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Long-term Specialization and Trade Flow Patterns of Heavy Industrial and Light Industrial Goods:

A Comparative Analysis of Anglophone and Nordic countries

by

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Abstract: Recent studies focusing on the analysis of emissions embodied in trade have shown that high-income countries are increasingly becoming net importers of emissions. This is commonly explained by the economies' changing trade specialization in heavy and light industrial goods. The purpose of this thesis is to investigate and compare the trade specialization patterns of twelve Anglophone and Nordic countries between 1962 and 2016 by using two trade specialization indicators: the normalized trade balance and the revealed symmetric comparative advantage (RSCA) index. The results do not support the claim that the Anglophone or Nordic countries have increasingly specialized in the export of light industrial or the import of heavy industrial goods. Instead, it has rather been found that natural resources, such as wood or basic metals, have been very trade-determinant factors throughout the entire period. Overall, the results suggest that other reasons than a changing trade structure must be responsible for the increasing emissions embodied in imports.

Key words: Trade Specialization, CO_2 emissions, Heavy and Light Industry, Economic Development, Natural Resources

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List of Abbreviations

BEET	Balance of Emissions Embodied in Trade
CBA	Consumption-based Accounting
EEE	Emissions Embodied in Exports
EEI	Emissions Embodied in Imports
EKC	Environmental Kuznets Curve
GHG	Greenhouse Gas
NT	Normalized Trade Balance
OECD	Organisation for Economic Co-operation and Development
PBA	Production-based Accounting
PHH	Pollution Haven Hypothesis
RCA	Revealed Comparative Advantage
RSCA	Revealed Symmetric Comparative Advantage
SITC	Standard International Trade Classification
TBEET	Technology-adjusted Balance of Emissions Embodied in Trade
TCBA	Technology-adjusted Consumption-based Accounting
UN Comtrade	United Nations Commodity Trade Statistics Database
UNFCCC	United Nations Framework Convention on Climate Change
WIOD	World Input-Output Database

1. Introduction

The globalization of production processes has had the effect that goods as well as services have no longer one country of origin but involve different production stages across the globe. Correspondingly, the amount of both traded goods and services has increased substantially leading to a rise in emissions embodied in trade (Davis *et al.*, 2011; Edenhofer, 2014).

While many developed countries report decreasing territorial emissions, different studies have found that the emissions that are produced to serve their demands have increased rather than decreased if they are adjusted for international trade (e.g. Kanemoto *et al.*, 2014; Yang *et al.*, 2016).[1] This discrepancy results from allocating emissions using a consumption-based instead of a production-based perspective and is commonly associated with the outsourcing of emission-intensive activities to countries abroad or, in other words, with carbon leakage (Boitier, 2012; Kander *et al.*, 2015). By outsourcing carbon-intensive production activities, countries may be able to meet their emission targets without truly reducing global emissions. Instead, generated emissions are just shifted to other countries which, in turn, undermines global climate mitigation efforts (Aichele and Felbermayr, 2015).

Recently, Jiborn *et al.* (2018) have proposed a new method to quantify consumption-based emissions by calculating a country's 'technology-adjusted balance of emissions embodied in trade (TBEET)'. In contrast to traditional consumption-based accounting frameworks, this approach allows to determine emission leakage more accurately as it adjusts for differences in energy systems and production technologies in imports and exports. Consequently, net flows of embodied carbon emissions can exclusively be attributed to the following two factors: trade specialization and the monetary balance of trade (ibid.).

Based on this new approach, Baumert (2017) has used data from the World-Input-Output Database (WIOD) to analyze the TBEET of 30 countries for the period 1995-2009. Adjusting for technological differences, he finds a mixed result of carbon leakage for advanced countries: While many high-income nations, such as the Nordics, are rather net exporters of emission-intensive goods, the USA, the UK, Canada, and Australia, on the contrary, are specialized in carbon-intensive imports and are, thus, outsourcing emission-intensive production activities abroad based on their trade structure. Nevertheless, while the USA has consistently outsourced

[1] The terms "territorial emissions" and "production-based" emissions will be used interchangeably in the following and refer to the emissions physically generated within a country's territorial or juridical boundaries (Edenhofer, 2014).

its emissions in the period between 1995-2009, this seems to be a rather recent phenomenon for the other three Anglophone countries included in the analysis (ibid.).

By decomposing the TBEET into the two main drivers trade specialization and trade balance, the method proposed by Jiborn *et al.* (2018) further helps to analyze in how far countries shift from more carbon-intensive (heavy) to less carbon-intensive (light) exports or imports over time. Both Baumert (2017) and Jiborn *et al.* (2018) note that the impact of trade specialization for most high-income countries has become increasingly negative during the observed period due to a changing trade structure. However, since the WIOD only provides data from 1995 onwards, the evolution of trade specialization in emission-intensive and less emission-intensive goods before 1995 is not well known.

Theories on trade specialization or comparative advantage also play a central role within classical economic literature. While economic trade theories suggest that economies specialize according to their comparative advantage when engaging in trade, empirical research on long-term specialization patterns has found mixed results (Findlay, 19995; Brasili *et al.*, 2000; Benedictis *et al.*, 2009). One strand of research proposes that a country's trade pattern becomes more polarized with increasing per capita income whereas another strand argues that it becomes less specialized (ibid.). However, country-specific factors and initial conditions, such as resource endowments and the size of the country, can also substantially influence trade patterns in the long run (Syrquin and Chenery, 1989). Simultaneously, economic development literature and the Environmental Kuznets Curve (EKC) hypothesis suggest that a country's trade specialization changes from heavy industry and resource-dominated sectors towards the export of light industries and services along with higher per capita income (Rostow, 1959; Bell, 1999; Dinda, 2004). Hence, the overall relationship between economic growth and trade specialization is not clear.

Building upon these results, this thesis therefore aims at gaining a better understanding of the historical import and export specialization of Anglophone and Nordic countries. While studies on emission accounting generally argue that industrialized countries increasingly export light industry and import heavy industry goods, the actual trade patterns and the composition and scale of the countries' import and export portfolios have received little attention. Altogether, this thesis seeks to address the following questions: (1) Do the Anglophone country group and the Nordic country group, respectively, show common long-term trade patterns? (2) Do the long-term trade patterns of Anglophone and Nordic countries reflect a shifting trade specialization either in the import structure towards heavy industry goods, or in the export structure towards less emission-intensive products, or both?

Due to the limited availability of environmental input-output tables and the quantity of traded commodities for earlier periods, the analysis relies on monetary trade statistics and focuses on trade specialization in heavy and light industry goods. By using data from the United Nations Commodity Trade Statistics (UN Comtrade) database, the long-term trade patterns of the Anglophone countries Australia, Canada, Ireland, New Zealand, South Africa, the United States and the United Kingdom as well as of the Nordic country group Denmark, Finland, Iceland, Norway, and Sweden are investigated and compared for the period 1962-2016.[2] Next to a qualitative assessment of the research questions, this thesis uses the normalized trade balance as well as the revealed symmetric comparative advantage (RSCA) index to assess the long-term trade specialization for the twelve countries.

Through the discussion and analysis of long-term trade specialization patterns and their consistency between 1962 and 2016, this thesis will complement the studies of Baumert (2017) and Jiborn *et al.* (2018) by including a historical, long-term perspective on the trade composition of the two country groups. The main finding of this thesis is that the long-term trade structures of the twelve countries neither show a common shift in their trade specialization pattern from exporting predominantly heavy industry towards light industry goods nor an increase in the import of heavy industry products. Carbon leakage, thus, seems to be a phenomenon which can be rather attributed to particular countries or to emission accounting practices. In contrast to economic development literature and the EKC hypothesis, the results rather suggest that natural resource endowments still play an important role in determining a country's export specialization.

The remainder of this thesis is structured as follows: Section 2 first provides an overview of emission accounting for both the country and sectoral level. This is followed by a review of the Environmental Kuznets Curve (EKC) hypothesis and the role of international trade and structural change in shaping the curve before further elaborating on economic development and trade specialization more generally. Section 3 presents the data and explains the method of classifying the sectors into heavy and light industries. Moreover, the two trade specialization indicators used for the analysis are introduced. The empirical analysis in Section 4 discusses the results and limitations of the approach and Section 5 concludes.

[2] Norway, Iceland, South Africa and New Zealand are not included in the WIOD database but are added in the present analysis to complement the Anglophone and Nordic country groups respectively.

2. Literature Review and Previous Research

This section presents an overview of theoretical considerations and previously conducted research relevant to the topic. Section 2.1 first summarizes recent developments and findings of emission accounting methods and discusses the sectoral responsibilities of global emissions embodied in trade. In Section 2.2, the Environmental Kuznets Curve (EKC) hypothesis is introduced along with a presentation of two potential explanatory factors: international trade and structural change. Section 2.3 finally reviews the relationship between economic growth and trade specialization as well as the role of path dependence.

2.1 Emissions Embodied in Trade

2.1.1 **Emission Accounting**

It is estimated that the global mean surface temperature will rise between 3.7°C and 4.8°C by the year 2100 compared to pre-industrial levels, if the anthropogenic emissions in the atmosphere are not reduced internationally. (Edenhofer, 2014). This is why the Kyoto Protocol of 1997, an international agreement initiated by the United Nations Framework Convention on Climate Change (UNFCCC), suggested a production-based framework for the measurement and reduction of greenhouse gas (GHG) emissions (Ahmad and Wyckoff, 2003). A production-based accounting (PBA) approach relates industrial GHG emissions of goods to the country in which the goods are produced and thus, in which the emissions are generated (Boitier, 2012). Based on the CO_2 measurements proposed in the Kyoto Protocol, countries were encouraged to limit their emissions by setting reduction targets (Falkner, 2016).

In more recent years, however, the PBA framework has increasingly been criticized for allowing the possibility of carbon leakage (Jiborn *et al.*, 2018). Calculating only domestically-produced emissions neglects the emissions embodied in traded goods and services. Hence, to adjust for international trade flows, various scholars have suggested to rather use consumption-based accounting (CBA) when calculating emission inventories (e.g. Davis and Caldeira, 2010; Barrett *et al.*, 2013).

Consumption-based emissions are calculated by subtracting a country's emissions embodied in exports from production-based emissions and adding the emissions generated from the production of imports abroad. Unlike the PBA approach, this method thus allows to calculate the balance of emissions embodied in trade (BEET) which reflects the difference between emissions embodied in exports and emissions embodied in imports (see Table 1)

(Jiborn *et al.*, 2018). The calculation of consumption-based emission inventories for a number of countries has thereby revealed that a considerable share of CO_2 emissions is traded internationally (e.g. Davis and Caldeira, 2010; Barrett *et al.*, 2013).

Moreover, studies comparing production-based and consumption-based emissions show that the country-level results can diverge substantially. Most industrialized countries display higher CO_2 emissions embodied in consumption than developing nations whereas the latter present higher production-based emissions (Boitier, 2012; Davis *et al.*, 2011). The discrepancy between CBA and PBA is often seen as evidence for the outsourcing of emission-intensive activities by high-income countries (Davis and Caldeira, 2010).

Boitier (2012) for example calculated that the consumption-based emissions of the European Union had a surplus of 24 percent compared to PBA in 2008 emphasizing the significance of emissions embodied in trade. For this reason, the literature generally refers to industrialized countries as net importers of emissions and to emerging markets as net exporters, when consumption-based emissions are calculated (e.g. Wiedmann, 2009; Davis and Caldeira, 2010; Boitier, 2012).[3] Nevertheless, while researchers often use this categorization, this might be oversimplified. For instance, although the overall BEET is rather small, emissions embodied in production have typically exceeded those embodied in consumption for Canada and Australia during the past years, which is why they are commonly listed as net exporters in the literature (Ahmad and Wyckoff, 2003; Peters *et al.*, 2012; Davis and Caldeira, 2010).

While a negative BEET is perceived as an indicator for the outsourcing of emission-intensive activities, Jakob and Marschinski (2013), on the contrary, argue that the transfer of carbon emissions through trade can have many reasons aside from carbon leakage. A deficit in a country's net emission-trade balance can for example be the result of a cleaner or more efficient energy system used for production compared to the trading partners. For instance, if two countries exchange identical goods with the only difference that country A has a less emission-intensive production system compared to country B, the calculation of the BEET would result in a deficit for country A and a surplus for country B. Hence, country A would be labeled a net importer of emissions and would be suspected of carbon leakage, even though its products have produced less emissions and are 'cleaner' (ibid.). According to Jakob and Marschinski (2013), the determination of a country's trade specialization based solely on the calculation of emissions embodied in trade is, thus, not sufficient for guiding climate policies. Consequently, the two authors suggest to decompose carbon-trade balances according to the

[3] Being a net importer of emissions implies that a country has a deficit in carbon emissions embodied in trade whereas an exporter reports a surplus (Jakob and Marschinski, 2013).

following four factors: (1) trade specialization; (2) trade balance; (3) energy intensity of production within the economy; (4) carbon intensity of energy within the economy. By decomposing the BEET for the largest exporters and importers of embodied emissions, Jakob and Marschinski (2013) show that the drivers of emission transfers can significantly vary depending on the country and the relative importance of the factors.

In relation to this, Kander *et al.* (2015) propose the usage of a technology-adjusted consumption-based accounting (TCBA) framework which is considered to "represent a conceptually better metric than simple carbon footprinting" (Sachs *et al.*, 2017: p. 23). Instead of using the domestic average of sectoral carbon intensities for export-related emissions, a weighted world average serves as a basis to recognize differences in production technologies and export intensities. Unlike the CBA framework, the TCBA therefore takes possible changes in the carbon efficiency of the export sector into account and encourages countries to reduce their export-related emissions (Kander *et al.*, 2015).[4]

Based on this approach, Jiborn *et al.* (2018) further suggest to standardize the relative carbon intensities of both imports and exports by using world average production technologies which thereby ignores differences in carbon efficiencies between countries (see Table 1). The resulting 'technology-adjusted balance of emissions embodied in trade' (TBEET) can then further be decomposed into the two remaining drivers: trade specialization in heavy and light industries and the monetary trade balance. The difference between the calculation of the BEET and the TBEET is illustrated below in Table 1.

A more detailed comparison between the two methods goes beyond the scope of this thesis, since it would also require an extensive explanation of input-output analysis. However, as indicated in the table and as further explained by Jiborn *et al.* (2018), the major difference between the two approaches is that TBEET relies on world average carbon intensities for both imports and exports whereas BEET uses domestic intensities for the exports, while emissions embodied in imports are calculated based on foreign production technologies. The latter indicator (BEET) disregards that countries may have more carbon or energy efficient systems than their trading partners. As previously mentioned, the CBA approach may, thus, attribute higher emissions to a country's national inventory, even though their 'cleaner' production reduces overall global emissions (Kander *et al.*, 2015; Jiborn *et al.*, 2018). Using world average intensities, on the contrary, has the effect that these differences are cancelled out and that

[4] For a more detailed explanation see Kander *et al.* (2015).

deficits or surpluses in the net balance of emissions can exclusively be related to the monetary balance of trade and to the trade specialization in heavy or light industries.

