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Austria, Germany and the Netherlands: A Race Against The Net Zero Clock

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Abstract

While the global climate crisis intensifies, countries keep seeking for more solutions to lower their carbon footprint. Several countries have already legislated a target year for reaching net zero emissions. This paper analyses net zero target years of three European countries, namely Austria, Germany and the Netherlands. These countries have different target years, and that is why in this paper, they were studied to compare their progress and policies. A linear regression was used on emissions and GDP data to investigate possible decoupling effects in the relationship between GDP and CO_2 emissions. Using these regressions, I found evidence on decoupling in all three countries. Furthermore, this paper focuses on countries' goal to reduce CO_2 emissions by at least 55% by 2030. Through forecasting models, it was predicted that countries will not suffice their goals for 2030 and are not likely to make their net zero target years. As much as these results in line with the most recent and relevant studies, the forecast predictions are questionable.

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1. Introduction

Carbon dioxide (CO2) is one of Earth's most occurring components. Known for being produced through respiration by animals, plants, and other organic matters, but also through human activities. After World War 2 the world saw a surge in economic growth through industrialization and urbanization. Due to the widespread use of fossil fuels, CO2 emissions rapidly increased. As can be seen in Figure 1, the post-industrial decades show a strong correlation between GDP and CO2 emissions (IEA, 2024). Nevertheless, CO2 is one of the most important reasons behind global warming and climate change, as an excess amount of CO2 causes a greenhouse effect in Earth's atmosphere.

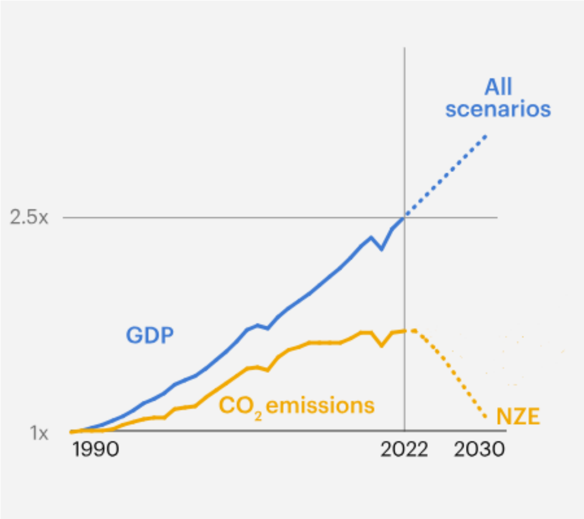

Figure 1 GDP and CO2 emissions worldwide 1990-2022. NZE shows Net zero emission (IEA, 2024)

During the last decades, global warming and climate change have become an increasingly widespread topic across countries. Countries want to decouple themselves from this positive relationship between GDP and CO2 emissions (IEA, 2024). They want to grow economically but at the same time decrease their carbon footprint (Chen et al, 2018). During the 21st Conference of the Parties (COP 21) in 2015 in Paris, 196 countries adopted a legally binding international treaty on climate change. In this treaty, the overarching goal concluded to keep the average temperature increase below 1.5 degrees Celsius until 2100. This is compared to the pre-industrial average temperature. To reach this goal, science suggested that net zero emissions by 2050 are highly necessary (WRI et al., 2023). More than a hundred countries decided to implement net zero emissions by 2050, as part of the commitments made under the Paris Agreement. In the following years, not just countries but also the European Union legislated the 2050 net zero target. Countries in the EU were now obliged to reach net zero by 2050. Nevertheless, various (European) countries had more ambitious plans and thus set a more optimistic target year. One of those countries is Austria, who is committed to reach net zero emissions by 2040. Germany also averted from the EU's goal and set its target for 2045.

So, these countries have a different target year for reaching net zero. But what makes it that Austria and Germany are so optimistic in reaching net zero sooner? The Netherlands is a country known for their sustainable efforts in several sectors. However, they did not change their target year and kept it on 2050. In recent studies, researchers are skeptical about the 2050 target year. Some view it from a mostly financial perspective where they conclude the goal is too ambitious for (developing) countries (Deutch, 2020). Others find that current government policies are insufficient and claim that countries could improve on how they approach their targets (Marteau et al., 2021; Rogelj et al., 2021).

By narrowing the scope of research to Austria, Germany, and the Netherlands, and studying their policies and economies, I formulate the following research question:

"To what extend are the target years of Austria, Germany and the Netherlands to reach net zero emissions achievable?"

To answer this question, I conduct an extensive analysis based on data obtained from official statistics. With these statistics I tend to predict the future carbon emissions of each country. However, it is difficult to predict emissions all the way up to 2040, 2045 and 2050. Forecasting more years into the future is challenging due to the extra uncertainty it brings and the higher chance of structural changes in the data. Despite that, by 2030, all three countries want to have their emissions reduced by at least 55% compared to their 1990 levels. Thus, instead of predicting all the way up to the net zero target year, predictions will go up to 2030, which will reveal whether countries are on track to reach net zero by their target year.

This paper has been structured as follows. In the following section the current literature will be reviewed, and I will present the key findings of previous relevant literature. In this section I will also compare each countries' policies and six hypotheses will be formed. Secondly, the Data and Methodology section will offer a better understanding of the data and empirical approach used in this paper. Subsequently, the results of the research will be shown and clarified. Lastly, a conclusion will be drawn, whereafter implications, importance and shortcomings of the paper will be discussed.

2. Theoretical Framework

2.1 Background

In 1958, Charles David Keeling started measuring the concentration of carbon dioxide in Earth's atmosphere on the island of Hawaii. It became clear fast that the concentration was rapidly increasing. From this time forth, the Keeling Curve (Figure 2) became visualizing confirmation of the alarming increase in carbon dioxide in Earth's atmosphere. The curve brought attention to the rising problem and in the following decades various climate change establishments were formed.

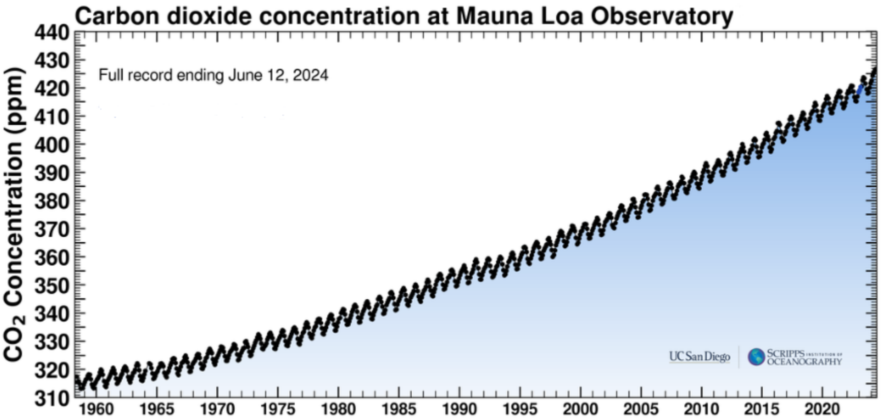

Figure 2 The Keeling Curve. Yearly carbon dioxide concentration in ppm observed at Mauna Loa Observatory, Hawaii (UC San Diego, 2024).

