A Work Project, presented as part of the requirements for the Award of a Master's degree in Finance from the Nova School of Business and Economics.

THE COMMITMENT TO SUSTAINABLE INVESTMENT IN THE PUBLIC TRANSPORTATION SECTOR AS AN OPPORTUNITY FOR EUROPEAN CITIES TO REACH CARBON NEUTRALITY.

IDA MARGARETE NIELSEN

51364

Work project carried out under the supervision of:

Pranav Desai

16-12-2022

Abstract: Sustainable infrastructure projects play a crucial role in supporting European cities to adopt the goal of the Paris Climate Agreement. The broader research topic addresses the prospects for European transportation companies to commit to sustainable actions and support the goal of carbon neutrality by 2050. While other studies investigated the effect of a commitment to sustainable efforts on customer loyalty, this is the first study to examine that a commitment has no direct impact on European cities' Co2 emissions. Furthermore, it depicts the weak financial performance of European public transportation companies, indicating that they need financial support to realize their commitment targets.

Keywords: Paris Climate Agreement, Co2 emission, commitment, urban transportation, green infrastructure, sustainable finance, European cities

This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209).

1. Introduction

The dedication to the Paris Climate Agreement poses a challenge to European cities. Countries must realize and promote sustainable projects to prevent global warming from exceeding two degrees Celsius compared to pre-industrial times. One way to adapt to this goal is to restructure infrastructure projects. Significantly the transportation sector must be improved since it accounted for 20.27% of worldwide carbon dioxide (Co2) emissions in 2020 (EDGAR/JRC; al., 2021) and is expected to rise further (European Environment Agency, 2022).

This study focuses on transportation activities resulting from public transportation providers. Multiple companies operating in public transportation agreed to take environmental action, resulting in a more substantial reputation and attracting clients. Vicente et al. (2020) examined hard and soft factors that improve public transportation. Besides reliable, efficient, and customer-oriented service, the study explored a positive relationship between commitment and service quality. Furthermore, a direct positive effect of environmental commitment on customer loyalty was empirically detected. Vicente et al. (2020) assumed a relationship between increased ridership and improved customer loyalty. However, this was not empirically proven. Under the assumption that customer loyalty increases ridership, it reduces personal vehicle traffic and has an indirect impact on emissions reduction.

This indirect link is partially evaluated in my study. The novelty of this paper is featured by empirically proving a relationship between a commitment by European public transportation companies and the actual reduction of Co2 emissions.

It generally assesses the potential of public transportation providers supporting Europe's goal of reaching carbon neutrality by 2050. This research is, to my knowledge, the first to examine the direct effect of public transportation providers' commitment to the reduction of the cities' Co2 emission level. This study examines to what extent a commitment to sustainable investments leads to a reduction of Co2 emission growth in European cities.

Furthermore, this paper evaluates the opportunity for infrastructure investments in European cities. It is motivated by Denmark's green e-ferry project. Denmark incorporated a new sustainable ferry solution for the small Danish islands and crossings. It was developed in collaboration with PensionDanmark, Odense Maritime Technology, and Faergesekretariatet according to a Public-Private-Partnership (PPP) structure (Houmann, 2022). Faergesekretariatet is a ferry secretary representing 18 Danish municipalities operating ferry services and oversees the services' daily operation. This project is a motivational example of how sustainable public infrastructure investments accelerate economies of scale while giving municipalities a different approach and expert advice on improving public services and tailoring them to passengers' needs.

The literature stresses the importance of considering environmental, social, and economic sustainability in infrastructure projects. Profitability is the essential prerequisite for the success of a project. In the context of public procurement, macroeconomic critical success factors like economic and governmental stability were discovered since they significantly influenced the project's success.

This study focuses on profitability as a critical success factor for infrastructure investments. The first section depicts the financial position of companies operating in Europe's public transportation system.

The second part is an empirical study evaluating the effect of the companies' commitment on Co2 emission growth in European cities by controlling for multiple cross-city factors influencing the Co2 emission.

A dataset including 30 European companies operating in the public transportation sector is manually collected. The company's profitability is analyzed using the company's financial performance indicators. The second part of this study evaluates the relationship between the companies' exact year of commitment, the cities' Co2 emissions data from 2010 until 2020, and other controlling factors. This study uses mainly primary data, which was collected from Capital IQ and other open sources.