Table 1: Comparison of Calculating Emissions Embodied in Trade – BEET and TBEET

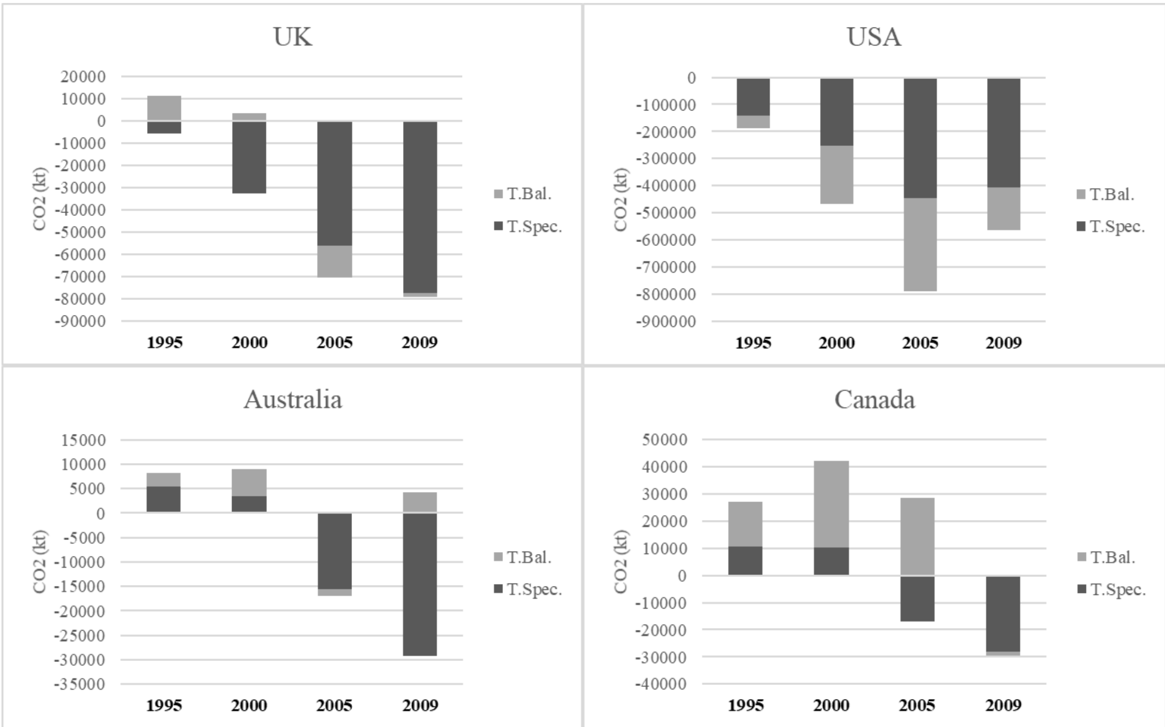
	Balance of Emissions embodied in Trade (BEET)	**Technology-adjusted BEET (TBEET)**
Publication	Jakob and Marschinski (2013)	Jiborn *et al.* (2018)
Basic Formula	$BEET_i = CEX_i - CM_i$	$TBEET_i = CEX_i^{WA} - CM_i^{WA}$
Description	CEX_i = emissions embodied in exports: emissions which were directly generated within the borders of country *i* in consequence of production of goods that are exported CM_i = emissions embodied in imports: emissions which directly occurred outside country *i*'s territory in consequence of production of goods that are imported	CEX_i^{WA} = emissions embodied in exports using world average carbon intensities CM_i^{WA} = emissions embodied in imports using world average carbon intensities
Decomposition in driving factors	(1) trade specialization, (2) trade balance, (3) average carbon and (4) energy intensity compared to the rest of the world	(1) trade specialization, (2) trade balance

Source: Own construction based on the two mentioned publications.

By calculating and decomposing the TBEET for Swedish and UK trade, Jiborn *et al.* (2018) find that the composition of the countries' imports and exports between 1995 and 2009 have changed. The TBEET of Sweden remains positive throughout the observed period due to a strong trade surplus and is nearly balanced in 2009. The TBEET of the UK, on the contrary, turns negative at the end of the 1990s and grows increasingly negative in the following years. For both countries, however, the negative impact of trade specialization increases substantially over time reflecting a changing composition of the import and export structure with an import specialization in heavy goods and an export specialization in light industrial products (ibid.).

Following the method proposed by Jiborn *et al.* (2018), Baumert (2017) extends the calculation of the TBEET to all countries included in the 2013 released WIOD. According to his results, particularly the Anglophone countries, including the USA, the UK, Australia, and Canada, are specialized in carbon-intensive imports compared to exports at the end of the observed period. Figure 1 shows the composition of the TBEET, separated into the countries' trade specialization and monetary trade balance, calculated by Baumert (2017) for the four countries. As can be seen, the negative TBEET is a rather recent phenomenon for Australia, Canada, and the UK whereas the US has been a net importer already before 1995. Most of the other high-income countries' balance of emissions embodied in trade, on the contrary, is positive between 1995-2009 if adjusted for technological differences. These results contradict findings of traditional consumption-based emission studies in which Australia and Canada are rather exporters of emissions embodied in trade and most EU countries are net importers (e.g. Barrett *et al.*, 2013).

Figure 1: Decomposed TBEET – Anglophone countries included in Baumert (2017)



Source: Own counstruction based on Baumert (2017)

The impact of trade specialization can substantially influence the result of the technology-adjusted balance of emissions embodied in trade both negatively and positively, as can be seen in Figure 1 and Figure 2. Figure 2 illustrates the TBEET and its composition for Finland, Denmark, and Sweden based on Baumert (2017). While the TBEET for the three countries is positive throughout the entire period, the trade specialization for both Finland and Sweden turns negative during the observed period. This pattern is similar to the EU-27 countries as a whole and its members. Even though the impact from trade specialization for the EU-27 countries is positive throughout 1995-2009, the trend for many industrialized countries is generally towards an increasingly negative impact (Jiborn *et al.*, 2018; Baumert, 2017).

Figure 2: Decomposed TBEET – Nordic countries calculated by Baumert (2017)

Source: Own constructions based on numbers kindly provided by Baumert (2017)

The reason for this development can be related to changes in both the import and export structure of a country as it specializes in less emission-intensive goods or imports more emission-demanding products. Hence, the outsourcing of emission-intensive production activities becomes evident if a country's exports are dominated by light industrial commodities and if imports are largely composed of heavy industrial products (Jiborn *et al.*, 2018). Building upon the results of Baumert (2017) and Jiborn *et al.* (2018), the analysis in Section 4 therefore relies on trade statistics and the evaluation of trade specialization indicators since the countries' trade portfolios should also reflect the changing trade composition.

2.1.2 Emissions Embodied in Trade on the Sector Level

The previous section aimed at establishing a general understanding of emission accounting and at providing an overview of recent methodological developments on a country-level basis. Yet, focusing on the sectoral level reveals that the industry sector is accountable for approximately one third of global energy usage and carbon emissions, with emissions being estimated to substantially increase in the upcoming years if no changes are implemented (Edenhofer, 2014). A consumption-based accounting approach can thereby reveal the dominant sources of emissions embodied in trade caused by the manufacturing sector which can help to develop strategies for key energy-intensive and trade-intensive products such as the improvement of production technologies or the reduction of material usage (Barrett *et al.*, 2013; Sato, 2014).

Calculating emissions embodied in trade on the product level demonstrates that only a small share of globally traded goods is responsible for the generation of the majority of emissions in the industry sector. Sato (2014) for example finds that of the 1080 goods in her analysis, ten percent of the products generate around 70% of global emissions embodied in trade. The lion's share of these products hereby belongs to the heavy industry with iron and steel accounting alone for around 13% of emissions embodied in trade followed by the petroleum, primary plastic, organic chemicals, and non-ferrous metal sectors (ibid). By examining the product compositions of emissions embodied in imports (EEI) and emissions embodied in exports (EEE) for China, the US and the EU, Sato (2014) further shows that significant differences in the import and export structures of the three regions exist. However, the carbon imports of all three economies are generally dominated by primary products and resource inputs for production (Sato, 2014).

In addition, Aichele and Felbermayr (2015) find that both carbon intensities as well as carbon leakage of emissions differ substantially across sectors. Carbon leakage thereby seems to especially prevail in the basic metals, other nonmetallic mineral products and paper and pulp industries. Similarly, the analysis by Kanemoto *et al.* (2014) of countries willing to set emission reduction targets (Annex B of the Kyoto Protocol) illustrates that the sectors reporting a reduction of production-based emissions are often the same ones which have an increase in the emissions embodied in imports (EEI).[5] Moreover, Sakurai *et al.* (2009) note that the traded volume of carbon-intensive goods, such as chemicals and iron and steel, has significantly

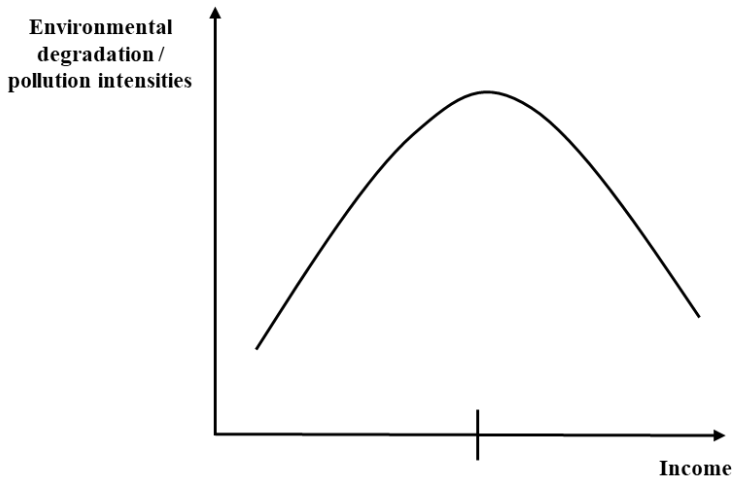
[5] The group of countries included in the Annex B of the Kyoto Protocol are the ones who have agreed and signed to set emission reduction targets for 2000 (Edenhofer, 2014).

increased between the mid-1990s and the early 2000s, especially for non-OECD countries. Hence, instead of reducing emissions on a sectoral basis through cleaner production technologies or the use of more environmentally-friendly inputs, the evidence seems to suggest that the emission-intensive activities are simply shifted abroad (Kanemoto *et al.*, 2014). Nevertheless, the increase in EEI could also be related to differences in production technologies. Adjusting for technological differences within sectors might therefore result in a diverging outcome.

2.2 Trade, Emissions, and the Environmental Kuznets Curve (EKC)

The role of trade in influencing a country's emission, energy, or, more broadly, its pollution inventories has already been part of a discussion about the relationship between economic growth and the environment in the 1990s and early 2000s. Studies analyzing the relation between income and different pollution indicators have led to the hypothesis that the environmental degradation in the early phase of a country's development significantly increases, while it improves and decreases at later stages (Dinda, 2004). This empirical phenomenon has been called the Environmental Kuznets Curve (EKC), as it follows an inverted-U shape, and is depicted in Figure 3. It implies that economic growth in high-income countries slows down allowing different factors, such as environmental policies or technological innovations, to be implemented and to contribute to the reduction of environmental damages (Stern, 2004).

Figure 3: The Environmental Kuznets Curve (EKC)



Source: Own construction based on Dinda (2004)

The research on the existence of the EKC incorporates the analysis of various indicators such as energy, CO_2 emissions, clean water, and municipal waste and has produced ambivalent results for both the different pollutants as well as for individual countries (Panayotou 2016; Dinda, 2004; Kander *et al.*, 2017). While most studies rely on the analysis of absolute pollution measures such as CO_2 emissions ('strong hypothesis for the EKC'), some publications also focus on the 'weak hypothesis for the EKC' where pollution intensities are investigated (Kander *et al.*, 2017). Different explanations exist for both hypotheses on which factors or outcomes of economic development may potentially impact and induce the shape of the EKC (Dinda, 2004). Since the evidence on the existence of the EKC is rather inconclusive and highly disputed, the different arguments and results will not be further discussed in detail.[6] However, two forces explaining the upward and downward sloping of the curve are especially worth mentioning in relation to this thesis: structural change and international trade (Dinda, 2004; Stern, 2004). The former can thereby be seen as the proximate cause whereas the latter can be referred to as the ultimate cause.

Even though the two explanations refer to different factors, they both reflect interconnected processes of economic development. The first explanation for the shape of the EKC simply suggests that the curve depicts the structural transformation of the economy (Dinda, 2004). The upward slope, thus, illustrates the process of industrialization in which the economy shifts towards heavy industry and in which pollution and energy usage is high. In the later phase of economic development, the emphasis changes and the economy moves towards lighter manufacturing and services which, in turn, reduces the pollution intensity and the impact on the environment (Cole, 2004; Stern, 2004). Kander (2013), for instance, attributes the improvement in energy usage after the 1970s in Europe to the Third Industrial Revolution and its associated increase in the share of light manufacturing in the economy, its new technologies helping to save energy as well as its accompanied shift towards the service sector. However, by focusing on energy intensities (weak hypothesis), Kander *et al.* (2017) do not find empirical support for a universal inverted-U curve for all European countries as several nations present a flat or declining energy intensity for the period 1870-1935.

The second factor explaining a possible inverted U-shape for both the weak and strong hypothesis refers to changing patterns of international trade which induces structural change (Dinda, 2004; Kander *et al.*, 2017). The industrialization of countries is thereby interconnected with an increase in the production and export of heavy industrial goods whereas the shift

[6] See Dinda (2004) for a more detailed summary.

towards less energy-intensive commodities commonly leads to an increase of manufactured imports (Nielsen, 2017). Expressed more generally, the downward slope of the Environmental Kuznets Curve (EKC) can be explained by international trade as a country shifts its pollution-intensive industries abroad or specializes in the export of lighter manufacturing commodities while importing heavy industrial goods.

These two possibilities, through which international trade can shape the EKC, are also referred to as the Displacement Hypothesis and the Pollution Haven Hypothesis (PHH) (Dinda, 2004). The former hereby implies that the inverted-U curve reflects changes in international specialization and trade patterns with industrialized countries specializing in 'cleaner' industries and services, which is also captured by the earlier mentioned consumption-based accounting (CBA) frameworks. The PHH, on the contrary, rather suggests that an increase in environmental standards in high income countries leads to a shift in trade patterns and gives countries with low environmental regulations a comparative advantage. Instead of reducing pollution in the long run, as indicated by the downward slope of the EKC, the pollution is simply transferred to lower income countries (Dinda, 2004; Cole, 2004; Stern, 2004). Yet, the evidence for a tendency to strategically move polluting industries to less regulated countries is rather inconsistent (Krugman *et al.* 2015).

Altogether, both structural change and international trade may serve as an explanation for the inverted-U shape of the EKC as a country's economy shifts to less emission-intensive activities after industrialization and increasingly imports heavy industrial goods. Even though only weak evidence for the universal existence of the EKC exists, the evaluation of consumption-based emission inventories and the results of the technology-adjusted balance of emissions embodied in trade (TBEET) in Baumert (2017) also point towards changing trade patterns across countries. The subsequent section will therefore further elaborate on the relationship between economic growth and trade specialization.

2.3 Economic Development, Trade Specialization, and Path Dependence

As noted in the previous section, the Environmental Kuznets Curve might simply illustrate the natural transformation of any economy as society moves from being pre-industrial to industrial and finally to becoming post-industrial. Describing the process of economic development, Bell (1999: p. 73) thereby refers to a “technological ladder” with five different phases. According to him, the stages an economy passes through are: (1) a resource-based economy dominated by agrarian and extractive industries; (2) a concentration on light manufacturing such as textiles, shoes and the like; (3) a focus on heavy industry production such as steel and automobile manufacturing; (4) a high-tech dominated economy which is followed by (5) science-based biotechnology and aerospace technology. Simultaneously, while moving from heavy industry to light and high-tech manufacturing, services increasingly account for the largest share in a nation’s Gross Domestic Product (GDP) (ibid.).