Despite the growing awareness and discussions on reducing CO2 emissions in the 80s and 90s, emissions continued to rise. Economic expansion, industrialization in developing countries and dependence on fossil fuels had a large share in why emissions kept growing. As seen in Figure 1, the economic expansion and the increase in GDP that came with it, strongly correlated with CO2 emissions. This relationship was studied in Greece during and around the economic recession of 2008. During the recession, CO2 emissions, energy consumption and economic growth decreased all together and proved the coupling relationship CO2 and GDP tended to have (Roinioti & Koroneos, 2017). For some the relationship was so clear, that future GDP growth was predicted by examining the CO2 emissions of a country (Marjanović et al., 2016).

As countries now want to decouple themselves from this relationship and reach net zero emissions, it is the question whether countries can find a solution to reduce their emissions without having to sacrifice economic growth. Energy is a key factor in production and hence of economic growth (Ayres, 2016). As CO_2 is emitted during production, a higher production not only boosts the GDP, but increases emissions as well (Haberl, 2020). Several studies have discussed the possibilities of decoupling.

Chen et al. (2018) showed through a decoupling analysis of CO_2 emissions in OECD countries, that decoupling is in fact possible. It was argued that energy consumption is one of the main factors causing high emissions. To counter this, Chen et al. (2018) suggested to implement more renewable sustainable energy sources, rather than fossil fuels. Wu et al. (2018) used an OECD model to visualize decoupling and to show how these countries were performing over the years. Germany, France, and the UK showed the strongest decoupling results over the most recent period of 2006 to 2015.

These studies show that reducing emissions while having economic growth is possible. Austria, Germany, and the Netherlands have rather large industry sectors. It intrigued me to explore their relationship between emissions and GDP and whether they show signs of decoupling. Therefore, the first three hypotheses of this study are as followed:

H1a: Austria's positive relationship between CO_2 emissions and GDP growth decoupled between 1990 and 2022.

H1b: Germany's positive relationship between CO_2 emissions and GDP growth decoupled between 1990 and 2022.

H1c: The Netherlands' positive relationship between CO_2 emissions and GDP growth decoupled between 1990 and 2022.

2.2 Net zero

Decoupling is in a way just the first step for countries to be able to reach net zero. Before I discuss the relevant literature, we first need to clarify what net zero means. Net zero refers to the state where the carbon emissions produced and emitted are balanced by the gasses removed from the atmosphere (Fankhauser et al., 2022). It is different from emitting (close to) zero carbon emissions. This will be the next big goal on the agenda; however, it will not be discussed in this paper.

John Deutch critically examined the targets by the U.S. and the world to achieve net zero by 2050 (Deutch, 2020). Deutch argues that developing countries are unlikely to reach net zero by 2050 as they do not have the (financial) resources for it. When it comes to the U.S. and other wealthy countries, net zero 2050 is theoretically possible, but the costs are tremendously high. It is questioned whether 2050 is financially workable. He concludes that these 30 years to reach net zero by 2050 will most likely not be enough. In this paper, Deutch also advocates for a global net zero program, rather than every individual country trying to reach net zero by themselves.

In addition, Seto et al. (2021) do not only focus on countries but mainly on cities within. They argue that a one-size-fits all strategy is not the solution to reach net zero, as cities vary by climate, city type and their development. Seto et al. (2021) believe cities can reach net zero or get near net zero, however a systemic transformation is necessary. Individual strategies and policies are essential.

A recent study by Rogelj et al. (2021) suggests that nations and firms should improve three aspects of their targets to help reach their climate goals. By clarifying their scope, having adequacy and fairness, and making a road map, countries have a better start on their journey to reach net zero. If countries keep their vague claims and promises, they will miss their net zero target (Rogelj et al., 2021). Marteau et al. (2021) also argues that current government policies are insufficient for the rapid decrease in emissions that is needed to reach net zero by 2050. They analyzed the current vision and road map of countries and how governments, firms and citizens should all work together in a balanced way to reduce emissions. Marteau et al. (2021) argued that governments should improve on the availability of sustainable options when it comes to food and transportation.

2.3 Policies

2.3.1 European Union

To be able to reduce emissions and reach climate goals, policies play a vital role. Both on national and intercontinental level. Countries in the European Union not only have their own laws and policies they must follow, but also from the European Parliament. For instance, the goal of net zero emissions is enshrined in the EU’s climate law and should be followed by all countries. Just like the goal of reducing 55% of emissions compared to the 1990 emission levels of a country. Setting more ambitious targets is of course allowed and encouraged by the European Parliament. Some key solutions and policies from the European Parliament are shown below:

Use of renewable energy sources

- As energy supply creates the largest share of CO_2 emissions, the EU tries to encourage the use of renewable energy, and to encourage efficient use of energy below (EU Monitor, 2023).
- If the total population of the EU is growing, but the efficiency improves by a higher rate, reducing emissions through efficiency is still workable (EU Monitor, 2023).

Carbon market

- With the Emissions Trading System (ETS), firms buy permits to emit CO_2. This way, firms are encouraged to pollute less as they will also have to pay less (European Union, 2023).
- Currently, sectors as construction, agriculture and waste management are not yet included in the ETS. The EU keeps revising the ETS, so all polluting sectors will eventually be included in the system (European Union, 2023).

Road/aviation transport and import

- The EU is targeting zero CO_2 emissions from new cars and vans from 2035 and forth.
- In 2022, the European Parliament voted for an ETS for aviation within the European Economic Area (EEA). In 2023, the proposal was revised where the free emission permits are gradually phased by 2026 below (EU Monitor, 2023).
- To discourage import from countries with lower climate ambitions, the Parliament adopted rules on imposing a carbon price on imports from carbon-intensive countries below (EU Monitor, 2023).

2.3.2 Austria

In its current legislative program, Austria has the ambitious target of reaching net zero emissions by 2040. By 2030 they want its emissions reduced by 55% compared to the 1990 level. There are several components on Austria's strategy to reach its climate goals (Federal Ministry for Sustainability and Tourism, 2019):

Decarbonization of the industry and transport sectors

- In the industry sector, coal and other harmful fossil fuels will be replaced by more sustainable sources.

- Second, industrial processes will be electrified and powered by green gas and renewable hydrogen. Austria has a large iron and steel industry, and renewable hydrogen will play a particularly significant role here.
- To reduce emissions in the transport sector, Austria promotes driving electric vehicles through subsidies and promotes public transport and cycling.

