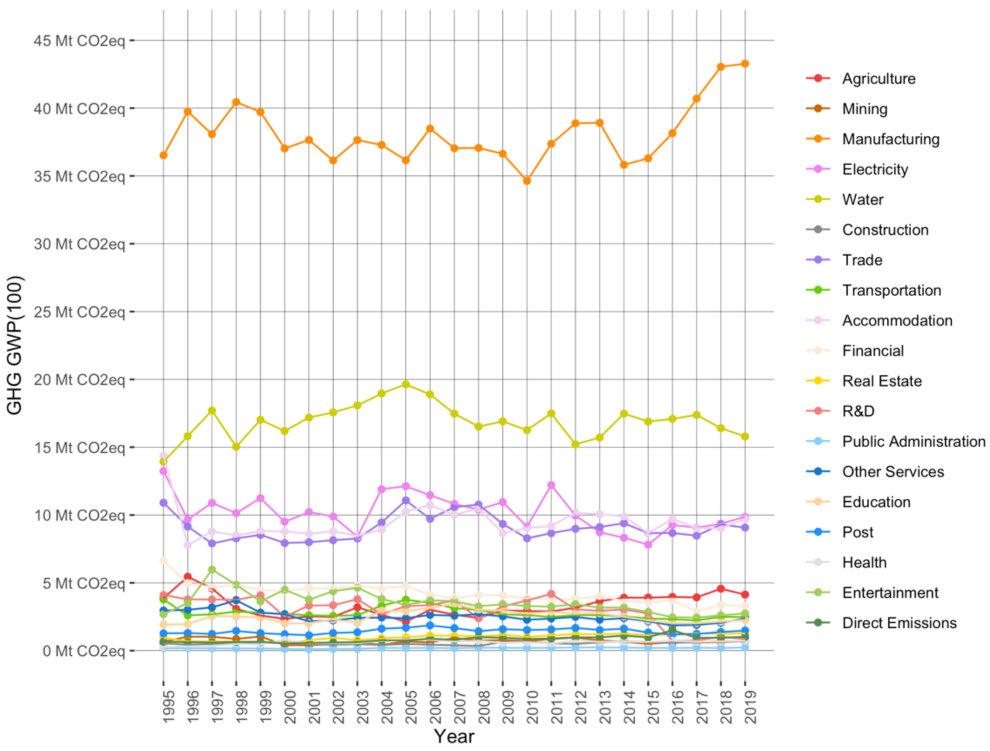

Figure 15: Austrian CBA GHG Emissions of Sectors from 1995 until 2019 in Mt CO_2eq

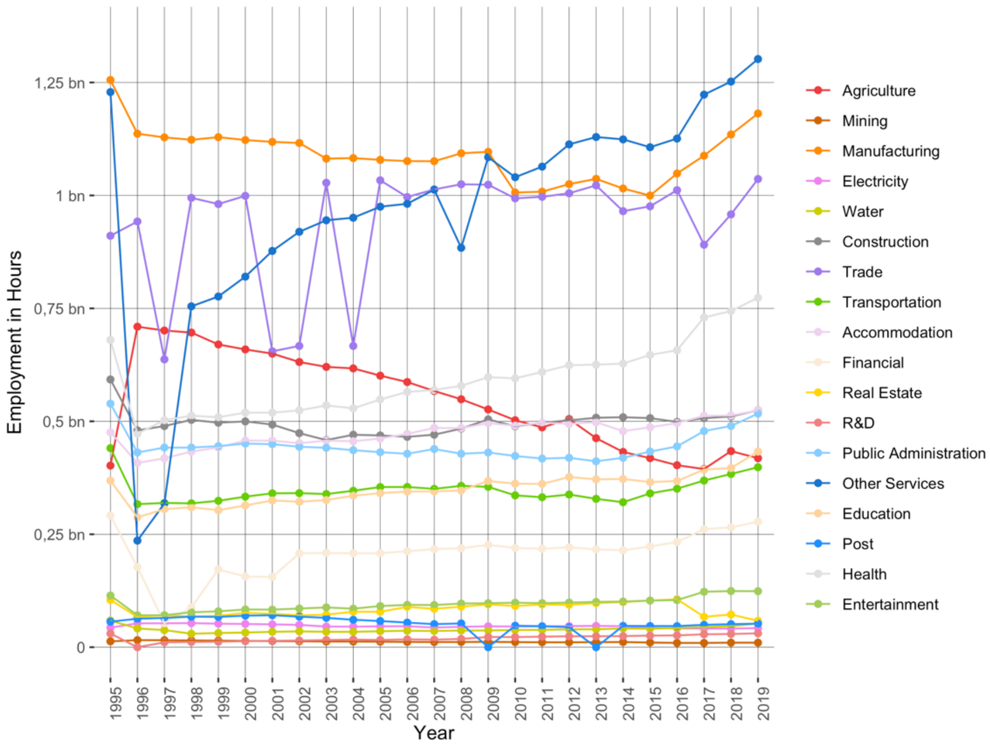

Figure 16: Austrian PBA Employment of Sectors from 1995 until 2019 in Billion Hours