Similarly, Rostow (1959) notes that the leading sectors in an economy change along with its development. During the “drive to maturity” (Rostow, 1959: p. 1), for instance, both technological innovations and natural resource endowments determine the leading sectors which results in heavy industries, such as chemicals and steel production, dominating the economic landscape. However, due to the changing structure of the economy, together with technological substitution, the transport revolution and globalization, the role of natural resource endowments becomes less important over time in determining a country’s comparative advantage and economic structure (Findlay, 1995; Bell, 1999).

2.3.1 **Theories and Empirical Research on Trade Specialization**

The changing structure of an economy and the specialization in certain industries should, by implication, also be reflected in the level and composition of trade (Syrquin and Chenery, 1989). Classical trade theory suggests that open economies specialize along with their comparative advantage in the long run. However, the overall relationship between trade specialization and economic growth is not clear and both theory and empirical evidence propose different arguments for long-term specialization patterns (Benedictis *et al.*, 2009; Brasili *et al.*, 2000; Krugman *et al.* 2015). To establish a better understanding of possible long-term trade and specialization patterns, some key findings of empirical research shall therefore be recognized.

According to the Heckscher–Ohlin theorem, countries specialize in the export of goods that are intensive in the use of that economy’s relatively abundant factor and in which the country has a comparative advantage (Findlay, 1995). Hence, a change in the composition of trade flows will occur slowly as a country's factor endowments are rather consistent. This static behavior of trade flows is supported by the study of Gagnon and Rose (1995) who analyze imports and exports for the period 1962-1990. They find a high persistency for goods to be either predominantly imported or exported throughout the observed period with only few changing from being net imports (exports) to becoming net exports (imports). Dalum *et al.* (1998) also confirm the stickiness of national specialization patterns but further recognize a trend towards de-specialization in the medium- and long-run.

Empirical literature focusing on the evolution of trade specialization and economic development generally provide ambivalent predictions and results on specialization patterns over time. Depending on the methods applied, the measure of specialization, or the data set, one strand of research argues that national trade patterns become more polarized along with higher per capita income whereas another strand suggest a lower degree of specialization (Brasili *et al.*, 2000; Benedictis *et al.*, 2009). By analyzing the commodity export of a large set of countries covering the years 1985-2001, Benedictis *et al.* (2009) for example find that countries have the tendency to diversify their exports especially during the early phases of economic development. Similar to Dalum *et al.* (1998), Brasili *et al.* (2000) also identify a tendency for both industrialized and emerging economies towards a lower degree of specialization. However, they also note a much more persistent trade specialization pattern for industrialized countries than for emerging economies. Studies using data on sectoral employment and value added, on the contrary, predict that economies first diversify while at a certain point in the development process, sectoral specialization increases again (e.g. Imbs and Wacziarg, 2003; Koren and Tenreyro, 2005).

In his study, Steingress (2015) further distinguishes between two specialization dimensions: the range of goods, which refers to the production and export of as many different goods as possible, and the sales volume of goods. Using product level data, he finds that countries overall export a smaller variety of goods and thus show a more concentrated export portfolio whereas the import structure is much more diverse. The main factors determining these specialization patterns are thereby: the elasticity of substitution, trade costs, as well as the absolute and comparative advantage of a country (ibid.).

The comparison of cross-country differences further reveals the importance of geography as larger countries tend to have a more diversified product range for both imports and exports in contrast to smaller countries which are more specialized (Steingress, 2015; Syrquin and Chenery, 1989). Resource endowments can thereby significantly influence the trade composition and orientation of the different economies with small and resource-rich countries, for example, specializing in trade of primary commodities (Syrquin and Chenery, 1989). Altogether, country-specific factors and initial conditions, including the already mentioned factors size and resource endowments as well as politics or institutions, can significantly influence long run trade patterns and development paths (Benedictis *et al.*, 2009; Brasili *et al.*, 2000).

Furthermore, countries differ according to their economic complexity and the prevailing product space. The product space thereby refers to a network which connects pairs of products with high probabilities to be co-exported (Hausman *et al.*, 2011). Said differently, countries have the tendency to produce and export products similar to the ones which already exist and for which the capabilities are already given. If a country has a highly connected product space, economies tend to produce more complex goods and have a higher growth potential as it is easier to accumulate the relevant knowledge. Hence, a country's location in the product space can determine the economy's ability to diversify and to become more complex and, thus, has the possibility to influence its development path (ibid.).

2.3.2 **Path Dependence in the Economy**

Due to its relevance for this topic, the meaning and role of path dependence in the economy will be briefly presented in the following, although an in-depth discussion goes beyond the scope of this thesis. Countries might show signs of path dependence regarding their specialization in heavy or light industry goods, since long run trade patterns and economic growth tend to be dictated by initial conditions and self-reinforcing mechanisms (Brasili *et al.*, 2000).

Path dependence can be described as a 'non-ergodic' process or system meaning that a dynamic process depends on its own history (David, 2005) or, in the words of Martin and Sunley (2006: p. 399), "a path-dependent process or system is one whose outcome evolves as a consequence of the process's or system's own history". Although different sectors follow their own distinct paths of industrialization, it can be said that industries generally follow "a road map in which an established direction leads more easily one way than another" (Walker, 2002: Section 8). Hence, a country's specialization in certain industrial sectors will guide the evolution of development paths as it sets the possibilities for future outcomes. This does not mean, however, that an economy or an industry cannot take different trajectories or that a common path of industrialization for all countries exists. It simply implies that past processes influence present as well as future outcomes or possibilities and can condition, for example, long run trade patterns and economic growth (Brasili *et al.*, 2000; Walker, 2002; Martin and Sunley, 2006).

With the economy inheriting historical processes, economic trajectories can only be explained ex post as they can be altered at any point of time. Consequently, instead of using complex mathematical models, the concept of path dependence needs to be analyzed by considering the history in the economic processes, contingency and context dependency (Martin and Sunley, 2006). Evaluating the trade patterns of the Anglophone and Nordic countries, as it is done for this thesis, should therefore provide a better understanding in how far path dependence impacts trade specialization in the long run.

2.4 Expected Results

Based on the preceding sections, different expectations and assumptions can be formulated for the following analysis. Building upon the literature on trade specialization, it can be expected that first, the portfolio of exports is more specialized than the one of imports and that second, the trade structure of larger countries is less specialized compared to smaller economies. Third, due to a higher persistency of trade specialization patterns among industrialized countries and due to path dependency, it can be assumed that changes in trade patterns will occur rather gradually. Fourth, the trade structure of the Anglophone and Nordic countries should reflect the findings of Jiborn *et al.* (2018) and Baumert (2017). Since the trade specialization increasingly contributes to a lower or negative technology-adjusted balance of emissions embodied in trade (TBEET) in most economies, this change should also be mirrored in the trade structure. Hence, a shift either in the export structure from heavy industry to light industry, or a shift in the import structure from light towards heavy industry, or both, should be observable in particular across the Anglophone trade pattern (Baumert, 2017; Jiborn *et al.*, 2018). With mostly high-income nations included in the analysis (except for South Africa), a common export specialization pattern in light industry goods and an increasing volume of heavy industry imports would additionally support the Environmental Kuznets Curve (EKC) hypothesis and the theory of a common process of economic development.

3. Data and Methods

While the monetary value of traded goods does not always reflect the embodied CO_2-emissions in trade, trade data generally represent a good indicator for specialization dynamics within an economy (Benedictis *et al.*, 2009; Moran *et al.*, 2013). Thus, data on import and export values are compiled for the Anglophone countries Australia, Canada, Ireland, New Zealand, South Africa, the United States and the United Kingdom as well as for the Nordic countries Denmark, Finland, Iceland, Norway and Sweden.

The trade data used in the following analysis is derived from the United Nations Commodity Trade Statistics Database (UN Comtrade) as it provides export and import statistics from 1962 onwards. Within the database, international trade flows are reported based on the Standard International Trade Classification (SITC) Revision 1 in which commodities are grouped according to their distribution channels (Rozanski and Yeats, 1994). The SITC is divided into different product levels which are designated by code numbers ranging from 1 to 5 digit-levels. The first digit hereby reflects broad economic categories or divisions such as 'chemicals' which are then further classified into more differentiated subgroups (United Nations, 1961).

3.1 Consistency of the Data

For the analysis, data on commodity exports and imports with the partner 'world' was extracted according to the two-digit level for the Anglophone and Nordic country groups as well as for the Organisation for Economic Co-operation and Development (OECD).[7] The partner 'world' is an aggregated group consisting of all obtainable trading partners within an individual commodity section (United Nations, 2010). Table A.1 (Appendix) provides an overview of the different commodity categories that were established along with the corresponding SITC headings and codes.[8]

As noted by Rozanski and Yeats (1994), trade data has to fulfill certain conditions to be internally consistent. Thus, in order to regroup the SITC commodity categories into other product groups, the following equation has to be adhered to:

(1) $$Z_{i,j+1,T} \equiv \sum_{j=1} Z_{ijT}$$

[7] Note that for Norway no data is provided for the years 1986 and 1987.
[8] A more detailed description of the grouping decision process will follow in the subsequent section.

where Z_{ijT} represents the reported export or import values of SITC commodity digit-level j by country i in year T. This implies that the reported monetary amount of imports or exports at a given product category has to sum up to the next higher commodity level. Hence, three-digit products must add up to two-digit totals, two-digit product categories to the one-digit total and all digit-levels added up should equal total exports or imports. Moving between levels should therefore not affect the calculation of trade statistics (Rozanski and Yeats, 1994).

Against this background, the mean deviations of the aggregated commodity groups from the reported total trade flows per year were calculated to check for possible inconsistencies in the data. Table 2 below presents an overview of the twelve countries along with the mean deviation of the data for imports and exports. As can be seen, the total value of imports or exports only deviates slightly from the given UN Comtrade total trade values. The data for the UK, next to the OECD, presents the highest inconsistency between reported and aggregated trade flows among the Nordic and Anglophone countries. Yet, this result still represents a high degree of data precision and reflects earlier findings by Rozanski and Yeats (1994) of maximum discrepancies between 3 and 6 percent for developed countries over the period 1962-1990.

Table 2: Mean Deviation of Aggregated Total and UN Comtrade Total

Country	Years	Imports	Exports
Australia	1963-2016	0.004%	0.005 %
Canada	1962-2016	0.000 %	0.000 %
Ireland	1963-2017	0.000 %	0.032 %
New Zealand	1964-2017	0.000 %	0.000 %
South Africa	2000-2016	0.000 %	0.000 %
United Kingdom*	1962-2016	0.298 %	0.205 %
United States	1962-2016	0.000 %	0.000 %
Denmark	1962-2017	0.000 %	0.000 %
Finland	1963-2017	0.000 %	0.000 %
Iceland	1962-2017	0.012 %	0.000 %
Norway	1962-1985 1988-2017	0.010%	0.148%
Sweden	1962-2016	0.000 %	0.000 %
OECD**	1962-2017	0.394 %	0.424 %

Source: Own construction and calculations based on import and export values of individual countries..
** The highest deviations for the UK occur in the years 1992 and 1993: The provided UN Comtrade import total exceeds the aggregated total by 2.46 % in 1992 (1993: 7.75 %) and for the export total by 2.9 % (1993: 2.5 %). ** The highest deviation for the OECD for both imports and exports occurs in the starting year 1962.*

Two main reasons can generally be identified for the divergence of the trade data. First, since 1990, most countries report their trade according to SITC Revision 3 or 4 standards (Dittrich and Bringezu, 2010). Even though the UN Comtrade still converts these trade statistics into the SITC Revision 1 system, they are not precisely adjusted. “It may occur that some of the converted commodity codes contain more (or less) products than what is implied by the official commodity heading” (United Nations, 2016). Second, some countries might not report the volume of each commodity traded in detail to the United Nations due to confidentiality issues. As a consequence, the reported total trade value might be higher than the aggregated total value as the commodities are not reported for lower digit-levels (ibid.). Since the discrepancies are rather neglectable and since the total trade should equal the sum of the commodity groups, the empirical analysis in Section 4 will rely on the aggregated trade volumes instead of the reported trade flows.

3.2 Classification of Sectors in Heavy and Light Industry

The Standard International Classification (SITC) system broadly classifies product groups according to similarities in distribution channels (Rozanski and Yeats, 1994).[9] However, the established groups of the SITC do not adequately represent industries or sectors such as the textile industry. Unmanufactured textile fibers, for example, fall in the section *crude materials, inedible, except fuels* whereas the sub-group *textile yarn, fabrics, made up articles, etc.* belongs to *manufactured goods classified chiefly by material*. *Clothing*, on the contrary, is part of the section *miscellaneous manufactured articles*. Hence, in order to analyze the trade pattern of the countries based on heavy and light industries, new sectors have been formed, which will be further explained in the following.

3.2.1 **Background**

International organizations, countries and researchers use different methods when defining product groups or industries and when publishing trade data. Consequently, trade statistics, product categories as well as the distinction between emission and non-emission intensive sectors can differ substantially among various sources (Rozanski and Yeats, 1994; Ramírez *et al.*, 2005). Ramírez *et al.* (2005), for example, present three different approaches on how to define sectors according to their energy-intensity. One possibility is to determine the most

[9] For more details on the SITC system and the product groups see United Nations (1961).

energy-intensive industries and treat the other sectors as a residual group (ibid.). The second option is to set a limit expressed in terms of energy intensity which distinguishes between energy and non-energy intensive industries. The third one uses a classification based on process characteristics or based on capital and labor intensities. However, due to the difficulty of defining processes and due to the ambivalent relationship between labor and energy intensity, the third approach can be neglected (Ramírez *et al.*, 2005). The first and second, on the contrary, represent more feasible options for the following analysis. As information on the emission intensity for the traded commodities over the entire period are lacking, the heavy and light industry sectors have been formed more broadly based on previously published papers and articles which discuss the emission or energy intensity of goods (e.g. Ahmad and Wyckoff, 2003; Edenhofer, 2014; Sato, 2014).

The table below (Table 3) provides an overview of different publications and their classification of heavy industrial sectors or products. The carbon and energy intensity of products generally varies across countries as industrial sectors rely on different energy sources and, more broadly, as countries' energy supply structures differ (Ahmad and Wyckoff, 2003; Kander *et al*., 2013). Relying predominantly on renewable energy sources or nuclear power will, hence, affect the share of indirect and direct emissions in total emissions generated within a sector. However, the relative position of a sector regarding its emission or energy intensity remains roughly the same across countries (Ahmad and Wyckoff, 2003).

Table A.2 in the Appendix furthermore presents mean CO_2 emissions per US dollar and per US dollar adjusted for purchasing power parity (PPP) differences by industries in 1995 based on the numbers provided by Ahmad and Wyckoff (2003). The sectors clearly standing out as emission-intensive, when adjusted for PPP differences, are thereby the electricity, non-ferrous metals, iron and steel, chemicals, and non-metallic minerals industries. Even though most of the literature includes the pulp and paper sector in the heavy industry category, the calculated CO_2 emissions per US dollar are not much higher compared to agriculture or the production of wood (compare Table 3 and Table A.2).