While other studies evaluated the effect of transportation infrastructure on the Co2 emissions or measured macroeconomic factors influencing the cities' Co2 emissions (Gherghina et al., 2018; Xie et al., 2017), I evaluated the effect of a commitment to sustainable investments on the cities' Co2 emissions, controlling for multiple macroeconomic factors. The core principle of Wang et al. (2012) model, quantifying different macroeconomic factors influencing Co2 emissions, is used. Further, this model is extended and adapted to answer this paper's research question.

Considering companies' commitment, recent literature investigated how to encourage stakeholders to implement suitable sustainable action plans, policies, or strategies and measure the effectiveness of the respective policies (Littlewood et al., 2018; Vicente et al., 2020). This paper is the first that measures the effect of the commitment on the cities' Co2 emissions. My findings offer an assessment of the effectiveness of companies' commitment to sustainable projects to reduce Co2 emissions

I expect that the commitment of European public transportation providers to make sustainable investments or sustainable operational restructuring can reduce Co2 emissions. However, the empirical study finds that the commitment of a company operating in the European public transportation sector has no significant reduction effect on the cities' Co2 emissions. Considering different periods, this study depicts a slight decrease in Co2 emission from companies that committed earlier. Commitments before 2010 have a smaller effect on Co2 emissions than commitments after 2010. This finding is consistent with my hypothesis. This study excepts a delayed evident impact due to the length and complexity of the sustainable infrastructure projects. The empirical results partially ensure this.

Nevertheless, the empirical study emphasizes that a simple commitment cannot significantly reduce the cities' Co2 emissions. It is an interplay of multiple factors, including social, economic, and environmental conditions.

In the context of profitability, this study presumes that strong financial performance is a critical success factor for the execution of sustainable investments. I assume that profitable entities have the financial power to efficiently and effectively realize sustainable investments and thus reduce the cities' Co2 emissions compared to unprofitable companies. The empirical study cannot ensure this result. Profitable entities increase the cities' Co2 emissions. This implies that financial stability is not the only critical success factor in supporting sustainable investments.

Limitations arise from collecting sensitive financial data. Furthermore, this study is solely focusing on the public transportation sector. Other sectors are not taken into consideration. The study considers only European countries with a strong focus on Western Europe. Further, it is limited by the restricted time horizon of ten years and the sample size, as it consists of 30 companies.

This paper's main challenge was gaining insights into the financial statements and reports. Furthermore, Co2 emissions are a complex phenomenon influenced by multi-dimensional cross-country factors. Thus, the correct assessment of factors explaining Co2 emissions was a challenge and led to the limitations of the empirical study.

The research gaps and directions can motivate researchers and practitioners to analyze other public infrastructure companies and a sustainable project to evaluate their potential to reach the goal of European cities for decarbonization by 2050.

2. Literature review

2.1. Sustainability in the context of infrastructure projects

Sustainable infrastructure development is an essential part of society. It enables the needs of current and future generations to be met through cost-effectiveness, physical resilience, social equity, and environmental sustainability (National Research Council (U.S.), 2009).

Literature offers multiple sustainability definitions and primarily distinguishes between three main aspects: **social**, **economic**, and **environmental** sustainability. The interdependency of these three aspects was formulated in the Brundtland World Commission on Environment and Development report published in 1987 as a three-dimensional framework. Further research suggests that infrastructural projects should be evaluated against this framework or so-called "triple bottom line" (Pei et al., p.9, 2010) to be effective (Mihyeon Jeon & Amekudzi, 2005).

According to Roseland M et al. (1998), **social sustainability** includes the impact of urban infrastructure on the accessibility and affordability of public services for every group within society.

Environmental sustainability describes the impact of infrastructure projects on the urban ecosystem. The mission is to limit emissions and waste so the planet can absorb them. Environmental sustainability is measured by efforts to reduce the demand for non-renewable resources consumed, restrict the consumption of renewable resources to sustainable yields, reuse and recycle their components and minimize land use and noise generation (Miller et al., 2016). Morelli (2011) stresses that environmental sustainability is the only pillar within the three-dimensional framework that can stand alone and serves as a foundation for social and economic sustainability.

Economic sustainability refers to long-term financial growth from conscious investments. Infrastructural projects have a long-term horizon. Thus, economic sustainability is essential and needs to be understood to assess sustainable development in infrastructure projects (Gupta et al., 2016). Efficient and stable financing of sustainable infrastructure investments requires the interplay of various stakeholders. This leads to high complexity and risks since the project's success depends on the financial stability of each stakeholder.