Use of renewable energy sources

- By 2030, Austria wants 100% of its electricity to be produced by renewable energy sources. Currently, Austria is one of the global leaders with more than 75% of its electricity being produced by renewable energy sources (IEA, 2020).
- In 2021, Austria legislated the Renewable Energy Expansion Act (EAG). It was implemented to help the country achieve its ambitious goals for 2030. One part of the EAG is the extra financial support and subsidies, and promotion for firms and communities to start using renewable energy and to become more sustainable goals (Federal Ministry for Sustainability and Tourism, 2019).

2.3.3 Germany

Germany has the largest economy in Europe and is Europe's leading country when it comes to manufacturing. The manufacturing sector is known for its high temperature and fossil fuel-driven processes, which produce enormous amounts of CO2 emissions. However, rather than keeping the net zero target year in 2050, Germany decided to aim for 2045. The German Federal Government tightened the climate regulations in their laws and legislated net zero emissions by 2045. Where the initial aim was to reduce emissions by 55% compared to 1990 levels by 2030, this was changed to an optimistic 65% (Bundesregierung, 2021) This translates to an extra reduction of one hundred megatons of carbon dioxide. Some key components of Germany's goal to reach its climate goals are:

Use of renewable energy sources

- In Germany's Renewable Energy Sources Act (EEG) the Federal Government aims for 80% of its electricity to be produced by renewable energy sources by 2030. (In 2019 this was only 43% and grew to over 50% by 2023 (Umweltbundesamt, 2024).
- Wind power is Germany's most important renewable energy source and wind capacity will be developed further (Umweltbundesamt, 2024).

Coal phase out

- Germany is still very reliant on coal as an energy source. The past years, coal usage generated over 15% of Germany's electricity output (Agora Energiewende, 2020). As it is well-known how harmful for the climate burning coal is, it is no surprise Germany wants to step away from using coal.
- In July 2020, Germany adopted its coal exit into its laws. All coal-fired plants must be shut down by 2038 the latest (Agora Energiewende, 2021).

2.3.4 The Netherlands

In contrast to Austria and Germany, the Netherlands did not change their net zero target year and decided to keep it in 2050. Just like Austria, they aim to reduce its emissions by 55% by 2030, compared to the 1990 levels. The Dutch Ministry of Business and Environment releases yearly climate notes where they discuss their current progress and policies and reveal new policies (Rijksoverheid, 2023). Some of the key components in the 2023 climate notes are in the following sectors:

Electricity Sector

- By 2030, between 75-90% of the electricity must be produced through wind and solar energy sources. Offshore wind sources at sea will be the largest renewable energy source (Rijksoverheid, 2023).
- The Dutch government strives to have a carbon-free electricity sector by 2035 (Rijksoverheid, 2023).

Industry sector

- By subsidizing firms, the Netherlands tries to encourage firms to be and become more sustainable. The government introduced SDE+ for the first time in 2011. This subsidy system gives subsidies for renewable energy, but also for reducing emissions (Next Kraftwerke, 2018). The system improved over the years and evolved now into the SDE++.
- Around thirty firms cause around 60% of the Dutch industrial CO_2 emissions. By speaking to these firms individually, the government tries to encourage the firms to make ambitious and workable plans for becoming more sustainable (Rijksoverheid, 2023).

Studies show different views on countries and their goal of reaching net zero by at least 2050. As every country is different from one another, it can be seen how their policies and goals are dissimilar from each other. Studies mainly assess that policies are often not good enough yet to reach net zero. As it is intriguing to test whether countries are on track of reaching net zero by their own target year, this will not be done in this study. Target years are 15 to 25 years ahead in the future and predicting that far will make the results less significant. As countries all have a target in 2030 for a minimal reduction in CO_2 emissions compared to their 1990 emissions, the following hypotheses are formed:

H2a: By 2030, Austria will reach its desired 55% reduction in CO_2 emissions compared to the 1990 emissions.

H2b: By 2030, Germany will reach its desired 65% reduction in CO_2 emissions compared to the 1990 emissions.

H2c: By 2030, the Netherlands will reach their desired 55% reduction in CO_2 emissions compared to the 1990 emissions.

By testing these hypotheses, we will get a clearer view whether countries are on track to reach net zero emissions on time.

3. Data

For testing the first hypotheses whether the relationship between CO_2 emissions and GDP is loosening for Austria, Germany and the Netherlands, a data sample is taken from the period of 1990 to 2022. The sample starts from 1990 as there were no data on emissions before 1990. The sample does not include 2023 as the emissions per country have not been published yet. The dependent variable is the CO_2 emissions in kilotons and is offered by the European Environment Agency (EEA). The independent variable is GDP in billion euros and this data is offered by Statista.

Austria is chosen to study as the country changed its net zero target year to 2040, 10 years sooner than the initial target in the Paris Agreement. Researching its optimistic goal might give us more intel on how countries should approach net zero. Germany is chosen as it has the largest economy out of all European countries and an ambitious target year of 2045. The Netherlands is chosen as they are known for their ambitious climate policies and innovative renewable energy initiatives. However, they kept their net zero target year in 2050.

For the data on CO2 emissions, the EEA provides emissions per sector. This gives us a better understanding of which sectors emit the most carbon in a country. In Table 1 the sectors are displayed.

Table 1 Largest emitting sectors in Austria, Germany, and the Netherlands.

Sectors
Energy supply
Domestic transport
Industry
Residential and Commercial
International Shipping (only in the Netherlands)
Others

In Figures 3, 4 and 5 the sectoral shares per country are shown. To examine whether these proportions change over the years, three different years are examined. The first and the last year of the data sample, and a third year that is roughly in the middle of 1990 and 2022.

In the Netherlands there are five sectors emitting roughly 90% of the total emissions per year (Figure 3). 2008 has been chosen as it is the year with the highest recorded emissions and quite centered in the dataset. It can be noticed that the Energy Supply sector is the biggest CO2 emitter in the Netherlands, handling over 25% of the total emissions per year.

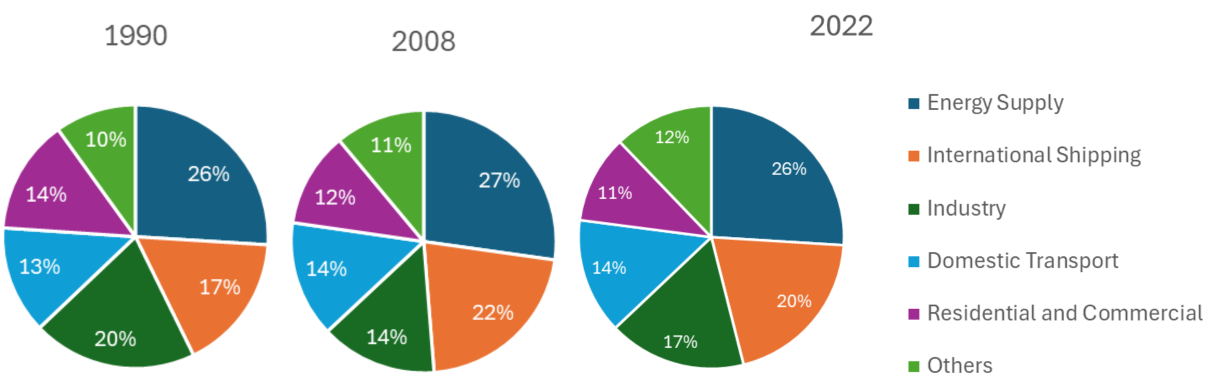

Figure 3 Percentual share per sector of annual emissions in the Netherlands for the years 1990, 2008 and 2022.