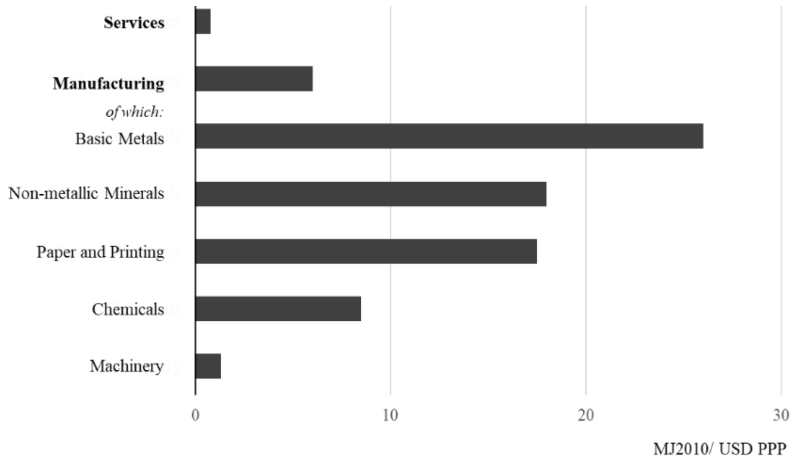
Table 3: Classification of Heavy Industrial Products according to Different Publications

	Focus	**Products or Sectors characterized as heavy industry**
Ahmad and Wyckoff (2003)*	CO_2 emissions embodied in international trade of goods; 24 countries	*heavy industry:* electricity, non-ferrous metals, iron and steel, chemicals, non-metallic minerals, (mining) *light industry:* wood and products, pulp and paper, other metal products & machinery equipment, transportation equipment, other manufacturing & recycling
Enevoldsen *et al.* (2007)	Energy-intensive industries in Scandinavia	pulp and paper, glass, basic chemicals, cement, sawmills, veneer sheets, fish processing industry**
Edenhofer (2014)	Report on Climate Change Mitigation	iron and steel, non-metallic minerals, chemicals (including plastic), fertilizers, pulp and paper, non-ferrous metals, food processing, textiles
Sato (2014)	Carbon emissions in bilateral traded products; 195 countries	iron and steel, primary plastic, chemicals, petroleum, non-ferrous metals, paper and pulp, glass
Branger and Quirion (2014)	Carbon leakage and heavy industry competitiveness losses	chemical products, non-metallic minerals, iron and steel, non-ferrous metals

Source: Own construction.
** See Appendix Table xy for calculated mean CO_2 emissions. The industries were categorized according to their CO_2-emissions per US dollar (heavy industries > 0.8 Kg CO_2 per USD PPP).*
*** Carbon intensity differs among industries in the three countries Denmark, Sweden, and Norway.*

Figure 4 additionally presents the energy intensities of manufacturing and services for the International Energy Agency (IEA) member countries, with the manufacturing industry being further divided into different subsectors. In the figure, the basic metals sector shows the highest energy intensity as it incorporates both ferrous metals such as iron and steel as well as non-ferrous metals such as aluminum. This is followed by the non-metallic minerals, the paper and printing and the chemical industry (IEA, 2017).

Figure 4: Energy Consumption per Value added on the Sector Level (2014)



Source: Own reproduction of Figure 10 in IEA (2017: p. 8)

3.2.2 Final Classification

Table 3, Table A.2, Figure 4, as well as the SITC Revision 1 system serve as basis for the final classification. After having gathered import and export data on the two-digit level codes from the UN Comtrade database for each country, thirteen distinct commodity groups were created and divided into heavy and light industry goods, which is illustrated in Table 4. Table A.1 in the Appendix further presents the newly classified sectors along with the corresponding SITC headings and codes.

Table 4: Categorization of Newly Created Commodity Groups

Heavy industry	Light industry
Basic Metals and Manufactures	*Electrical Machinery*
Chemicals and Chemical Products	*Food and Beverages*
Iron and Steel	*Machinery & Transport*
Mineral Fuels and Lubricants	*Miscellaneous*
Non-metallic Minerals & Manufactures	*Rubber and Products*
Pulp and Paper	*Textiles, Clothing & Footwear*
	Wood & Manufactures

Source: Own construction.

As already mentioned before and as illustrated in Table 3, the distinction between heavy and light industry is not clear-cut and the terms are used for both emission- and energy-related classifications. However, most of the literature as well as Figure 4 consider *Non-metallic Minerals and Manufactures, Basic Metals and Manufactures, Mineral Fuels and Lubricants, Chemicals and Chemical Products* and *Iron and Steel* as highly energy- and emission-intensive industries which is why they are assigned to the heavy industry sector. The group *Mineral Fuels and Lubricants* is a classification used by the SITC Revision 1 and incorporates commodities such as coal, petroleum, and gas which all represent very emission-intensive commodities. Moreover, since the sector *Pulp and Paper* is commonly attributed to the heavy industry with its high energy consumption (Figure 4), it is also included in the heavy industry category for the present analysis, even though the CO_2-emissions provided by Ahmad and Wyckoff (2003) do not support this classification.

The categories *Food and Beverages, Miscellaneous, Rubber and Products, Wood and Manufactures, Textiles, Clothing & Footwear, Machinery and Transport, and Electrical Machinery,* on the contrary, can be characterized as less emission- or energy-intensive compared to the other six sectors and are thus classified as light industry. Nevertheless, this does not mean that no emissions occur during the production of, for example, machinery and transportation equipment, as can be seen in Table A.2 or in Sato (2014). It only implies that less emissions arise, and less energy is used, compared to the first group of products, and that the literature commonly refers to the first group of products (sectors) when talking about emission-, energy, or carbon-intensive industries.

3.3 Trade Specialization Indicators

Having discussed the data and the procedure of classifying the commodity groups, this subsection will now explain the methodological approach and specify its relevance for the research purpose. To evaluate the trade patterns of the two country groups, the underlying analysis is based on two commonly used trade specialization indicators: the normalized trade balance and the revealed (symmetric) comparative advantage (R(S)CA) index proposed by Balassa (1965).

Whereas some approaches suggest to use the number of goods or product lines to calculate export specialization or diversification (e.g. Persson and Wilhelmsson, 2016), the two mentioned indices are based on monetary trade values. Since the availability of reported trade quantities is limited, using the number of exported goods would reduce the time period under study significantly. Moreover, due to the high development of the analyzed countries and due to the trading partner ‘world’, an index based on the number of product lines would not be adequate as the economies conduct trade within nearly every product line.

3.3.1 The Normalized Trade Balance

The normalized trade balance reflects the ratio of net exports to the total value of trade (imports plus exports) and is defined as follows:

$$NT_{ij} = \frac{X_{ij}-M_{ij}}{X_{ij}+M_{ij}} \quad (2)$$

where X_{ij} represents exports of country *i* in the good or sector *j* and M_{ij} imports (Iapadre, 2001; Gnidchenko and Salnikov, 2015).[10] The value of the index ranges from -1 to +1 and allows ”unbiased comparisons across time, countries and sectors” (OECD, 2005: p. 11). Hence, if a country reports an index well below zero, it would imply that the country is dependent on imports for this sector whereas in the opposite case, having an index of well above zero, the country would export more of the commodities than it imports.

Normalizing the trade data has the advantage that it adjusts for trends in inflation and growth and that it takes macroeconomic trade balance effects into account (Gagnon and Rose, 1995). Another advantage of this indicator is that it incorporates the value of imports in its calculation instead of only focusing on export specialization, as it is done by other specialization indices (e.g. the RCA index), and therefore considers that countries import commodities which they also export (Gnidchenko and Salnikov, 2015). Furthermore, the normalized trade balance is easily computable, since it only relies on trade flows, and can be used as an index for both the whole economy as well as for single sectors (ibid.).

One of the disadvantages of the normalized trade balance, however, is that the index might not reflect specialization patterns adequately. If a country for example reports strong specialization (an index of 1) in a certain sector, it does not provide any additional information on the relative importance of exports or imports. With no imports in the sector, the volume of exported goods in the sector can be very small, while the index indicates high specialization (Iapadre, 2001; Gnidchenko and Salnikov, 2015). Moreover, taken individually, the index itself mainly reflects the trade performance of a country instead of trade specialization. This is why Iapadre (2001) suggests to compare the country- and sector-specific results with the global

[10] The normalized trade balance is also referred to as ‘relative net export index’ (see Gnidchenko and Salnikov, 2015).

balance. A normalized trade balance greater than the global average, thus, signifies that the country is specialized in the sector or product and vice versa. For the analysis in the subsequent section, the normalized trade balance will therefore be calculated on the national level and for the different country groups and will be considered in relation to the normalized trade balance of the OECD economies.

3.3.2 **Revealed (Symmetric) Comparative Advantage Index**

The revealed comparative advantage (RCA) index, also called *Balassa index*, is one of the most commonly used indicators to determine trade specialization patterns and compares the sectoral share of a country's total exports or imports with that of the world or another reference group (Brasili *et al.*, 2000). The formula reads as follows:

(3) $$RCA_{ij} = \frac{X_{ij}/\sum X_i}{X_{aj}/\sum X_a}$$

where X_{ij} represents the exports of country *i* in sector *j* and the subscript *a* denotes the reference group which, in this study, is the OECD country group. Altogether, the calculation of national RCA indices serves as a relative measure of specialization which compares the export structure of the country to the one of the reference group, or in this case, the OECD (Laursen, 2015). The value of the index can range from 0 to + ∞ which leads to an asymmetric distribution of the RCA index. If the value of the RCA index equals 1, it implies that the country has the same level of specialization in the sector as the OECD reference group. A value lower than 1, on the contrary, indicates no specialization whereas a value greater than 1 signals specialization in the sector. Using the equation above, the RCA index can similarly be applied for the calculation of import dependency (Gnidchenko and Salnikov, 2015)

Due to the asymmetric characteristic of the index, however, several authors rather suggest the following symmetric transformation (e.g. Dalum *et al.*, 1998; Brasili *et al.*, 2000; Laursen, 2015):

(4) $$RSCA_{ij} = \frac{RCA_{ij}-1}{RCA_{ij}+1}$$

This specialization indicator is also referred to as the 'revealed symmetric comparative advantage' (RSCA) index and takes values between -1 and +1 (Laursen, 2015). The interpretation is similar to the normalized trade balance, since values above zero suggest specialization and indices below zero no specialization. According to Laursen (2015), the RCA index should always be adjusted for its asymmetry in any study. This is why the analysis in Section 4 focuses on the RSCA indices for the Anglophone and Nordic countries.

One of the main advantages of the RCA/RSCA index is that its construction is rather simple and that it can be calculated based on export or import data. Moreover, by using a reference group, the indicator reveals a country's relative level of specialization and, thus, facilitates the interpretation of the results. Another advantage mentioned by Laursen (2015) refers to a better reflection of the concept of specialization compared to other trade specialization indices. However, Gnidchenko and Salnikov (2015) also note that the RCA index should not be used for the analysis of heterogenous countries but should only be considered for countries with similar levels of development because of its sensitivity to the number of exported commodities. In general, countries with a diversified trade portfolio would report lower index values compared to countries with few exported goods. Since this thesis focuses mainly on industrialized country groups, the latter disadvantage should not affect the following analysis.

4. Empirical Analysis

Before presenting and discussing the results of the calculations, the expectations formulated in Section 2.4 are briefly repeated in the following: First, export portfolios should be more specialized than the import structure. Second, geographical differences in the trade specialization patterns should be reflected in a more diversified trade structure by larger countries. Third, trade specialization patterns should be characterized by a high persistency and changes should occur rather gradually. Fourth, a shift either from heavy industry to light industry in the export portfolio or an increase in heavy industry imports, or both, should be observable in particular across the Anglophone trade structure.

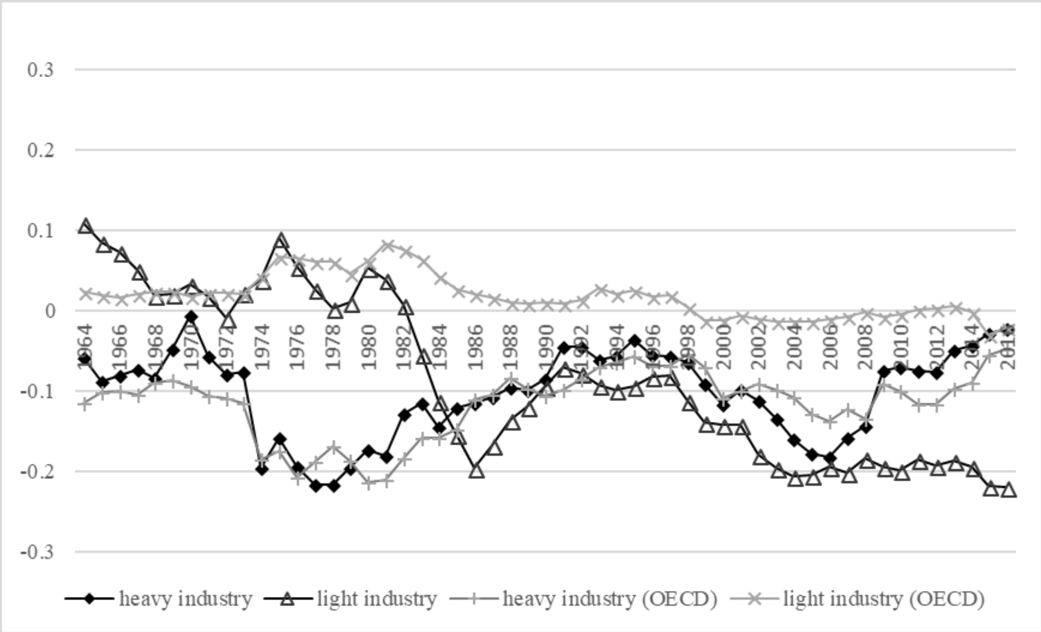
4.1 Discussion and Results

4.1.1 **The Anglophone Country Group**

The aggregated Anglophone country group consists of Australia, Canada, Ireland, the UK, the U.S., and New Zealand. South Africa is only considered individually due to its limited data availability (2000-2016) and due to the economy's different development stage compared to the other countries.

According to Figure 5, the Anglophone country group has been a net importer of heavy industrial goods throughout the observed period and a net importer in both heavy and light industry sectors since the 1980s. Although the aggregated group is continuously a net importer of heavy industry goods, the graph also shows that its normalized trade balance (NT) fluctuates. In the 1970s, for instance, the gap between heavy industry imports and exports seems to have widened, which could be related to the oil crisis in the 1970s, whereas in the mid-1990s the trade is more balanced as the NT approaches zero. However, between 1995 and 2006 the import dependency rises again which is followed by a reduction in the level of heavy industry imports. This pattern is similar to the overall trade development of the OECD as a whole. The light industry sector, on the contrary, diverges from the normalized trade balance of the OECD as it reflects a higher and an increasing import dependency compared to the OECD group.