2.2. The commitment to sustainable policies

Europe's carbon neutrality objective demonstrates its commitment to green and low-carbon development. The European Union intends to reduce greenhouse gas emissions (GHG) by 55% by 2030 and reach carbon neutrality by 2050 (Agency, 2022). As a result, guidelines and action plans are being actively disseminated and distributed, affecting the overall economy.

Multiple companies implemented corporate strategies, action plans, and climate policies to support the reduction of Co2 emissions. Littlewood et al. (2018) examined the factors and results of business commitment to climate change action in Europe's high-emitting industries. The study focuses on business drivers, sustainability drivers, and stakeholder pressure in encouraging corporate commitment to climate change action. Only business incentives and stakeholder pressure promote corporate commitment to climate change action in Europe's high-emitting industries, resulting in improved firm GHG performance.

Another study by Sullivan (2010) analyzes the relationship between the performance of 125 European companies and climate mitigation policy. According to their findings, most European corporations have implemented administrative systems and policies to control their GHG emissions and associated operating risks. They are, however, unable to meet both their targets and the ambitions of the EU.

Boiral et al. (2012) discovered evidence of a link between corporate policy quality and financial performance results. While companies with stronger policies are more likely to outperform, only a small percentage of those with the greatest policies commit to absolute reductions in GHG emissions. The findings reveal a win-win link between the pledge to decrease greenhouse gas emissions and financial performance. These findings support the idea that high-commitment enterprises have a higher reputation, a stronger credit rating, and lower agency and information asymmetry costs, enabling them easier access to long-term finance markets, which was discovered by Lemma et al. (2021). They analyzed S&P 500 companies from 2015 to 2019 and showed that corporations that engage in higher levels of commitment to climate change activities issue a higher share of debt with longer terms to maturity.

Even though multiple European companies have committed to supporting and reaching the goals of the Paris climate agreement, there are just a few studies measuring the effect of such commitment. Especially for companies operating in the transportation sector, there is no clear evidence that a commitment affects the Co2 emission growth in Europe.

2.3. Measuring Co2 Emissions in transport infrastructure

One-quarter of the EU's greenhouse gas emissions are caused by transportation. Literature indicates a trade-off in transportation infrastructure investments. On the one hand, investments can amplify sustainable economic growth and environmental development, but Co2 emissions arising from these investments negatively influence the economy.

Awaworyi Churchill et al. (2021) estimated the impact of transportation infrastructure on Co2 emissions over nearly 150 years for a panel of OECD nations. The paper provided evidence that population and economic expansion are two factors that the transportation system uses to affect Co2 emissions. The study applied an empirical framework indicating that a 1% increase in transportation infrastructure is related to an increase in Co2 emissions of roughly 0.4%.

Furthermore, Xie et al. (2017) evaluated the effect of transportation infrastructure projects on urban emissions in China. The findings demonstrate that transportation infrastructure affects the intensity and quantity of urban carbon emissions. The study used panel data from 283 Chinese cities covering ten years (2003-2013) and applied the STIRPAT model. This statistical model is used by researchers all around the world to investigate the interconnections between human impacts on the environment. Findings depict a strong impact of transportation infrastructure on urban emissions. While the population scale helps to reduce carbon emissions, the impact of transportation infrastructure on economic growth and technological advancement causes carbon emissions to rise.

This finding is substantiated by Gherghina et al. (2018). The paper's findings align with the study conducted by Xie et al. (2017). Co2 emissions and other toxic gases arising from transport infrastructure negatively affect economic growth.

However, investments in transportation infrastructure have a beneficial effect on economic growth, positively influencing the gross domestic product per capita (GDPC). These studies highlight the contradictory trade-off between CO2 emissions from transportation and investment amplifying economic strength.

The Co2 emission level in European cities is affected by multiple country-specific factors. Wang et al. (2012) developed a model measuring Co2 emission while considering cross-country factors influencing the emission. The model is controlled by the economic and urbanization level, industry proportion, and resource consumption.

This study uses the core principles of Wang's model to prove the research hypotheses, defined in the next section. The model is modified and adapted to this studies research question. The adjusted and improved model aims to measure the direct effect of the sustainable commitment of public transport companies on the Co2 emissions of cities. The exact model structure is described in section 4.2 of this paper.