From Figure 4 we learn that the division between sectors in Austria is quite different. Approximately 95% of yearly emissions come from four sectors. International shipping not being one of them can be explained by the fact that Austria is not next to a sea, and they barely have any maritime transport. Industry and Domestic Transport are the main sectors, and their share seems to be increasing whereas the Energy Supply and Residential and Commercial sectors are relatively decreasing.

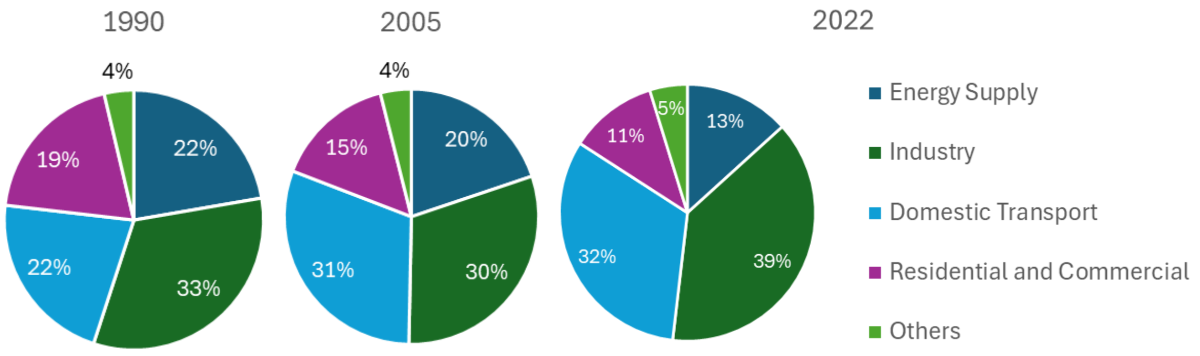

Figure 4 Percentual share per sector of annual emissions in Austria for the years 1990, 2005 and 2022.

For Germany around 95% of the emissions come from the four same sectors as in Austria (Figure X). However, the share each sector has, is rather different. Germany's emissions are dominated by Energy Supply. This is likely because of the intensive coal use of Germany to produce electricity (Next Kraftwerke, 2018). However, it can be noticed that the share of Energy Supply has decreased. The earlier mentioned coal phase-out will help bring down this share even more.

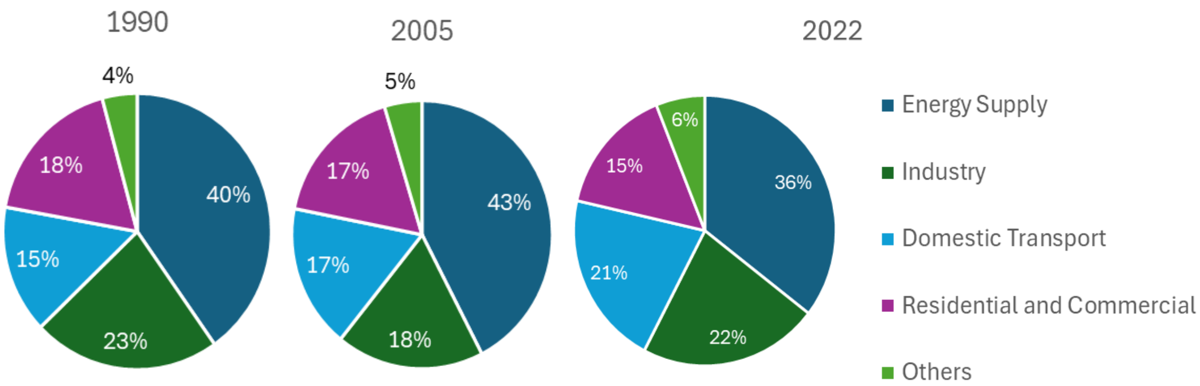

Figure 5 Percentual share per sector of annual emissions in Germany for the years 1990, 2005 and 2022.

In the second part of the analysis, forecast models will be used. In all forecasts the input variable is the CO2 emissions. The same data sample from 1990 to 2022 will be used. The years that will be used to forecast differs per country and is dependent on any structural breaks in the data. In the next section, the importance of these structural breaks will be discussed, and it will be explained how the forecast will work.

4. Methodology

To test whether Austria, Germany and the Netherlands show decoupling effects between 1990 and 2022, a linear regression analysis will be performed. This will show whether and how significant the CO2 emissions are decreasing when the GDP is increasing. As I am not trying to find a causal relationship between CO2 emissions and GDP, no control variables will be added to the model. The regression will thus look as follows:

$$CO2i = \beta_0 + \beta_1 GDP_i + \varepsilon_i$$

The period used for the regression will differ per country as not all countries have similar emission trends. Policy changes, external shocks and other factors can cause a significant change in the trend of a time series. These so-called structural breaks can be detected by using a structural break test (Bauwens, 2015). Although plotting the data can help find any changes, this will not tell whether the break is significant. In this paper I used the Supremum Wald test to find any significant breaks.

To test whether countries will succeed in reaching their climate goals by 2030, several forecasts will be used on the data. The goal is to forecast the emissions per country up to 2030. Both Austria and the Netherlands need to have their emissions reduced by 55%, compared to their 1990 emissions. Germany needs to have its emissions reduced by 65%. In the first model I will forecast the emissions 8 years ahead only based on data on emissions from 1990 to 2022. This is done as a baseline for the forecasting in the second model. In the second model I will forecast variables that could have an influence on the emissions per year. In this model, I will forecast every extra input variable individually first. By forecasting these variables, I can use them as data to predict the CO2 emissions again up to 2030. By using more input variables, I try to make the forecast model more dependable.

The period that will be used in the forecasting will also depend on the results of the structural break test. Breaks are important for forecasting as they can help filter out errors and make the predictions more dependable (Bauwens, 2015).

Mushtaq (2011) emphasizes that it is important that the most suitable form of data is chosen for a time series. In a forecast model it is important for the underlying assumptions that the time series is stationary and thus does not have a unit root (Mushtaq, 2011). By performing an Augmented Dickey-Fuller test, it is tested whether a unit root is present. With a low enough p-value, the null hypothesis that a unit root is present can be rejected. Testing all variables as absolute numbers revealed that the time series of all variables were not stationary. For all three countries the time series of all variables are only stationary when the data is converted into a growth rate compared to the previous year. Having finished the forecast, the predicted CO_2 growth rates will be transformed back to CO_2 emissions in kilotons.