Figure 5: The Normalized Trade Balance of Heavy and Light Industrial Goods - The Anglophone Country Group (1964-2016)

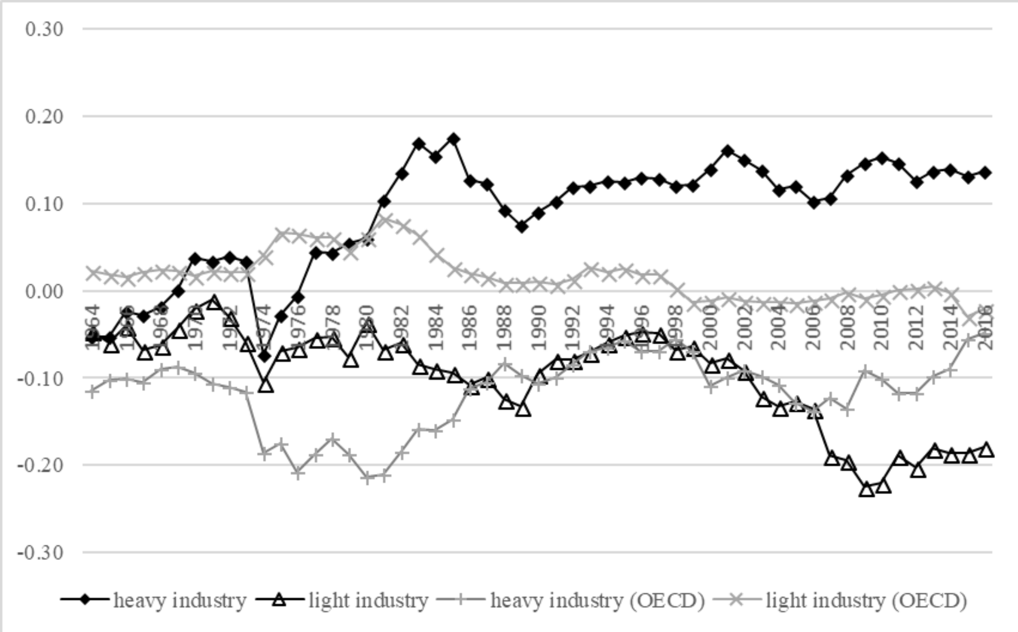


Source: Construction based on own calculations.

Nevertheless, the NTs of the individual countries (Appendix Figure A.1) show that Australia, Canada, the UK, South Africa, and Ireland (since the 1990s) are largely net exporters of heavy industrial goods during the period 1962-2016. The only countries which appear to export more or nearly an equal amount of light industrial goods compared to what they import are New Zealand, the U.S. and Ireland (before the 1990s). The other countries, on the contrary, are largely import dependent on commodities from the light industry sector while exporting a larger share of heavy industry goods. These specialization patterns hereby present a high persistency as changes in the normalized trade balance of the individual countries occur rather slowly.

Furthermore, by comparing the Anglophone trade pattern with the one of the U.S., it becomes evident that the trade conducted by the United States significantly shapes the overall trade pattern of the country group. Figure 6 below therefore presents the normalized trade balance for the Anglophone group without the U.S. As can be seen, the exclusion of the U.S. leads to a different development of heavy and light industry trade, with the Anglophone countries being rather net exporters of heavy industry goods and net importers of light industrial commodities. The trade pattern thereby diverges from the OECD trend as the OECD is a net importer of heavy industry goods throughout the entire period.

Figure 6: The Normalized Trade Balance of Heavy and Light Industrial Goods - The Anglophone Country Group excluding the U.S. (1964-2016)



Source: Construction based on own calculations.

Table 5 further demonstrates the revealed symmetric comparative advantage (RSCA) index for the individual sectors which gives an indication on the export specialization of the Anglophone countries in relation to the OECD. Taking the Anglophone countries as a group, a clear specialization pattern in heavy or light industry goods is not revealed. The sectors *Minerals Fuels and Lubricants* and *Wood and Manufactures* present the highest RSCA indices across the time period due to the export structure of Canada, New Zealand, the UK and Ireland.

The exclusion of the United States, however, changes the export structure of the Anglophone country group and reveals a specialization influenced by natural resource endowments. The sectors with the highest RSCA index include *Basic Metals and Manufactures*, *Mineral Fuels and Lubricants* and *Pulp and Paper* which all belong to the heavy industry. In addition, *Food and Beverages* and *Wood and Manufactures* are also exported more extensively compared to the OECD average. Even though the latter two sectors are attributed to the light industry, they both are characterized by the use of natural resources such as wood.

Additionally, Table 6 presents the sectoral import dependency of the Anglophone countries. In general, the export portfolios appear to be more specialized than the import structure across countries, due to the fact that less sectors report RSCA indices above zero and that the export indices are much higher compared to the import indices (compare Table 5 and 6). The export portfolios of Ireland and South Africa present the strongest specialization pattern in heavy industry commodities, since four out of the six heavy industry sectors report high RSCA indices between 1965 and 2015. However, also the UK appears to be specialized in the export of heavy industry goods and only periodically reports a specialization in light industry sectors. For instance, between 1965 and 1975, the UK exported a higher share of products in the *Machinery and Transport* as well as *Rubber and Products* sector compared to the OECD average whereas it declined in the following year. The only country showing an export specialization predominantly in the light industry is the United States. The sectors *Electrical Machinery*, *Machinery and Transport*, and *Miscellaneous* all report a slightly higher export ratio in contrast to the OECD.

Table 5: Periodical Average of Revealed Symmetric Comparative Advantage (RSCA): Anglophone Sectors – Exports (1965-2015)

	Anglophone countries					Anglophone without US					Canada				
	1965-75	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**
Basic Metals and Man.	.07	.05	.04	.03	.13	0.24	0.20	0.18	0.13	0.27	.41	.29	.25	.18	.19
Chemicals/ Ch. Products	-.12	-.04	-.01	.01	.03	-0.20	-0.07	-0.03	0.04	0.06	-.49	-.31	-.31	-.31	-.24
Iron and Steel	-.39	-.47	-.38	-.36	-.41	-0.31	-0.34	-0.20	-0.27	-0.34	-.44	-.34	-.30	-.30	-.28
Mineral Fuels and Lub.	.04	.09	.16	.12	.20	0.11	0.29	0.37	0.36	0.36	.31	.30	.41	.48	.50
Non-met. Min. & Man.	.03	-.02	-.12	-.06	.03	0.16	0.12	-0.02	-0.01	-0.07	-.10	-.12	-.21	-.24	-.11
Pulp and Paper	.07	.10	.09	.04	.02	0.24	0.24	0.22	0.13	0.04	.59	.60	.56	.46	.39
Electrical Machinery	-.08	-.07	-.03	-.01	-.11	-0.20	-0.27	-0.22	-0.19	-0.37	-.41	-.58	-.43	-.40	-.47
Food and Beverages	.09	.12	.06	.05	.07	0.14	0.14	0.15	0.14	0.15	.07	.05	-.01	.01	.07
Machinery & Transport	.06	.02	.01	-.01	-.11	-0.01	-0.07	-0.04	-0.06	-0.17	-.03	.03	.05	.02	-.08
Miscellaneous	.05	.03	.04	.04	.09	-0.15	-0.13	-0.08	-0.02	-0.04	-.45	-.41	-.23	-.08	-.14
Rubber and Products	-.06	-.12	-.11	-.10	-.18	-0.09	-0.08	-0.08	-0.15	-0.29	-.25	-.06	-.04	.00	-.10
Text., Clothi., Footwear	-.21	-.23	-.27	-.25	-.29	-0.08	-0.17	-0.20	-0.27	-0.27	-.77	-.77	-.69	-.49	-.57
Wood & Manufactures	.08	.17	.22	.19	.13	0.17	0.25	0.30	0.36	0.26	.56	.62	.64	.67	.56
	United States					Australia					United Kingdom				
	1965-75	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**
Basic Metals and Man.	-.18	-.16	-.14	-.10	-.09	.39	.51	.58	.58	.75	.00	-.01	-.05	-.06	-.05
Chemicals/ Ch. Products	-.05	-.01	.00	-.01	.00	-.43	-.16	-.15	-.18	-.40	.01	.08	.10	.07	.08
Iron and Steel	-.47	-.63	-.61	-.47	-.39	-.32	-.29	-.26	-.34	-.77	-.19	-.31	-.08	-.14	-.19
Mineral Fuels and Lub.	-.05	-.27	-.23	-.41	-.11	.17	.39	.65	.64	.62	-.14	.27	.30	.23	.16
Non-met. Min. & Man.	-.15	-.22	-.25	-.12	.10	-.54	-.43	-.24	-.21	-.52	.37	.30	.14	.23	.14
Pulp and Paper	-.17	-.11	-.08	-.07	-.01	-.82	-.83	-.72	-.53	-.60	-.49	-.44	-.30	-.31	-.29
Electrical Machinery	.02	.07	.10	.12	.06	-.74	-.78	-.69	-.66	-.85	.02	-.05	-.04	.00	-.19
Food and Beverages	.04	.10	-.04	-.06	-.02	.52	.51	.47	.52	.35	-.28	-.20	-.08	-.10	-.09
Machinery & Transport	.12	.09	.06	.03	-.04	-.65	-.72	-.61	-.53	-.75	.12	-.02	-.01	-.03	-.04
Miscellaneous	.18	.15	.14	.09	.15	-.27	-.20	-.33	-.11	-.25	.01	-.01	.01	.04	.10
Rubber and Products	-.04	-.16	-.14	-.05	-.06	-.70	-.87	-.70	-.70	-.89	.10	.00	-.01	-.10	-.21
Text., Clothi., Footwear	-.37	-.31	-0.35	-.23	-.25	.37	.22	.24	.05	-.23	-.04	-.12	-.14	-.17	-.06
Wood & Manufactures	-.04	.06	.12	-.10	-.08	-.65	-.21	-.08	-.05	-.08	-.83	-.73	-.75	-.63	-.64

	New Zealand					Ireland					South Africa		
	1965-75	**'76-'85**	**'86-'95**	**'96-2005**	**'06-'15**	**1965-75**	**'76-'85**	**'86-'95**	**'96-2005**	**'06-'15**	**2000-2005**	**2006-2010**	**2011-2015**
Basic Metals and Man.	-.63	-.01	.12	.10	-.12	-.16	-.19	-.33	-.65	-.64	.60	.68	.65
Chemicals/ Ch. Products	-.56	-.45	-.31	-.21	-.46	-.36	.12	.24	.50	.60	-.19	-.29	-.28
Iron and Steel	-.92	-.70	-.43	-.34	-.47	-.31	.05	.36	.60	.21	.63	.54	.45
Mineral Fuels and Lub.	-.66	-.65	-.38	-.33	-.33	.85	.62	.69	.33	.08	.34	.15	.13
Non-met. Min. & Man.	-.87	-.68	-.73	-.64	-.66	-.74	-.74	-.64	-.86	-.87	.58	.43	.40
Pulp and Paper	-.06	.27	.33	.33	.28	.10	.69	.79	.82	.72	.07	.00	.03
Electrical Machinery	-.82	-.70	-.70	-.56	-.60	-.59	-.83	-.89	-.94	-.83	-.68	-.64	-.58
Food and Beverages	.67	.67	.78	.76	.78	-.65	-.61	-.69	-.83	-.88	.19	.10	.16
Machinery & Transport	-.91	-.76	-.81	-.66	-.66	-.24	-.30	-.29	-.33	-.32	-.27	-.21	-.20
Miscellaneous	-.11	-.05	-.10	-.19	-.19	-.82	-.88	-.90	-.95	-.95	-.39	-.59	-.51
Rubber and Products	-.83	-.73	-.59	-.44	-.75	-.21	.01	-.20	-.73	-.88	-.11	-.27	-.24
Text., Clothi., Footwear	.44	.46	.26	.06	-.01	.15	.12	-.16	-.57	-.67	-.32	-.47	-.31
Wood & Manufactures	.13	.31	.59	.72	.78	-.52	-.57	-.58	-.72	-.51	.14	-.04	-.08

Source: Construction based on own calculations.

Table 6: Periodical Average of Revealed Symmetric Comparative Advantage (RSCA): Anglophone Sectors – Imports (1965-2015)

	Anglophone countries					Anglophone without US					Canada				
	1965-75	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**
Basic Metals and Man.	.07	.05	.04	.03	.13	-.08	-.05	-.06	-.07	-.09	-.19	-.09	-.05	.01	-05
Chemicals/ Ch. Products	-.12	-.04	-.01	.01	.03	-.05	.00	.00	.00	-.02	-0.12	-.09	-.10	-.04	-.04
Iron and Steel	-.39	-.47	-.38	-.36	-.41	-.21	-.14	-.16	-.16	-.17	-.13	-.20	-.18	-.03	.01
Mineral Fuels and Lub.	.04	.09	.16	.12	.20	-.13	-.32	-.32	-.36	-.17	-.30	-.43	-.37	-.29	-.21
Non-met. Min. & Man.	.03	-.02	-.12	-.06	.03	.09	.12	-.05	.00	.02	-.21	-.20	-.19	-.18	-.07
Pulp and Paper	.07	.10	.09	.04	.02	.07	.11	.08	.06	.06	-.46	-.29	-.22	-.03	.04
Electrical Machinery	-0.08	-0.07	-0.03	-0.01	-0.11	-.01	.06	.04	.00	-.09	.11	.06	.06	-.02	-.05
Food and Beverages	.09	.12	.06	.05	.07	.05	.00	-.04	.01	.08	-.26	-.17	-.20	-.12	.02
Machinery & Transport	.06	.02	.01	-.01	-.11	.13	.21	.13	.12	.10	.38	.39	.24	.18	.19
Miscellaneous	.05	.03	.04	.04	.09	-.01	.04	.00	.01	.07	-.02	-.01	-.04	-.06	-.05
Rubber and Products	-.06	-.12	-.11	-.10	-.18	.00	.02	.03	.05	.01	.05	.05	.11	20	.15
Text., Clothi., Footwear	-.21	-.23	-.27	-.25	-.29	-.07	-.01	-.09	-.08	-.01	-.18	-.19	-.26	-.26	-.17
Wood & Manufactures	.08	.17	.22	.19	.13	-.01	-.06	-.11	-.16	-.02	-.39	-.34	-.30	-.19	-.04
	United States					**Australia**					**United Kingdom**				
	1965-75	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**
Basic Metals and Man.	.00	-.05	-.13	-.12	-.16	-.49	-.31	-.22	-.18	-.16	.03	.02	-.03	-.07	-.06
Chemicals/ Ch. Products	-.32	-.29	-.29	-.20	-.14	.17	.09	.08	.07	-.06	-.11	-.01	.00	-.02	-.03
Iron and Steel	.10	.07	-.13	-.19	-.21	-.23	-.20	-.22	-.18	-.18	-.33	-.15	-.14	-.22	-.29
Mineral Fuels and Lub.	-.08	.05	.03	.05	.04	-.33	-0.37	-.30	-.11	-.03	-.02	-.27	-.31	-.41	-.19
Non-met. Min. & Man.	-.02	-.08	-.06	.03	.08	.04	.03	-.08	-.08	-.09	.22	.25	.02	.11	.10
Pulp and Paper	.18	.02	-.09	-.13	-.17	.17	.16	.08	.07	-.01	.23	.25	.19	.11	.08
Electrical Machinery	.00	.10	.13	.04	.08	.18	.20	.06	-.02	-.03	-.16	.01	.02	.00	-0.12
Food and Beverages	.05	-.08	-.21	-.21	-.15	-.57	-.36	-.30	-.21	-.13	.24	.13	.07	.11	.14
Machinery & Transport	.03	.06	.10	.05	.05	.28	.22	.14	.13	.14	-.20	.04	.05	.05	.01
Miscellaneous	.02	-.02	.03	.03	.01	.08	.12	.04	-.04	.00	-.02	.06	.01	.05	.15
Rubber and Products	.01	.04	-.03	-.07	-.02	.28	.22	.20	.19	.16	-.12	-.06	-.05	-.09	-.14
Text., Clothi., Footwear	-.07	-.06	.04	.08	.09	.11	.10	-.07	-.09	-.07	-.07	.03	-.02	.04	.09
Wood & Manufactures	-.02	-.08	-.13	.04	-.08	-.24	-.10	-.12	-.17	-07	.17	.08	.00	-.09	.01