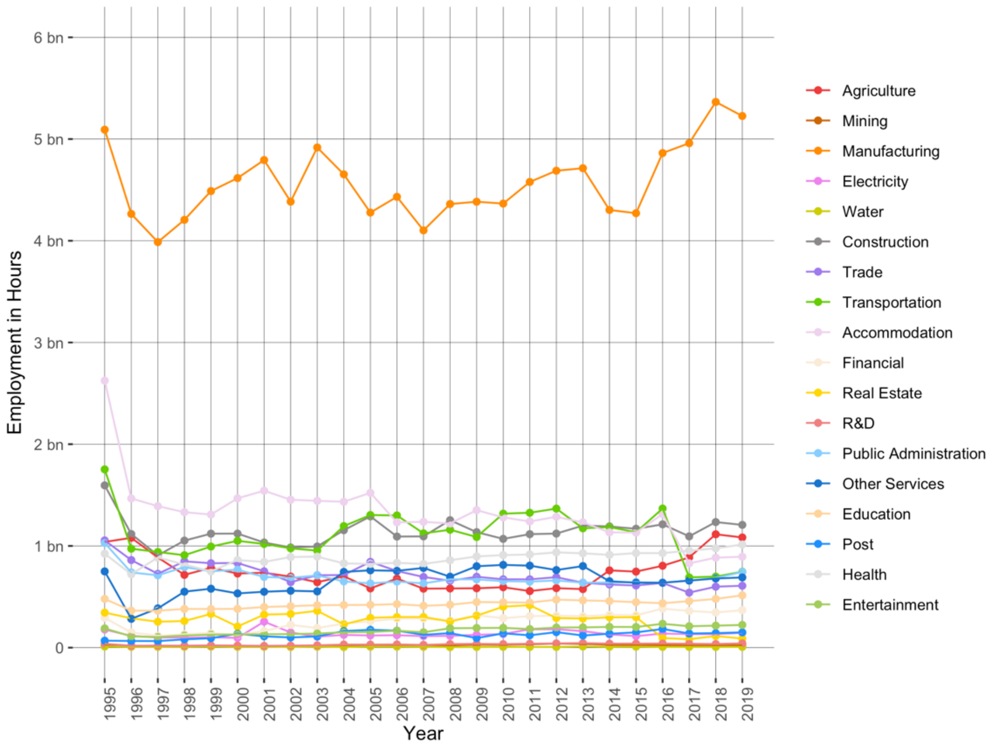

Figure 17: Austrian CBA Employment of Sectors from 1995 until 2019 in Billion Hours

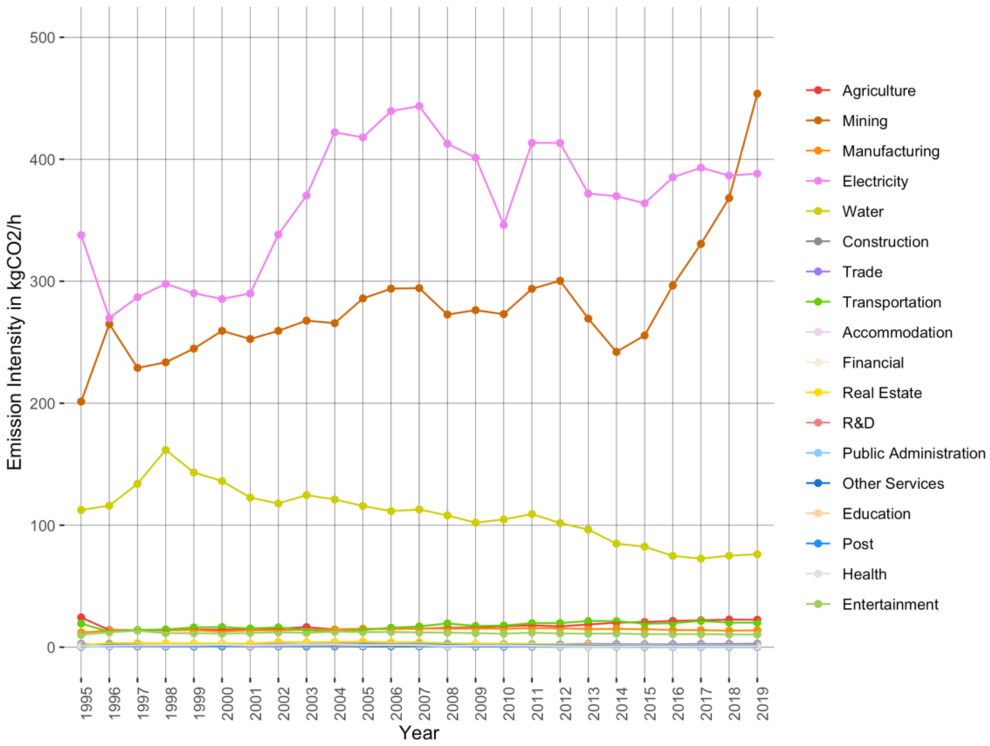

Figure 18: PBA Emission Intensity of Austrian Sectors from 1995 until 2019 in kg of CO_2eq per Hour of Employment