5. Results

After implementing the earlier mentioned analysis methods, statistical results were conducted and will be discussed in this section. The first hypotheses that will be answered is whether the individual countries are succeeding in decoupling from the relationship between CO_2 emissions and GDP.

5.1 Regression Results

Let us first consider Austria who has aimed to reach net zero emissions in 2040. From Figure 6 it can be noticed how GDP and emissions are both increasing in the first 15 years. Emissions reached a peak in 2005 with over 81,000 kilotons being emitted into the atmosphere. After 2005, the relationship between emissions and GDP seems to change. Emissions slowly start to decrease, while the Austrian GDP keeps on increasing in a more fluctuating line. The Wald test confirms the significant structural break in 2005. Regression results from 2005 to 2022 show that for every billion euros the Austrian GDP increases, the CO_2 emissions decrease by over 91 kilotons (Table 2). The earlier mentioned ETS got implemented in 2005. This could explain why Austria finally started to see decoupling results, as firms now had to pay more if they wanted to emit more CO_2.

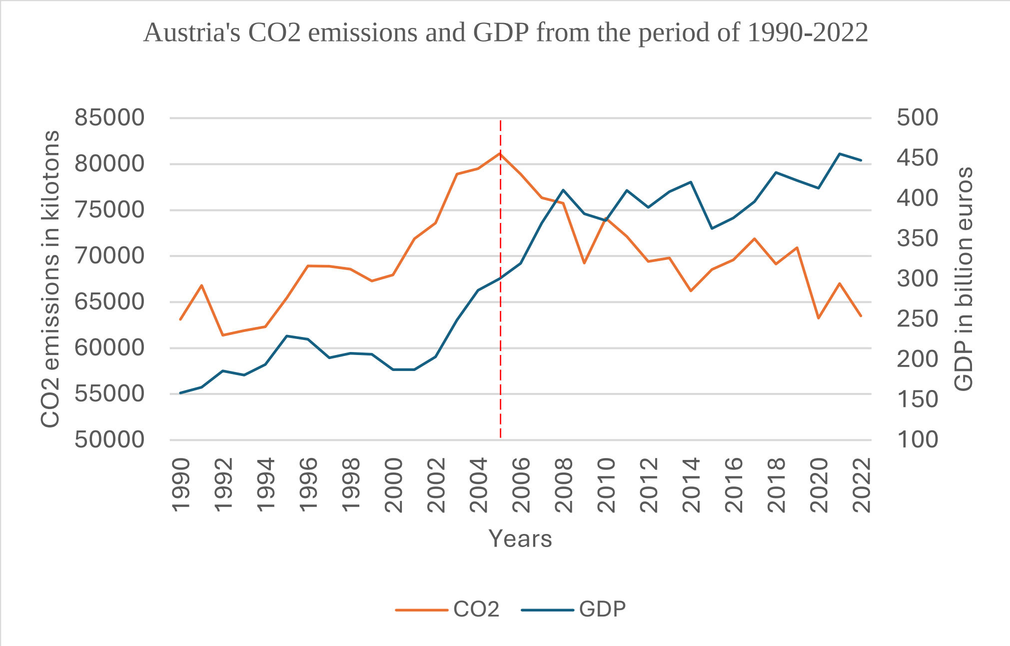

Figure 6 Austria's CO2 emissions and GDP from the period of 1990 to 2022.

Notes: According to the Wald test, a significant structural break took place in 2005. The test statistic was 250.728 with a p-value of 0.000, making it statistically significant at a 1% level.

Table 2 Regression Results for kilotons CO2 in Austria from the period of 2005 to 2022.

Variable	**Kilotons CO2**
GDP in billion euros	-91.268*** (19.750)
Constant	106,883*** (7,817)
Observations	18

Notes: Standard errors are reported in parentheses.

{, **, *** indicates significance at the 90%, 95% and 99% level, respectively.}*

Where the decoupling in Austria starts after 2005, Germany's relationship between emissions and GDP has been loosening since the start of the observable data (Figure 7). Regression results show significant results for decoupling in Germany since 1990. From 1990 to 2022, for every billion euros the GDP increases, the CO2 decreases by over 110 kilotons (Table 3). Even though there are significant decoupling results since 1990, a Wald test showed how there was a significant break in 2016. From the structural break in 2016 to 2022, for every billion euros the GDP increases, the CO2 decreases by 187 kilotons. However, this statistic is only significant at a 90% level. Where Austria had a structural break after the start of the ETS, Germany's trend remains overall unchanged.

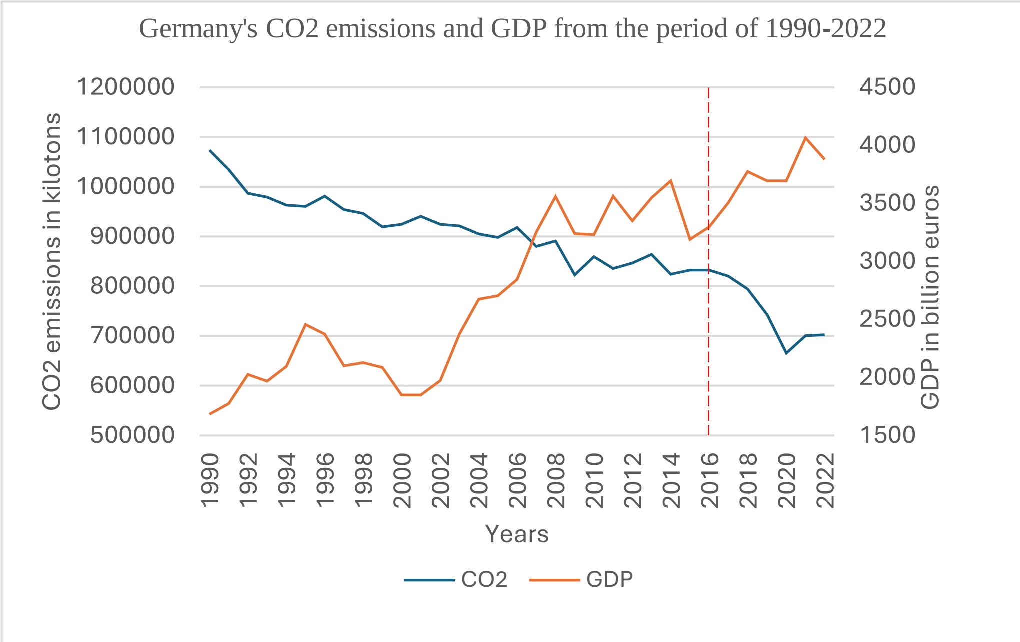

Figure 7 Germany's CO2 emissions and GDP from the period of 1990 to 2022.