	New Zealand					Ireland					South Africa		
	1965-75	**'76-'85**	**'86-'95**	**'96-2005**	**'06-'15**	**1965-75**	**'76-'85**	**'86-'95**	**'96-2005**	**'06-'15**	**2000-2005**	**2006-2010**	**2011-2015**
Basic Metals and Man.	-.17	-.19	-.14	-.16	-.26	-.26	-.13	-.11	-.26	-.35	-.20	-.25	-.25
Chemicals/ Ch. Products	.25	.28	.22	0.12	-.01	.16	.20	.17	.09	.17	.06	-.05	-.04
Iron and Steel	.27	.26	-.02	-.05	-.24	-.15	-.13	-.24	-.31	-.40	-.26	-.24	-.16
Mineral Fuels and Lub.	-.20	-.18	-.20	-.05	-.02	-.16	-.28	-.28	-.42	-.21	.12	.13	.13
Non-met. Min. & Man.	.12	.12	-.03	03	0.09	-.14	-.17	-.22	-.23	-.17	.23	.20	.09
Pulp and Paper	-.31	-.22	.01	.11	.19	.09	.14	.10	-.07	.03	-.18	-.10	-.05
Electrical Machinery	.13	.00	.01	-.13	-.15	.03	.09	.08	.11	-.23	-.05	-.05	-.07
Food and Beverages	-.35	-.26	-.13	.04	.14	-.04	.03	.02	-.01	.20	-.30	-.21	-.14
Machinery & Transport	.18	.16	.09	.08	.10	.04	.06	.00	.10	.13	.02	.07	.04
Miscellaneous	-.17	-.09	-.04	-.08	-.03	.14	.07	.06	.06	.02	.09	.02	.04
Rubber and Products	.10	.13	.08	.03	.03	-.01	.02	-.16	-.32	-.36	.13	.10	.08
Text., Clothi., Footwear	.09	.02	-.08	-.05	.01	.10	.17	.00	-.21	-.11	-.22	-.16	-.10
Wood & Manufactures	-.53	-.62	-.55	-.45	-.29	-.05	-.08	-.24	-.13	-.11	-.36	-.36	-.35

Source: Construction based on own calculations.

How do these results relate to the findings of Baumert (2017) and Jiborn *et al.* (2018) and the technology-adjusted balance of emissions embodied in trade (TBEET)? According to Baumert (2017), the Anglophone countries, consisting of the U.S., the UK, Australia, and Canada, have been or have become net importers of carbon emissions between 1995 and 2009 (Figure 1). However, the calculation of the NT and the sectoral RSCA indices do not completely confirm a changing trade specialization pattern across the Anglophone countries. While the aggregation of the normalized trade balance as a group in Figure 5 indicates that the Anglophone countries are net importers of both heavy and light industrial commodities since the early 1980s, the exclusion of the U.S. changes the trade pattern and the group becomes a net exporter of heavy industrial goods from 1976 onwards (Figure 6). This result would therefore rather indicate that the Anglophone country group is a net exporter of carbon emissions, if the U.S. is excluded.

Even more interesting is the comparison of the individual country profiles. Considering the increasingly negative trade specialization of the UK, the USA, Australia and Canada illustrated in Figure 1, the trade specialization indicators should theoretically depict a changing specialization pattern in either the import or the export structure, or both. Yet, the normalized trade balances of Australia, Canada, and the UK in Figure A.1 show a rather persistent pattern of heavy industry exports. Among the three countries, Canada is the only one which shows a decreasing trend in the export level of heavy industry goods. Hence, the result of the NT does not suggest that the countries' trade specialization in the export or import of heavy and light industrial goods is shifting.

Apart from this, the sectoral RSCA indices do not reveal a clear pattern which would support the claim that the import or export structures of the Anglophone countries are changing. For instance, even though the UK's specialization in *Mineral Fuels and Lubricants* and *Non-metallic Minerals and Manufactures* is decreasing during the observed period, the country neither reports an increasing export specialization in light industry goods nor does it show an increasing import dependency in the two sectors. The imports of *Pulp and Paper* and *Non-metallic Minerals and Manufactures* products seem to be rather decreasing since the period 1965-1975. An explanation for the increasing negative impact of trade specialization depicted in Figure 1 could, however, be that the decrease in the level of heavy industry exports has exceeded the decline in heavy industry imports, as the RSCA indices only reflect relative numbers. This, in turn, may be responsible for the increasing level of emissions embodied in imports calculated by Jiborn *et al.* (2018).

Among the Anglophone countries, the U.S. is the only country which presents specialization patterns in the export of light industrial goods such as *Electrical Machinery* or *Miscellaneous*. This, on the contrary, supports the finding of Baumert (2017) who found that the U.S. has been a net importer of carbon emissions throughout 1995-2009. The NT balance shows that the U.S. has imported heavy industry goods already before 1962 which is in line with publications by Wright (1990) and Gierlinger and Krausmann (2012). Both recognize a rising import dependency of the U.S. in minerals, ores, and metals after World War II. However, Wright (1990) also emphasizes that the U.S. did not become resource poor compared to the rest of the world but that globalization processes such as the reduction of transport costs have changed the importance of country-specific resource endowments.

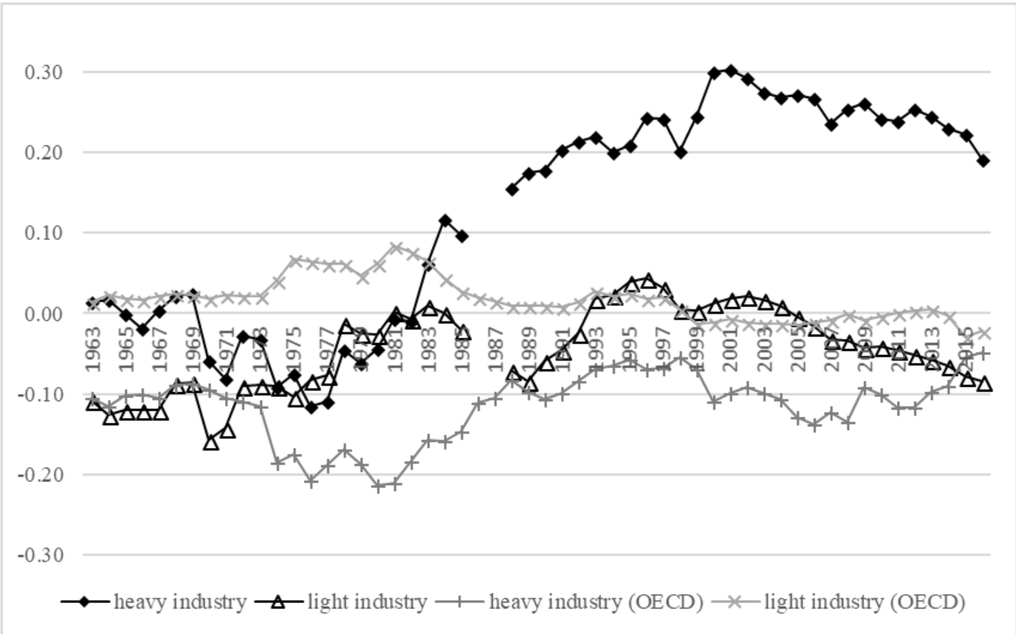
Overall, the diverging trade structure between the U.S. and the other Anglophone countries could also be due to the fact that the former may be in a different stage of economic development. Most of the other economies may instead be in a transition period from an industrial to a post-industrial society as the export structures are largely dominated by natural resources. Bell (1999) already characterized the United States in 1999 as a post-industrial society whereas the Western-Europe and Japan were still classified as industrial. The different long-term trade patterns may, therefore, be an indication for the highly advanced development stage of the U.S.

The trade pattern of Ireland, by contrast, reflects the catching-up process of the economy which was triggered in 1958 through the commitment to economic openness (Teague & Currie, 2012). Ireland has industrialized rather late and has, thus, passed through the economic development process at a different time than the U.S. or the U.K. Furthermore, South Africa's high export specialization indices clearly represent its different development stage compared to the high-income countries with the heavy industry strongly dominating the economy of South Africa. Hence, the U.S. may have already reached the highest phase in Bell's (1999: p. 73) "technological ladder" up until now and in 20-50 years, the other countries may present a similar trade pattern and development level compared to the one of the U.S.

4.1.2 The Nordic Country Group

The development of the normalized trade balance (NT) of the heavy and light industries for the Nordic country group is depicted in Figure 7. The graph shows that the Nordic region as a whole is a large exporter of heavy industry goods since the beginning of the 1980s which diverges strongly from the overall OECD trend. In the light industry sectors, however, the Nordic country group varies from being a net importer to reporting a rather balanced trade as the NT approaches zero. Hence, Figure 7 supports the claim that the Nordic countries are generally net exporters of emissions.

Figure 7: The Normalized Trade Balance of Heavy and Light Industrial Goods - The Nordic Country Group (1963-2016)



Source: Construction based on own calculations.

The NTs of the individual countries, on the contrary, reveal that the economies' trade profiles largely differ from each other during the observed period, with Denmark and Sweden showing a rather persistent trade specialization pattern (Appendix Figure A.2). Denmark, Sweden, and Iceland are net exporters of light industry goods whereas Finland and Norway are predominantly net exporters of heavy industrial products. While the former three countries largely depend on heavy industry imports, the gap between imports and exports in this sector has become smaller between 1962 and 2016 with Iceland even reaching a balanced trade. Finland and Norway, by contrast, have been net exporters in both heavy and light industry sectors from the beginning of the 1990s until 2009. Norway's trade pattern for the period 1962-

1985 shows large fluctuations in the normalized trade balance for both heavy and light industries which may be related to the trade data, since trade statistics for the years 1986 and 1987 are also missing.

The revealed symmetric comparative advantage (RSCA) indices for the thirteen export sectors are presented in Table 7. Similar to what the normalized trade balance in Figure 7 suggests, the Nordic country group is largely specialized in heavy industry exports. However, the countries also seem to export more products belonging to the *Wood and Manufactures* and the *Food and Beverages* industry compared to the average of the OECD. Natural resource endowments, hence, also seem to influence the export structure of the Nordic country group. Furthermore, the specialization in *Basic Metals and Manufactures* appears to decrease over time whereas the export specialization in *Mineral Fuels and Lubricants* seems to increase. Both the *Pulp and Paper* and the *Wood and Manufactures* sectors report very high RSCA indices in contrast to the OECD average indicating their overall importance for the region.

Considering the individual countries' export specialization patterns, it is shown that they largely reflect the results of the distinct NTs. Denmark is specialized in the export of goods belonging to the light industry such as *Food and Beverages* or *Miscellaneous* whereas Norway reports higher RSCA indices in the heavy industry sectors, especially in the *Mineral Fuels and Lubricants* sector. The specialization pattern of the Nordic country group in *Pulp and Paper* and *Wood and Manufactures* results predominantly from the export structure of Denmark, Finland, and Sweden, while the RSCA indices in the *Basic Metals and Manufactures* sector mainly stems from the countries Iceland, Norway and Sweden.

Compared to the other Nordic countries' export structure, however, the export specialization pattern of Sweden does not reflect the results of the normalized trade balance. Figure A.2 in the Appendix clearly illustrates that Sweden is a net exporter of light industry and a net importer of heavy industry products. Table 7, on the contrary, reveals that, despite exporting more wooden commodities and electrical machineries than the OECD average, Sweden is also specialized in the export sectors *Basic Metals and Manufactures*, *Iron and Steel* and *Pulp and Paper* which all belong to the heavy industry. The difference between the NT and the RSCA index could be related to the fact that the NT rather represents the trade performance whereas the RSCA index is an indicator for trade specialization. Hence, the results suggest that Sweden imports a large amount of heavy industry goods while simultaneously specializing in the export of heavy industry products.

Table 7: Periodical Average of Revealed Symmetric Comparative Advantage (RSCA): Nordic Sectors – Exports (1965-2015)

	Nordic countries					Denmark					Finland				
	1965-75	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**
Basic Metals and Man.	.21	.11	.11	.08	.06	-.45	-.26	-.17	-.11	-.13	-.20	-.03	-.01	-.01	.04
Chemicals/ Ch. Products	-.28	-.25	-.17	-.19	-.23	-.21	-.13	-.08	-.01	-.08	-.58	-.35	-.25	-.28	-.23
Iron and Steel	-.02	-.02	.11	.14	.06	-.68	-.45	-.38	-.30	-.36	-.35	-.11	.23	.32	.38
Mineral Fuels and Lub.	-.45	.20	.35	.57	.50	-.31	-.31	-.16	.10	-.01	-.83	-.35	-.32	-.17	-.01
Non-met. Min. & Man.	-.36	-.37	-.30	-.33	-.35	-.25	-.19	-.19	-.18	-.15	-.57	-.40	-.28	-.23	-.19
Pulp and Paper	.65	.64	.61	.55	.51	-.54	-.37	-.39	-.32	-.31	.85	.83	.83	.79	.79
Electrical Machinery	-.11	-.12	-.13	.01	-.10	-.05	-.08	-.21	-.16	-.11	-.41	-.27	-.07	.28	.12
Food and Beverages	.04	.03	.11	.10	.07	0.54	0.53	0.53	0.50	0.43	-.48	-.48	-.54	-.53	-.48
Machinery & Transport	-.07	-.10	-.17	-.28	-.27	-.16	-.21	-.26	-.28	-.25	-.34	-.20	-.21	-.25	-.16
Miscellaneous	-.15	-.16	-.09	-.07	-.08	.15	.18	.24	.19	.21	-.42	-.29	-.38	-.39	-.25
Rubber and Products	-.33	-.41	-.43	-.38	-.43	-.48	-.49	-.54	-.53	-.62	-.70	-.65	-.49	-.29	-.12
Text., Clothi., Footwear	-.36	-.29	-.37	-.35	-.23	-.20	-.11	-.10	.08	.25	-.14	.06	-.28	-.50	-.47
Wood & Manufactures	.53	.54	.52	.47	.46	-.10	.13	.16	.18	.12	.81	.78	.73	.69	.71