3. Research Hypothesis

European cities must take action to reach carbon neutrality by 2050. Thus, investments amplifying Co2 Emission mitigation must be supported. Focusing on the transportation sector, investments that enhance public transportation reduce private vehicle travel and directly affect the reduction of emissions (Plötz et al., n.d.).

In 2015, the Paris Climate Agreement was adopted. The European Union and its member states legally agreed to implement strategies and support investments to mitigate Co2 emissions, reaching the goal of being a climate-neutral society by 2050.

The literature emphasizes that infrastructure projects are a successful way to stimulate the economy. However, the long-time horizon of these investments may postpone the positive effect (Sun et al., 2018).

Multiple international transport corporations agreed to support the Paris Climate Agreement's objectives. Some companies even committed long before 2015 to accelerate sustainable infrastructure. Under the assumption that a commitment to green operational measures or sustainable investments is followed by action. This study assumes a mitigating effect on the cities' Co2 emissions. Nonetheless, there is no sufficient evidence that a company's commitment affects the regional or national Co2 emission level. Therefore, this article tests the following hypotheses:

> *H_1: Companies' commitment to invest in sustainable infrastructure projects reduces the cities' Co2 emissions.*

However, the long-time horizon of operational restructuring or new investments may postpone the positive effect. There is no sufficient evidence that an early commitment affects the regional or national Co2 emission level. Therefore, this article proposes the following hypotheses:

> *H_2: A commitment before 2015 has a stronger reduction effect on the cities' Co2 emission growth than a commitment after 2015.*

Vicente et al. (2020) discovered a positive relationship between the commitment of the company to customer satisfaction and loyalty. The study measured the company's service quality by operational performance, comfort, and safety, as well as attractiveness and guarantee of service. All these factors require constant monitoring and improvement and call for significant investment and ongoing financial support. Entities operating in public sectors must have the financial stability to fund investments and maintain a highly qualified operating business.

To investigate the potential of sustainable investments in the European public transportation sector as an opportunity to support the decarbonization process in European cities, this study evaluates the effect of a commitment coming from profitable organizations on Co2 emissions. Compared to companies in financial distress, profitable companies are able to develop sustainable investments or business restructurings more efficiently and faster as they are detached from financial difficulties. Faster and better expansion accelerates the positive effect of sustainable projects, leading to the following hypothesis:

H_3: Profitable entities will substantially reduce the cities' Co2 emissions.

4. Methodology

I used quantitative data to offer a well-founded empirical study and answer the research question of to what extent European companies operating in the public transportation sector can support reaching carbon neutrality by 2050.

This study is divided into two parts. The first part assesses the financial power of 30 European companies operating in the public transportation sector to analyze if there can invest in new sustainable solutions. The key performance indicator of each company is visualized and discussed.

The second part focuses on the commitment to the Paris Climate Agreement. Each company is committed to taking action and mitigating Co2 Emissions. This is done by investing in sustainable projects or improving operational services. A statistical model was designed to evaluate the effect of the commitment on Co2 Emission growth in European cities.

4.1. Data collection

This study examines two different samples. The first sample size consists of 30 European companies operating in the public transportation sector. The authors selected the sample based on the following requirements:

1. The company operates in a city with more than 100.000 residents. The exclusion of smaller cities reinforces the assumption that public transportation is crucial for the city's infrastructure network since different social groups use it for different purposes.
2. Supporting this assertion, the operating companies offer more than one service line, providing a broad public transportation network.
3. Denmark's e-ferry project serves as a motivational example. Thus, the city must border a federal waterway for inland and passenger navigation, ensuring a possible introduction of an electric ferry service line in the public transportation network.
4. The company committed to the city's action of reaching the requirements of the Paris climate agreement by investing in sustainable projects. This is based on the assumptions of the literature because the willingness of all stakeholders is crucial for the project's success (Berrone et al., 2019), and commitment is positively related to customer loyalty, increasing ridership and, thus, reducing personal vehicle traffic (Vicente et al., 2020).

To single out suitable companies matching the above-stated requirements, the researcher checked the companies' websites, press releases, annual financial and sustainability reports, and other reports conducted by the municipal or state.

This paper is a cross-country data study where 30 European companies from 16 European countries including Austria, Belgium, Czech Republic, Denmark, France, Germany, Hungary, Latvia, Netherlands, Norway, Portugal, Romania, Spain, Sweden, Switzerland, and the United Kingdom are analyzed. All companies operate in the public transportation sector. Most recent financial data was available until 2020.