Notes: According to the Wald test, a significant structural break took place in 2016. The test statistic was 23.333 with a p-value of 0.000, making it statistically significant at a 1% level.

Table 3 Regression Results for kilotons CO2 in Germany from the period of 1990 to 2022 and 2016 to 2022.

Variable	**Kilotons CO2**	
	1990-2022	2016-2022
GDP in billion euros	-110.161***	-187.242*
	(10.635)	(82.449)
Constant	1,195,366***	1,444,433***
	(31,146)	(305,761)
Observations	33	7

Notes: Standard errors are reported in parentheses.

{, **, *** indicates significance at the 90%, 95% and 99% level, respectively.}*

Finally, let us examine the CO2 emissions and the GDP of the Netherlands from 1990 to 2022 (Figure 8). At first glance we can see that GDP and CO2 are both increasing over the first 18 years. In 2008 emissions reach a peak. Apart from 2010, 2008 seems to be the turning point where the upward sloping trend transitions into a downward sloping trend. Emissions start to decrease year by year, while GDP continues to increase. The results from the Wald test confirm that a significant structural break took place in 2008. Where the introduction of the Emissions Trading System did seem to influence emissions in Austria, it does not seem to be the case for the Netherlands, as the trend reaches its turning point a few years later.

In 2011, the Dutch government introduced the Stimulering Duurzame Energieproductie (SDE+). This system based on subsidies was founded to stimulate the sustainable production of energy (Next Kraftwerke, 2018). If we examine the results from the linear regression taken from 2010 to 2022, we see significant results in decoupling. For every billion euros the GDP increases, the emissions decrease by roughly 190 tons (Table 4). The SDE+ seemed to have played a role in the start of the decoupling between emissions and GDP in the Netherlands.

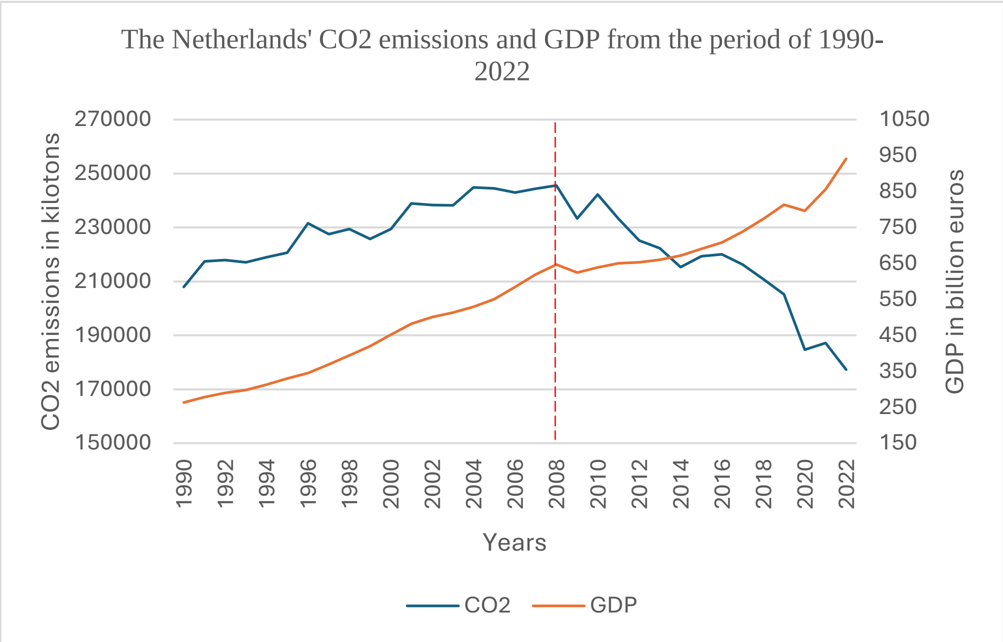

Figure 8 The Netherlands' CO2 emissions and GDP from the period of 1990 to 2022.

Notes: According to the Wald test, a significant structural break took place in 2008. The test statistic was 284.239 with a p-value of 0.000, making it statistically significant at a 1% level.

Table 4 Regression Results for kilotons CO2 in the Netherlands from the period 2008 to 2022.

Variable	Kilotons CO2
GDP in billion euros	-199.741*** (23.773)
Constant	360,527*** (17,351)
Observations	13

Notes: Standard errors are reported in parentheses.

{, **, *** indicates significance at the 90%, 95% and 99% level, respectively.}*

5.2 Forecast Results

Figure 9 shows the results for the forecasted emissions in Austria from 2023 to 2030. The earlier mentioned structural break took place in 2005 and thus the period of 2005 to 2022 was used to forecast the next 8 years. The model predicts that emissions will keep decreasing over the next 8 years, ending at roughly 58,000 kilotons in 2030. Austria's desired 55% decrease compared to 1990 levels comes out to a max of 38,000 kilotons in 2030. Comparing these numbers to the forecasted emissions indicates that Austria is not likely to reach their goal in 2030. It must be mentioned that the constant of the regression used to forecast was only significant at a 10% level. If we look at the 90% confidence interval of the forecast, the Lower Confidence Band is showing a more desired trendline for future emissions in Austria. By 2030, this trendline reached a little over 47,000 kilotons. Although these results do also not meet the 55% target, the Lower Confidence Band is approaching to the 2030 goal much closer.

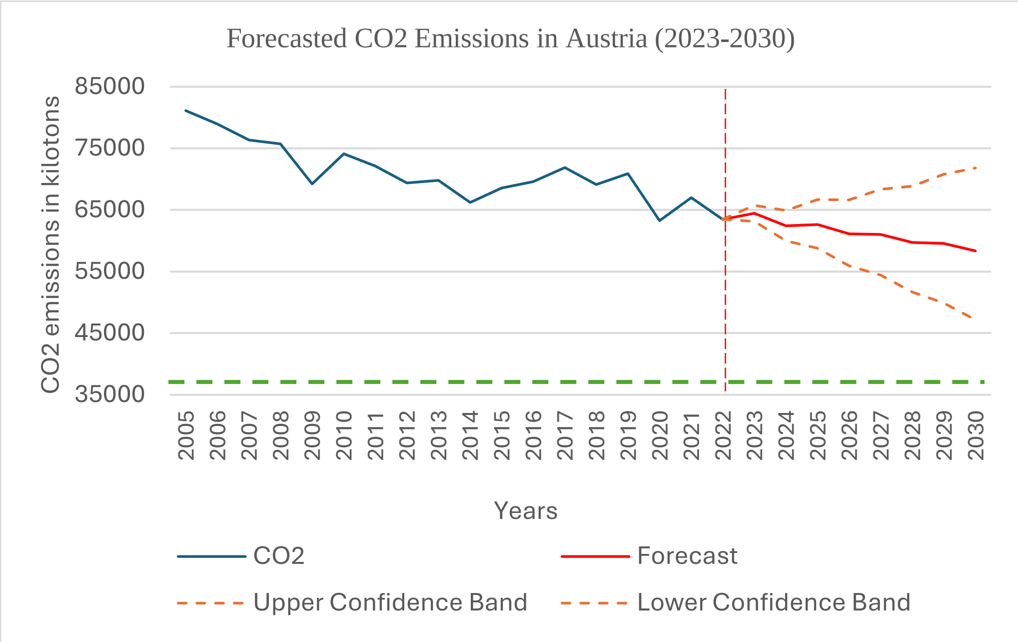

Figure 9 Forecast of CO2 emissions in Austria from 2023-2030.