	Iceland					Norway*					Sweden				
	1965-75	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’88-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**
Basic Metals and Man.	-.20	.38	.36	.57	.71	.46	.33	.35	.23	.05	.26	.14	.13	.07	.08
Chemicals/ Ch. Products	-.94	-.95	-.98	-.72	-.68	-.04	-.26	-.34	-.59	-.67	-.42	-.26	-.13	-.09	-.10
Iron and Steel	-	-.50	-.12	.03	.02	.08	-.08	-.10	-.22	-.46	.15	.17	.28	.31	.24
Mineral Fuels and Lub.	-	-	-	-.87	-.67	-.30	.67	.84	.86	.78	-.60	-.34	-.20	-.23	-.09
Non-met. Min. & Man.	-.63	-.53	-.50	-.63	-.67	-.18	-.51	-.39	-.51	-.62	-.49	-.39	-.37	-.40	-.41
Pulp and Paper	-.93	-.92	-.94	-.88	-.91	.55	.31	.08	-.15	-.40	.68	.69	.66	.61	.64
Electrical Machinery	-	-	-.99	-.94	-.84	-.32	-.51	-.61	-.65	-.65	.03	.06	.00	.13	.04
Food and Beverages	.72	.75	.81	.81	.71	-.10	-.23	-.01	.03	-.03	-.64	-.61	-.62	-.39	-.19
Machinery & Transport	-.94	-.93	-.85	-.73	-.62	-.15	-.32	-.47	-.57	-.60	.07	.08	.03	-.08	-.03
Miscellaneous	.24	.01	-.20	-.07	-.27	-.09	-.41	-.41	-.28	-.40	-.35	-.25	-.20	-.05	-.07
Rubber and Products	-	-.98	-.98	-.96	-.98	-.45	-.65	-.70	-.86	-.88	-.13	-.20	-.28	-.17	-.24
Text., Clothi., Footwear	-.63	-.25	-.64	-.73	-.85	-.49	-.69	-.78	-.81	-.85	-.48	-.45	-.53	-.47	-.31
Wood & Manufactures	-	-	-.96	-.95	-.94	-.17	-.26	-.01	-.24	-.33	.61	.60	.58	.54	.60

*Source: Construction based on own calculations; *Note: No data available for Norway for the years 1986 and 1987.*

Table 8: Periodical Average of Revealed Symmetric Comparative Advantage (RSCA): Nordic Sectors – Imports (1965-2015)

	Nordic countries					Denmark					Finland				
	1965-75	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**
Basic Metals and Man.	-.07	-.02	.05	.09	.10	-.28	-.15	-.09	-.04	-.10	-.20	-.07	.06	.17	.21
Chemicals/ Ch. Products	.12	.10	.08	.02	-.05	.13	.13	.11	.01	-.03	.17	.11	.12	.05	-.04
Iron and Steel	.16	.12	.15	.20	.13	.16	.19	.20	.17	.11	.19	.03	.13	.17	.10
Mineral Fuels and Lub.	-.12	-.09	-.13	-.16	-.19	-.03	-.09	-.26	-.37	-.35	.02	.05	.09	.07	.06
Non-met. Min. & Man.	-.15	-.15	-.11	-.11	-.06	-.15	-.20	-.20	-.08	-.01	-.15	-.11	-.04	-.07	-.08
Pulp and Paper	-.20	-.07	.00	.04	.09	.14	.23	.23	.20	.18	-.62	-.43	-.18	-.09	.02
Electrical Machinery	.16	.10	.02	.03	-.01	.13	.01	-.10	-.05	-0.07	.17	.08	.06	.17	.00
Food and Beverages	-.26	-.18	-.11	.03	.12	-.30	-.10	0.07	0.20	0.25	-.24	-.22	-.24	-.12	-.05
Machinery & Transport	.15	.08	.02	.00	.04	.06	-.03	-.06	-.05	.01	.16	.08	.01	-.06	-.07
Miscellaneous	-.05	.00	-.01	-.02	.01	.07	.13	.10	.05	.09	-.13	-.12	-.12	-.14	-.05
Rubber and Products	.09	.08	.07	.03	-.02	.10	.02	-.02	-.07	-.14	.15	.10	.06	-.03	-.03
Text., Clothi., Footwear	.05	.04	-.03	-.06	-.04	.03	.01	-.02	.08	.16	-.03	-.03	-.08	-.17	-.15
Wood & Manufactures	-.10	-.01	.06	.19	.36	.10	.12	.18	.29	.41	-.13	-.06	.01	.18	.31
	Iceland					Norway*					Sweden				
	1965-75	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’88-‘95**	**’96-2005**	**’06-‘15**	**1965-75**	**‘76-‘85**	**’86-‘95**	**’96-2005**	**’06-‘15**
Basic Metals and Man.	-.20	-.16	-.07	.02	-.11	.06	.10	.21	.25	.26	-.06	.01	.05	.04	-.01
Chemicals/ Ch. Products	.08	.17	.08	.08	.20	.10	.05	.06	.00	-.08	.10	.09	.07	.01	-.04
Iron and Steel	-.12	-.05	-.16	-.12	-.25	.17	.13	.18	.15	.00	.12	.12	.12	.27	.18
Mineral Fuels and Lub.	.30	-.08	.43	.48	.10	-.41	-.31	-.45	-.43	-.49	-.02	-.06	-.09	-.09	-.10
Non-met. Min. & Man.	.47	.69	.52	.56	.76	-.18	-.11	-.10	-.04	.03	-.12	-.15	-.10	-.20	-.11
Pulp and Paper	.06	.16	.18	.11	.09	-.23	.01	.06	.10	.07	-.45	-.31	-.18	-.09	.05
Electrical Machinery	.26	.18	-.01	-.08	.07	.12	.11	-.06	-.13	-.10	.21	.15	.08	.09	.04
Food and Beverages	-.19	-.06	.01	.16	.15	-.32	-.24	-.22	-.07	-.02	-.20	-.19	-.16	-.02	.13
Machinery & Transport	.13	.02	-.02	.01	-.06	.25	.20	.09	.09	.16	.10	.06	.04	.01	.03
Miscellaneous	-.11	-.01	-.02	-.08	-.16	-.13	-.03	-.03	-.02	.03	-.05	-.03	-.04	-.02	-.02
Rubber and Products	.13	.02	-.01	-.03	-.16	-.07	-.01	-.04	-.07	-.11	.16	.15	.15	.16	.07
Text., Clothi., Footwear	.07	.12	.04	-.05	-.12	.04	.07	-.02	-.06	-.04	.08	.06	-.02	-.16	-.13
Wood & Manufactures	.23	.36	.26	.32	.30	-.01	.03	.09	.29	.46	-.41	-.18	-.05	.02	.19

*Source: Construction based on own calculations; *Note: No data available for Norway for the years 1986 and 1987.*

Table 8 additionally presents the sectoral import RSCA indices for the Nordic country group and the individual economies. Similar to the Anglophone countries, the import specialization patterns reflect a much more diverse structure in comparison to the exports. All five countries appear to import a larger share of goods in contrast to the OECD in a variety of sectors.

Considering the research by Baumert (2017) and Jiborn *et al.* (2018), the individual trade patterns in the present analysis neither confirm their findings that Sweden, Denmark and Finland are largely specialized in the export of carbon-intensive goods nor that this is changing. As previously mentioned, the results for Sweden, for instance, present a rather ambivalent trade specialization. While the decomposition of the Swedish' technology-adjusted balance of emissions embodied in trade (TBEET) (Figure 2) reflects an increasingly negative impact of trade specialization, this pattern is not clearly depicted in the NT or the RSCA indices. Although the Swedish export specialization in *Basic Metals and Manufactures* has decreased since the period 1965-1975, the RSCA indices for *Iron and Steel* and *Pulp and Paper* remain very high until 2015. Moreover, the import dependency on products from the *Basic Metals and Manufactures* and *Chemicals and Chemical Products* seems to be decreasing between 1965 and 2015 compared to the OECD average. Hence, a shift from specializing in the export of carbon-intensive goods (heavy industry) to importing a higher share of heavy industry products since 1995, as suggested by Jiborn *et al.* (2018) in the Swedish case, is not confirmed by the trade specialization indicators of the present thesis.

Similarly, looking at the composition of the Danish TBEET (Figure 2), one would expect Denmark to be a net exporter of heavy industrial goods as the trade specialization contributes to a positive TBEET during 1995-2009. Yet, according to both the NT and the RSCA index, Denmark is a net exporter of light industrial products and a net importer of goods belonging to the heavy industry sector throughout the observed period. These diverging results indicate that using an emission accounting approach yields different results compared to specialization indicators based only on commodity trade statistics.

A possible explanation for this discrepancy could be the lacking data on electricity trade in the UN Comtrade SITC Revision 1 database. Electric energy is only included in connection with natural and manufactured gas whereas trade values on electricity from coal, oil or wind power is missing. In the WIOD database, on the contrary, 'electricity, gas and water supply' is part of the input-output tables. Since Denmark is a major net exporter of energy and wind electricity (Lund and Mathiesen, 2009; Green and Vasilakos, 2012), the usage of world average production technologies for the calculation of the TBEET may increase the emission embodied in exports substantially for Denmark, without being reflected in the SITC Revision 1-based trade structure.

4.2 Summary

The first research question (1) asked whether the Anglophone and the Nordic country group show common long-term trade patterns. To answer this, it is necessary to compare the sectoral import and export specializations between 1965 and 2015. Overall, the discussed results reveal that for both, the Anglophone and Nordic countries, the export portfolios present a more specialized pattern compared to the composition of imports, which supports the findings by Steingress (2015). Moreover, the large economies such as the U.S. or the UK have lower RSCA indices in their export sectors than the smaller economies such as New Zealand, Ireland, or Norway. The import structure, on the contrary, does not reflect large geographical differences, since the results rather indicate a diversified specialization portfolio for nearly all countries.

Considering the results of the country-specific NTs (Figure A.1 and A.2), the long-term trade development of Australia, Canada, Sweden, South Africa, Denmark, New Zealand, Iceland, and the UK largely support the hypothesis that changes in trade patterns occur rather gradually. All eight countries show high persistency in their heavy or light industry trade specialization with only marginal alterations. Similarly, the trade pattern of the U.S., as a net importer of heavy and light industry goods, has remained relatively constant since the end of the 1980s. Moreover, even though Finland, for example, shows stronger fluctuations in the trade balance, changes in its heavy industry trade occur rather slowly across time spans of 10 to 15 years. A gradually changing trade structure can also be observed in the export specialization of the individual countries, since the periodical increases or decreases in the sectoral RSCA indices are rather moderate between 1965 and 2015. Hence, the results overall support the studies conducted by Gagnon and Rose (1995) and Dalum *et al.* (1998). This high persistency could imply that long-term trade specialization patterns are at least partly influenced by path dependency. A common specialization pattern in the trade structure, however, cannot be found based on the normalized trade balances or the sectoral RSCA indices.

The second research question (2), on the contrary, aimed at investigating long-term specialization patterns in heavy and light industrial exports (imports) across and within the country groups. While the findings by Baumert (2017) and Jiborn *et al.* (2018) suggest that especially the

Anglophone countries are or have become net importers of emissions, this development is not supported by the individual trade profiles. The trade specialization indicators neither reflect any particular changes in the export structure towards light industrial goods nor a shift in the import structure towards heavy industrial products. The systematical outsourcing of emission-intensive production activities, as indicated by Jiborn *et al.* (2018), thus, cannot be confirmed based on the trade structure of the different countries.

The export specialization indices, by contrast, rather seem to imply that natural resources play an important role for the economies throughout 1965-2015. While all countries, except South Africa, have reached a highly developed stage and should have already passed through Rostow's (1959: p. 1) "drive to maturity" stage by now, natural resource endowments such as basic metals or wood still appear to determine the economies' comparative advantage even in more recent decades. According to economic development literature and the Environmental Kuznets Curve (EKC) hypothesis, one would however expect to see a diminishing specialization in the sectors dominated by natural resources (Bell, 1999; Dinda, 2004). The RSCA indices in Table 5 and Table 7, nevertheless, illustrate that most economies generally export more heavy industry goods or products belonging to the *Food and Beverages* or *Wood and Manufactures* sectors than the OECD average from 1965 to 2015. This suggest that natural resources are highly trade determinant factors.

Consequently, as proposed by Barbier (2003: p. 253), "natural capital", consisting of natural and environmental resource endowments, should be considered as an additional important economic asset in addition to physical and human capital, as it also adds to the economic opportunities of a country. Even though Bell (1999: p. 49) notes that "technological substitution reduces the export markets for […] natural products", the long-term trade patterns do not confirm a declining importance of these goods. Against this background, the presented results reinforce the importance of natural resources for a country's growth potential.

4.3 Limitations

The present empirical analysis of trade specialization patterns is subject to various limitations. First, using trade data based on the classification system SITC Revision 1 by the UN Comtrade has the disadvantage that the commodities are grouped according to affinities in the distribution channels instead of economic or production similarities (Rozanski and Yeats, 1994). As described in Section 3, newly aggregated groups were created with the help of the two-digit level codes. However, the products described by more disaggregated levels reveal that their categorization does not always fit into the original commodity group or in the newly established one. For instance, '71421 Electrical Computers' is attributed to the two-digit level code '71 Machinery, other than electric' which, in turn belongs to the economic category 'Machinery and transport equipment'. For the analysis, the two-digit level code was assigned to the sector *Machinery and Transport* since the other products belonging to this section mainly include heavy machinery such as nuclear reactors, agricultural machinery, and industrial processing machinery. Yet, considering the product composition, electrical computers should rather be assigned to the two-digit level code '72 Electrical machinery, apparatus and appliances', which is redefined as *Electrical Machinery,* instead of being categorized along with industrial machinery. As noted by Rozanski and Yeats (1994), the established SITC Revision 1 system has had difficulties to accurately attribute newly developed high-tech products to the existing commodity groups. Hence, the redefined commodity groups (see Table A.1) do not correspond completely to broader economic sectors or categories as they may include products which should rather be assigned to a different industry.

Second, the SITC Revision 1 data does not include statistics on traded electricity or energy. As previously indicated, the lack of this information could bias the results, since Denmark, for instance, is a net exporter of energy and wind electricity which could explain why Denmark is a net exporter of emissions in the study conducted by Baumert (2017). However, the normalized trade balances and the RSCA indices would rather imply that Denmark is a net importer of emissions. In the same way, Norway is a major exporter of electricity (Hauch, 2003) which makes it difficult to draw conclusions on the country's long-term CO2-emission development using the specialization indicators. Norway's export specialization in carbon-intensive goods might be much higher if data on electricity would be included. Hence, due to the divergence within the different data sources, the results need to be interpreted with caution.

Third, the international trade data used for the analysis has the disadvantage that it only reports traded goods and not services. With the service sector contributing to approximately 70 percent of world GDP in 2010 and with services being increasingly traded across borders, this sector should also be included in an analysis of international trade (Edenhofer, 2014). Even though the energy and carbon intensity of services are rather low, data on traded services may provide additional information on the relationship between economic development and trade specialization patterns. However, due to the lack of available long-term data on traded services, the analysis only uses statistics based on traded commodities.

Fourth, as already mentioned earlier, the two trade specialization indicators both have certain disadvantages in their application. Taken individually, the normalized trade balance, for example, could be rather considered as an indicator of trade performance than of trade specialization (Iapadre, 2001). Moreover, the results of the RSCA index largely depend on the reference group, in this case the OECD, since changes in the latter can affect the country-specific results. This could also be a possible explanation for the diverging results of the presented trade specialization indicators compared to the trade specialization calculated by Baumert (2017) and Jiborn *et al.* (2018). Similarly, the importance of a sector within an economy (the sectoral ranking) may be different to the export specialization reflected by the RSCA index (Laursen, 2015). Nevertheless, the two indices are commonly used when analyzing trade specialization patterns and despite certain drawbacks, they still provide valuable information on a country's long-term trade structure.