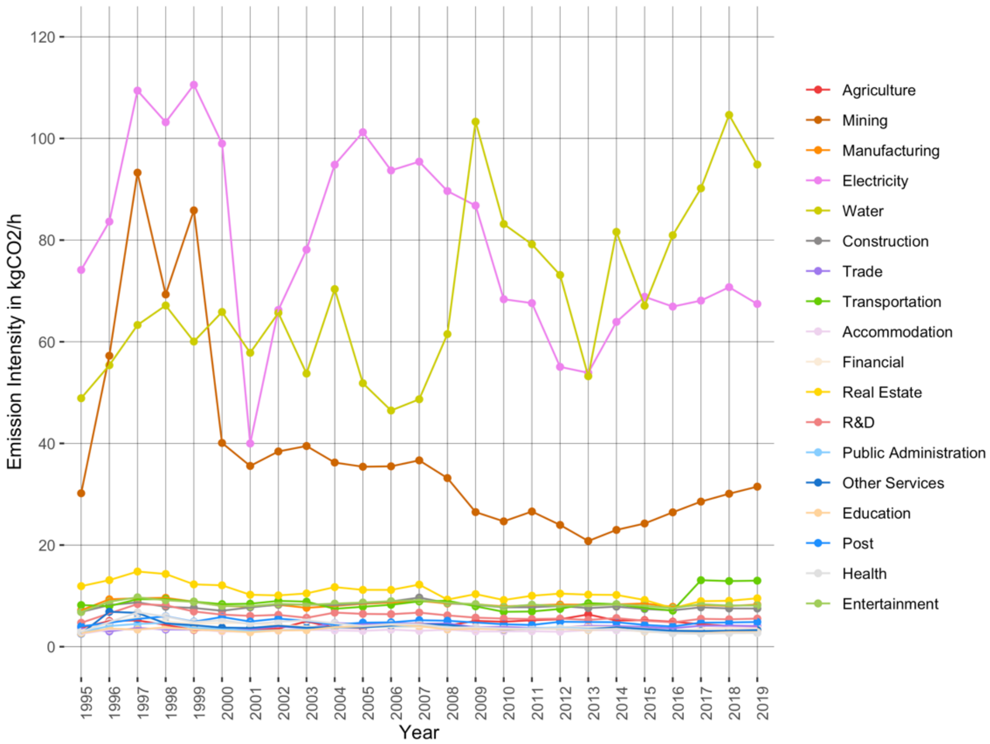

Figure 19: CBA Emission Intensity of Austrian Sectors from 1995 until 2019 in kg of CO2eq per Hour of Employment

Appendix D: GHG Emissions and Employment of the Austrian Sectors

	GHG Emissions		Employment	
Sectors	**Relative**	**Absolute**	**Relative**	**Absolute**
Agriculture	11.68	9437331	5.39	418369105
Mining	5.64	4554451	0.13	10037256
Manufacturing	20.25	16362078	15.23	1181304273
Electricity	20.33	16425637	0.55	42309637
Water	4.93	3985477	0.67	52315247
Construction	1.85	1496167	6.76	524446239
Trade	3.22	2602653	13.36	1036364499
Transportation	9.91	8009560	5.14	398388077
Accommodation	0.26	213896	6.76	524177606
Financial	0.14	113973	3.58	277792860
Real Estate	0.12	96825	0.75	58544378
R&D	0.03	22370	0.40	30738239
Public	0.24	190583	6.67	517055812
Other Services	0.54	438415	16.78	1301919650
Education	0.44	358184	5.58	433150189
Post	0.08	60609	0.67	52254058
Health	0.74	595616	9.97	773521305
Entertainment	0.07	55376	1.60	124015762

Table 3: PBA GHG Emissions and Employment of the Austrian Sectors in 2019 in Relative (%) and Absolute (MtCO_2eq and billion hours) Terms

	GHG Emissions		Employment	
Sectors	**Relative**	**Absolute**	**Relative**	**Absolute**
Agriculture	3.69	4133787	7.86	1083207145
Mining	0.63	705166	0.16	22392369
Manufacturing	38.65	43279050	37.93	5226607974
Electricity	8.81	9859805	1.06	146203907
Water	0.62	690514	0.05	7278706
Construction	8.10	9073130	8.76	1206824461
Trade	2.21	2478039	4.42	608371038
Transportation	8.67	9704812	5.42	746659152
Accommodation	2.93	3277888	6.49	893630909
Financial	1.14	1275607	2.68	368746040
Real Estate	0.76	846857	0.65	88901104
R&D	0.21	235562	0.31	42610888
Public	2.12	2373939	5.40	744236834
Other Services	2.02	2259568	5.01	690179688
Education	1.32	1480121	3.73	514422452
Post	0.65	730251	1.09	150169899
Health	2.45	2742190	7.36	1014361884
Entertainment	0.91	1024252	1.62	223149704

Table 4: CBA GHG Emissions and Employment of the Austrian Sectors in 2019 in Relative (%) and Absolute (MtCO_2eq and billion hours) Terms