The financial data is collected from Capital IQ, which reports economic and market data from 4.4 million private enterprises and 62,000 public companies. However, the Capital IQ database does not report some values; Thus, I reviewed the annual financial reports of the respective companies to complete the data set. Limitations arose due to poor information about the company's financial performance.

To evaluate the profitability, I collected critical financial performance numbers and indicators, including return on asset (ROA)[1] (in %). ROA is used as a proxy to measure the company's profitability. The results are analyzed and discussed in the 5th section of this paper.

The second part of this study focuses on the interaction between the companies' commitment to sustainable investments and its effect on Co2 emission growth. Each company operating in public transportation is committed to implementing measurements or investing in mitigating Co2 emissions. Data proofing the year of commitment was collected by reviewing companies' websites, sustainable reports, or press releases. Section C in the appendix shows the respective company and the time of commitment.

The Paris Climate Agreement (2015) legally binds the EU to implement sustainable strategies for climate protection. Since most companies operating in the public transportation sector are entirely or at least partially owned by the public, such regulations and strategies directly affect the companies' operating business.

[1] Detailed explanation of the variables is listed in section B in the appendix.

The second sample size includes the adjusted Co2 emission level (in million tons) of all European member states as well as 30 European cities covering ten years (2010-2020). The data is collected from Our World in Data Co2 and Greenhouse Gas Emissions database 2020 (Friedlingstein et al., 2022). The database measures each country's Co2 emissions per capita per million tons. Small adjustments were made. The Co2 emission level (per capita per ton) was scaled down to the city level by multiplying it by the population of the city. The cities' population data was collected by an open source over ten years (from 2010 until 2020).

Further, the cities' Co2 emission level was adjusted to the base year (2010) to enable comparability of the data.

The model is controlled by the normalized GDP per city, Co2 consumption per city (in million tons), energy use per city (kilowatt-hours), Co2 changes in land used per city (in million tons), trade Co2 (in million tons), and percentage of the urban population to the countries' total population[2].

The countries' GDP per capita was collected by the open-source of the World Bank national and OECD National Accounts. The raw database measured the countries' GDP per capita in U.S. dollars. To ensure consistency within the dataset, the GDP of each country was adjusted by the average exchange rate (U.S. Dollar to EUR)[3] from 2010-2020. Furthermore, the cities' GDP was adjusted by inflation. The inflation data was collected from the World Economic Outlook Database published by IMF. The normalized GDP has the advantage of adjusting scale ratios, resulting in improved comparability of different cities. The GDP per capita was scaled down to the city level by multiplication with the population of the respective city and year.

[2] An exact variable specification can be found in the appendix section B.
[3] The average exchange rates are listed in the appendix section C.

Other controlling variables were collected from Our World in Data Co2 and Greenhouse Gas Emissions database 2020 (Friedlingstein et al., 2022). Variables indicating the city level were collected per capita and scaled down.

4.2. Model specification

This papers' model uses balanced panel data to evaluate different conditions over time. The analysis covers ten years (2010-2020). An ordinary least squares model is used. The core principles of Wang et al. (2012) model, explaining the effect of macroeconomic factors on Co2 emissions, is modified and fitted to this study. The model includes random effects and time-fixed effects (λ) to explain cross-city differences over time. The model clusters the companies, to explain possible sub-group correlation.

The following model, testing H_1, was designed to evaluate the effect of the companies' commitment to act "green" on the cities' Co2 emissions:

I. $$Co2e_{i,t} = \beta_0 + \beta_1 Lengthofcommitment + \gamma_2 GDP_{i,t} + \gamma_3 Consumption_{i,t} + \gamma_4 Energy_{i,t} + \gamma_5 LUC_{i,t} + \gamma_6 Trade_{i,t} + \gamma_7 UP_{i,t} + \lambda_{i,t} + \varepsilon_{i,t}$$

The dependent variable is the cities' (i) Co2 Emission level over ten years (t) between 2010-2020. The length of commitment is the independent variable and variable of interest. It depicts the time (in years) of the commitment coming from the respective company, which operates in the city.

According to Awaworyi Churchill et al. (2021) population and economic expansion are two factors channeling Co2 emissions, thus $GDP_{i,t}$, $Consumption_{i,t}$, $UP_{i,t}$ control for social differences between the respective cities and years. Whereas $Energy_{i,t}, LUC_{i,t}$, $and\ Trade_{i,t}$ control for economic differences.