Fifth, unlike the calculation of the TBEET, the method applied in this present study does neither take actual generated emissions nor technological differences into account. No distinction is made between countries which produce heavy industrial goods with more carbon-efficient technologies compared to their trading partners. Whereas trade specialization in Baumert (2017) and Jiborn *et al.* (2018) is associated with different carbon intensities in the import and export structure, the present study rather considers trade specialization in relation to classical trade theory: as the specialization in products. By focusing solely on the import and export values of commodities, the analysis therefore diverges from the approach used by Baumert (2017) and Jiborn *et al.* (2018) which, in turn, reduces the comparability of the studies. Hence, due to the discrepancy between the two methods, caution must be applied when interpreting the results.

5. Conclusion

This thesis addressed the extent to which Anglophone and Nordic countries have shifted from being net exporters to becoming net importers of heavy industrial goods between 1962 and 2016. Moreover, by using import and export data based on the SITC Revision 1 classification system, the normalized trade balance and the revealed symmetric comparative advantage (RSCA) index have been calculated to investigate and compare long-term specialization patterns.

In line with previous research on trade specialization, the discussed results show that the export structures of the countries are more specialized than the import structures. Moreover, since smaller countries report much higher RSCA indices in the export structure compared to larger economies, they appear to be more specialized indicating that geographical difference can influence trade specialization patterns. Nevertheless, a common long-term specialization pattern across the different sectors is neither revealed by the countries' normalized trade balances nor by the sectoral RSCA indices.

Furthermore, the results do not support the claim that the Anglophone or Nordic countries have increasingly specialized in the export of light industrial or the import of heavy industrial goods. In both country groups, the individual economies show rather persistent specialization patterns in the two sectors. According to the normalized trade balance, Denmark, for instance, is specialized in the light industry sector whereas Norway or Finland export more heavy industry products during the observed period. Similarly, Canada presents an export specialization in the heavy industry sector and New Zealand exports more light industry products. The United States is the only nation which is a net importer of goods belonging to both sectors since 1983. Hence, the outsourcing of emission-intensive production activities appears to be rather a phenomenon which can either be attributed to particular countries or to emission accounting practices.

Moreover, the calculation of the sectoral RSCA indices further indicate that natural resource endowments are very trade-determinant factors. Even though economic development literature or the Environmental Kuznets Curve (EKC) hypothesis would suggest that the influence of natural resources on trade specialization decreases with economic development, such a pattern cannot be confirmed by the country-specific results. Even in more recent decades, natural resources, such as wood or basic metals, seem to shape the trade pattern of the high-income countries substantially making them an important asset for the economies analyzed in the present study.

The findings of this thesis are relevant for policy makers as they provide further insights into the long-term development of high-income countries' trade structures and may enable them to establish more targeted and effective climate policies. While research on emissions embodied in trade can provide valuable information to guide climate mitigation efforts, it is also necessary to consider the historical development of trade specialization. Unlike suggested by previous research, high-income countries do not seem to systematically outsource emission-intensive activities but remain largely dependent on their own natural resource endowments, both for the domestic production as well as exports. The increasing deficit in the balance of emissions embodied in trade of advanced countries may, hence, have different reasons than the suggested changes in trade specialization patterns or carbon leakage.

However, further research on trade specialization in heavy and light industry needs to be conducted as this thesis only relies on monetary export and import values. Future larger studies using information on trade-embodied environmental factors for earlier periods would thereby be of interest. Moreover, using more disaggregated trade data would help to divide commodities more precisely into heavy and light industry and information on traded electricity would enable a more thorough investigation of trade specialization patterns. Overall, considerably more work will need to be done to determine and understand the long-term relationship between trade specialization, natural resource endowments and CO_2-emissions.

Appendix

Table A.1: New Commodity Groups based on SITC Revision 1 Classification

Sector	Commodities	Commodity codes
Food and Beverages	Live animals	00
	Meat and Meat preparations	01
	Dairy products and eggs	02
	Fish and fish preparations	03
	Cereals and cereal preparations	04
	Fruit and vegetables	05
	Sugar, sugar preparations and honey	06
	Coffee, tea, cocoa, spices & manufactures thereof	07
	Miscellaneous food preparations	09
	Beverages	11
Miscellaneous	Feeding stuff for animals excluding unmilled cereals	08
	Tobacco and Tobacco manufactures	12
	Hides, skins and fur skins, undressed	21
	Oil seeds, oil nuts and oil kernels	22
	Crude animal and vegetable materials, nes	29
	Animal oils and fats	41
	Fixed vegetable oils and fats	42
	Animal and vegetable oils and fats, processed	43
	Leather, lthr. Manufs., nes & dressed fur skins	61
	Sanitary, plumbing, heating and lighting fixt.	81
	Furniture	82
	Travel goods, handbags and similar articles	83
	Scientif & control instruments, photogr gds, clocks	86
	Miscellaneous manufactured articles, nes	89
	Postal packages not class. according to kind	91
	Special transact. not class. according to kind	93
	Animals, nes, incl. zoo animals, dogs and cats	94
	Firearms of war and ammunition therefor	95
	Coin, other than gold coin, not legal tender	96
Rubber and Products	Crude rubber including synthetic and reclaimed	23
	Rubber manufactures, nes	62
Wood and Manufactures	Wood, lumber and cork	24
	Wood and cork manufactures excluding furniture	63

Pulp and Paper	Pulp and Paper	25
	Paper, paperboard and manufactures thereof	64
Textile, Clothing, Footwear	Textile fibres, not manufactured, and waste	26
	Textile yarn, fabrics, made up articles, etc.	65
	Clothing	84
	Footwear	85
Non-metallic Minerals and Manufactures	Crude fertilizers and crude minerals, nes	27
	Non-metallic mineral manufactures, nes	66
Basic Metals and Manufactures	Metalliferous ores and metal scrap	28
	Non-ferrous metals	68
	Manufactures of metal, nes	69
Mineral Fuels and Lubricants	Coal, coke and briquettes	32
	Petroleum and petroleum products	33
	Gas, natural and manufactures	34
Chemicals and Chemical Products	Chemical elements and compounds	51
	Crude chemicals from coal, petroleum and gas	52
	Dyeing, tanning and colouring materials	53
	Medicinal and pharmaceutical products	54
	Perfume materials, toilet & cleansing preptions	55
	Fertilizers, manufactured	56
	Explosives and pyrotechnic products	57
	Plastic materials, etc.	58
	Chemical materials and products, nes	59
Iron and Steel	Iron and Steel	67
Machinery and Transport	Machinery other than electric	71
	Transport equipment	73
Electrical Machinery	Electrical machinery, apparatus and appliances	72

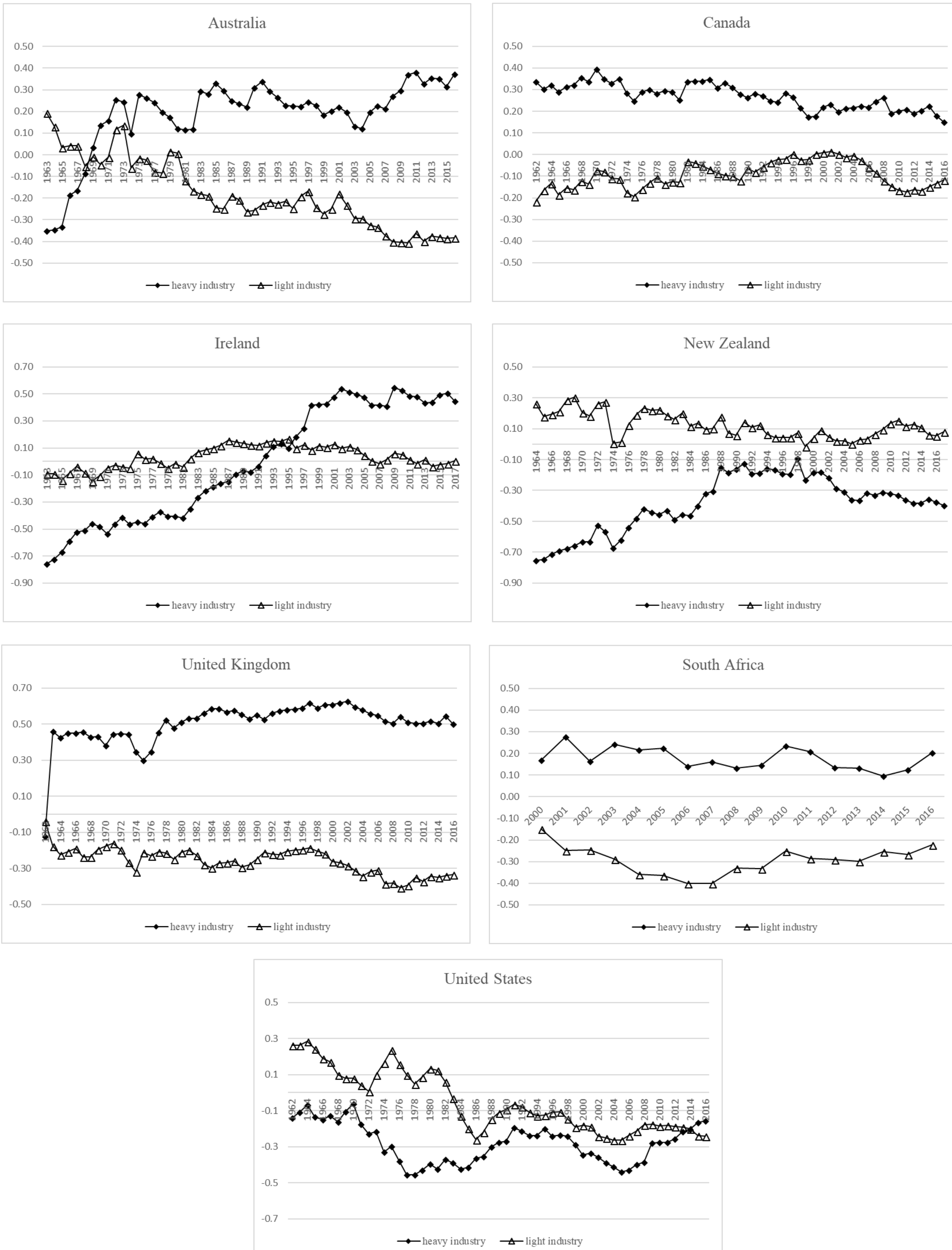
Source: Own construction based on SITC Revision 1 Classification System (United Nations, 2014)

Table A.2: Emission factors – embodied (direct + indirect) mean CO_2 emissions based on Ahmad and Wyckoff (2003)

Industry	**Kg CO_2 per USD (1995)**	**Kg CO_2 per USD PPP (1995)**
Agriculture, etc.	0.65	0.47
Mining, Extraction, Refining	1.57	-
Food, Beverages, Tobacco	0.64	0.45
Textiles, Leather, Footwear	0.60	0.43
Wood & Products of Wood & Cork	0.71	0.44
Pulp, Paper Printing & Publishing	0.77	0.50
Chemicals	1.57	0.98
Other Non-metallic Minerals	2.06	1.30
Iron and Steel	2.83	1.79
Non-ferrous Metals	1.66	1.06
Other Metal Products, Machinery Eqpt	0.89	0.50
Motor Vehicles, Trains, Ships, Planes	0.80	0.46
Other manufacturing & recycling	0.83	0.50
Electricity, Gas, Water	6.89	4.28

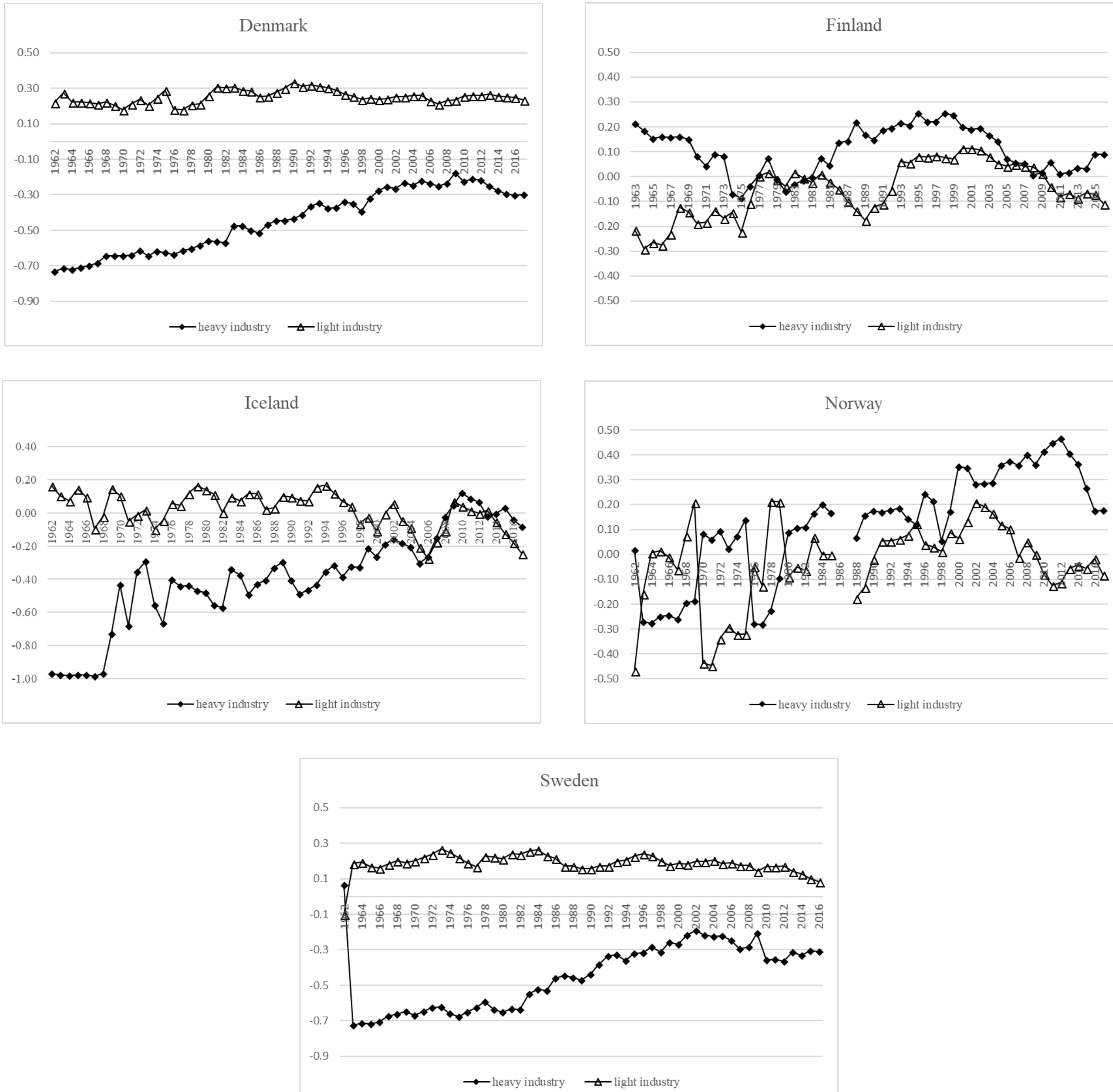
Source: Own construction and calculations based on Ahmad and Wyckoff (2003); Note: The emission averages are calculated based on Table 4 and Table B3 in Ahmad and Wyckoff (2003) and the 24 countries represented in the tables.

Figure A.1: The Normalized Trade Balance of the Anglophone countries (1962-2017)



Source: Constructions based on own calculations.

Figure A.2: The Normalized Trade Balance of the Nordic countries (1962-2017)



Source: Constructions based on own calculations.

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