Notes: A linear regression from the period 2005 to 2022 with 1 lag was used to forecast future emissions. The p-value for the lag was 0.009 and 0.080 for the constant. This makes the results statistically significant at a 1% and 10% level, respectively. The Lower and Upper confidence bands were calculated with a 90% confidence interval. The red dashed line indicates the start of the forecast. The green dashed line indicates the desired emission level in 2030 in Austria.

Figure 10 shows the results for the forecasted emissions in Germany from 2023 to 2030. Germany showed decoupling results since 1990. Although a structural break took place in 2016, the period of 2016 to 2022 was too short for the data to be stationary. That is why the complete time series from 1990 to 2022 was used to forecast the next 8 years. Where Austria had a more downward sloping forecast trend, Germany seems to have a wavier trend. By 2030, the 678,000 forecasted kilotons of CO2 are not much lower than the 2022 levels. According to the forecast, Germany will not reach their 65% reduction goal, compared to 1990 emission levels. If we look at the 90% confidence interval of the forecast, the total interval becomes quite large. The Upper Confidence Band reaches high emission levels in 2030. However, the Lower Confidence Band gets remarkably close to the desired emission level in 2030.

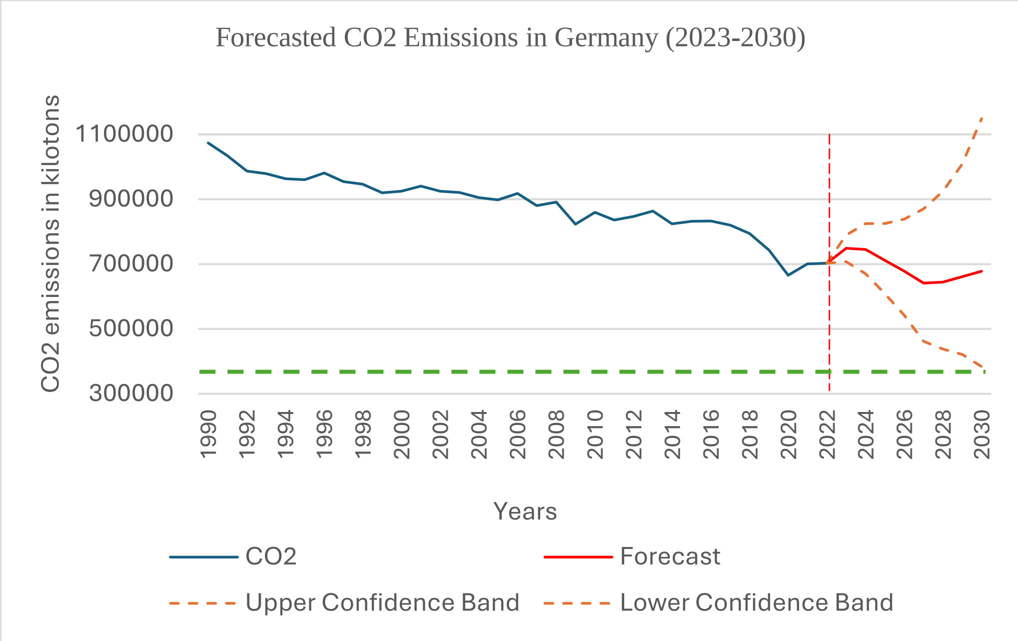

Figure 10 Forecast of CO2 emissions in Germany from 2023-2030.

Notes: A linear regression from the period 1990 to 2022 with 4 lags was used to forecast future emissions. The p-value for the fourth lag was 0.010 and 0.044 for the constant. This makes the results statistically significant at a 5% level. All other lags were not statistically significant. The Lower and Upper bound results were calculated with a 90% confidence interval. The red dashed line indicates the start of the forecast. The green dashed line indicates the desired emission level in 2030 in Germany.

The results of the forecasted emissions in the Netherlands are shown in Figure 11. In the Netherlands, a structural break took place in 2008 and thus the period of 2008 to 2022 was used to forecast the next 8 years. The trend of the forecast is quite like the forecast of Austria. The model predicts that emissions will keep decreasing over the next 8 years, ending at 150,000 kilotons in 2030. The Dutch desired 55% decrease compared to 1990 levels comes out to a max of 94,000 kilotons in 2030. Comparing these numbers to the forecasted emissions indicates that the Netherlands is not likely to reach their goal in 2030. It must be mentioned that the constant and the most significant lag of the regression used to forecast were only significant at a 10% level. If we look at the 90% confidence interval of the forecast, the size of the confidence interval is relatively smaller than those of Austria and Germany. The Upper Confidence Band forecasts steady emission levels. The Lower Confidence Band is showing a more desired trendline for future emissions in the Netherlands. In 2030, this trendline reaches a little over 125,000 kilotons. This number is getting closer to the desired emission level.

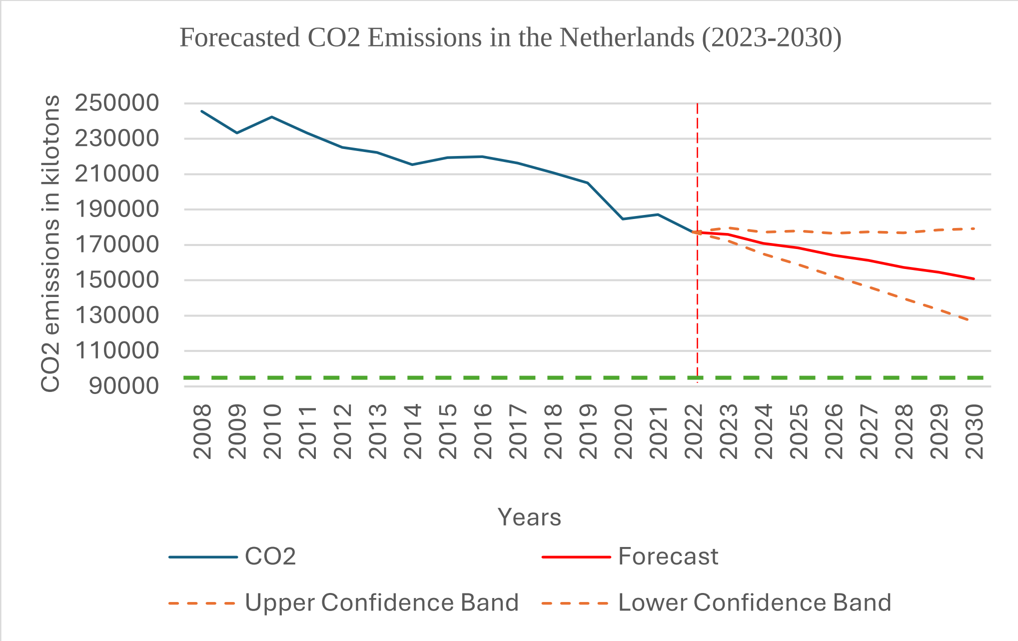

Figure 11 Forecast of CO2 emissions in the Netherlands from 2023-2030.

Notes: A linear regression from the period 2008 to 2022 with 5 lags was used to forecast future emissions. The p-value for the fourth lag was 0.091 and 0.069 for the constant. This makes the results statistically significant at a 10% level. All other lags were not statistically significant. The Lower and Upper bound results were calculated with a 90% confidence interval. The red dashed line indicates the start of the forecast. The green dashed line indicates the desired emission level in 2030 in the Netherlands.

6. Discussion

The findings that were obtained from the analyses give us a better understanding of how countries were performing on reducing CO2 emissions the last decades, and whether countries are on the right track to reach their 2030 emission goals. The results on decoupling indicate that all countries have shown significant signs of decoupling. Germany already has shown clear signs since at least 1990. This is in line with the research of Wu et. al (2018). Austria and the Netherlands have shown signs of decoupling since 2005 and 2008, respectively. The implementation of the ETS probably played a role in Austria's decreasing emissions. In the Netherlands, the implementation of the SDE+ presumably had an influence on the decreasing emissions. With these results we can confirm hypotheses 1a, 1b and 1c.

The forecast analyses suggest that all three countries are not likely to reach their desired emission levels in 2030. Most forecast results were only statistically significant at a 10% level, decreasing the dependability of the forecasts. Forecasts of Austria and the Netherlands predicted how emissions will decrease but will not get close to the desired levels. For Germany, a wavier trend was predicted that will reach emissions in 2030 which are not much less than the 2022 emissions. However, Germany was the only country where the Lower

Confidence Bound reaches emissions in 2030 that are remarkably close to the desired levels. With these results we cannot confirm hypotheses 2a, 2b and 2c.

Austria, Germany, and the Netherlands all saw 2030 as a measuring point for their progress on reaching net zero. Reaching their emission reduction goals in 2030 would show that they are on the right track to reach net zero by the end of their target years. The research question stated, *"To what extend are the target years of Austria, Germany and the Netherlands to reach net zero emissions achievable?"* With the current results I do not see any of the three countries reaching net zero in their target years. Austria only has 10 years left after 2030 to reach net zero and with their current decoupling results and forecasted decrease in emissions, net zero is still far away. With the ambitious net zero target year, I expected to see stronger decoupling results and a steeper decrease in forecasted emissions. Germany's forecast results were unexpected as the trendline does not show a large decrease in emissions the coming years. The results made me question the reliability of the forecast, as Germany had shown signs of significant decoupling from 1990 to 2022. Although the Netherlands does not seem to reach their 2030 goal, they still have twenty years after 2030 to reach net zero. Overall, there are some limitations to these results, and I will discuss them in the next chapter.

If countries do really want to reach their goals and targets, a visible change in the decrease of emissions is needed. Countries' policies and targets are all vastly ambitious and make you feel like they have it all under control. Despite that, they do not seem to be on course to reach their goals with the current policies. I think the policies are a bit too much bark and too less bite right now. I agree with the recent and relevant literature on how countries are handling their net zero targets and how they could improve. Countries can and should improve on clarifying their scope and improve the collaboration between the government, firms and citizens for decreasing emissions (Marteau et al., 2021; Rogelj et al., 2021). I agree that placing more individual focus on cities, considering their unique characteristics and differences, is a valuable improvement (Seto et al., 2021).

7. Conclusion

7.1 Summary

This research was conducted to compare three different countries with three different net zero target years. Austria legislated 2040, Germany 2045 and the Netherlands 2050. The research question was *"To what extend are the target years of Austria, Germany and the Netherlands* *to reach net zero emissions achievable?"* First, a regression analysis was done to determine whether countries show any significant signs of decoupling. By using a Wald structural break test, structural breaks were found and used to improve regressions. Every country showed significant signs of decoupling. Germany since 1990, Austria since 2005 and the Netherlands since 2008. Secondly, forecasts were conducted to predict future emissions up to 2030. All three countries have set an emission reduction goal in 2030. By using a forecast on the same years that were used in the regressions it was found that all three countries are not likely to reach their goals in 2030. The reliability of the forecast can be questioned, and this is discussed in the next section. However, considering the decoupling of all countries and carefully considering the forecasts, it is concluded that reaching net zero by the mentioned target years is probably not achievable. They lag in the race against the net zero clock. Countries still have plenty of things they can improve on. If countries turn things around and improve on decreasing emissions, they might be able to improve their race pace and prove recent studies wrong.

7.2 Limitations

It is necessary to mention the research limitations. As much as this research is in line with most studies about countries reaching their emission reduction targets and net zero target years, the forecast results are questionable. Firstly, forecasting with just the recent CO2 growth rates to predict the future growth rates, is too simplistic to get very reliable results. It was tried to forecast with more input variables such as GDP and the Energy Supply sector. However, the regressions for the forecasts were rather insignificant and thus was chosen to only predict emissions based on the earlier CO2 emission growth rates. Secondly, the regressions used to forecasts were only significant at a 10% level for some countries. This meant that these already skeptical forecasts were only partially significant. Another research limitation is that forecasting is in general hard to do as many factors can create sudden shocks in the data that could influence the emissions.

Furthermore, there were also some data limitations. Only three countries were examined so not much can be said about countries in general. Several emission sectors were discussed but could have been studied more extensively to get a better understanding of how every sector behaves and what policies influence certain sectors.

7.3 Future research

To provide more statistically reliable information, more research is necessary. The implications mentioned above should be taken into consideration for future research. If regressions can stay statistically significant while adding more input variables to the model, forecasts can become more reliable. Additionally, future research could dive deeper into other countries and their policies. Current and previous policies could be studied to determine what policies are most effective and what policies could be implemented to other countries as well. As mentioned above in the limitations, extensively researching countries' emission sectors was not done. Studying the sectors could provide useful information on how to decrease emissions faster. As mentioned before by Marteau et al. (2021), it is important that the government, firms and citizens together get involved in the matter of reducing emissions. Diving into the socio-economic aspect of emission reduction could help increase the acceptance and support by both firms and citizens. Exploring this side of emission reduction could even create an industry with new jobs.

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