To test H_2, and evaluate the effect of the time of commitment on the cities' Co2 emissions, the following model was constructed:

II. $$Co2e_{i,t} = \beta_0 + \delta_0 Combefore_{2010} + \gamma_2 CombeforeCo2_{2010} + \gamma_3 GDP_{i,t} + \gamma_4 Consumption_{i,t} + \gamma_5 Energy_{i,t} + \gamma_6 LUC_{i,t} + \gamma_7 Trade_{i,t} + \gamma_8 UP_{i,t} + \lambda_{i,t} + \varepsilon_{i,t}$$

III. $$Co2e_{i,t} = \beta_0 + \delta_0 Com_{2010-2014} + \gamma_2 ComCo2_{2010-2014} + \gamma_3 GDP_{i,t} + \gamma_4 Consumption_{i,t} + \gamma_5 Energy_{i,t} + \gamma_6 LUC_{i,t} + \gamma_7 Trade_{i,t} + \gamma_8 UP_{i,t} + \lambda_{i,t} + \varepsilon_{i,t}$$

IV. $$Co2e_{i,t} = \beta_0 + \delta_0 Com_{2015-2020} + \gamma_2 ComCo2_{2015-2020} + \gamma_3 GDP_{i,t} + \gamma_4 Consumption_{i,t} + \gamma_5 Energy_{i,t} + \gamma_6 LUC_{i,t} + \gamma_7 Trade_{i,t} + \gamma_8 UP_{i,t} + \lambda_{i,t} + \varepsilon_{i,t}$$

The dependent variable is the cities' Co2 Emission level over ten years between 2010-2020. The length of commitment is the independent variable. Each model (II-IV) considers different periods between 2010-2020. To capture the right effect of a commitment on the respective yearly Co2 emissions, the model includes dummy variables. The period of commitment is a binary variable and can be either 1 or 0.

II. $$Combefore_{2010} \begin{cases} 1, if\ commitment < 2010 \\ 0, if\ commitment \geq 2010 \end{cases}$$

III. $$Com_{2010-2014} \begin{cases} 1, \text{ if commitment} \geq 2010 \text{ and} \leq 2014 \\ 0, \text{ if commitment} > 2014 \end{cases}$$

IV. $$Com_{2015-2020} \begin{cases} 1, if\ commitment \geq 2015\ and \leq 2020 \\ 0, if\ commitment > 2020 \end{cases}$$

To measure the effect of a commitment coming from a profitable company on the Co2 emission, the following model was deployed:

V. $$Co2Emission_{i,t} = \beta_0 + \delta_0 posROA + \gamma_2 GDP_{i,t} + \gamma_3 Consumption_{i,t} + \gamma_4 Energy_{i,t} + \gamma_5 LUC_{i,t} + \gamma_6 Trade_{i,t} + \gamma_7 UP_{i,t} + \lambda_{i,t} + \varepsilon_{i,t}$$

The dependent variable is the cities' Co2 emissions between 2010-2020. The independent variable is the ROA in the respective year (t) of the respective company operating in the respective city (i).

The variable of interest is a binary variable.

$$PosROA\begin{cases}1, if\ ROA > 0\\ 0, if\ ROA \leq\ 0\end{cases}$$

5. Summary statistics

5.1. Financial performance

This study considers 16 European countries that are highlighted in Figure 1. The sample reviews 30 companies' European public transportation companies. Each city represents its own public transportation provider. The precise allocation of the city to its individual enterprise can be found in the appendix (section C).

The financial situation of each enterprise is assessed using recent financial data. The profitability of a company indicates whether it is able to make its own investments and thus meet its commitment targets. The transportation sector is an asset-heavy industry. Thus, the ROA is a suitable indicator for measuring the company's profitability related to its assets. The ROA of each company in 2015, 2019, and 2020 is shown in Figure 2.

The median (0.02%) in 2015 compared to 2020 (-0.47%) is substantially lower. Analyzing the ROA in 2020, the effects caused by Covid must be considered. Figure 2 shows that the ROA in 2015 and 2019 was slightly lower or almost equal for multiple companies compared to 2020. Companies operating in Bordeaux, Bremen, Copenhagen, London, Lyon, Prague, and Würzburg have a better ROA in 2020 than in 2015. This may come from increased public Covid grants or subsidies, which directly increase the net income and, consequently, the ROA.

Generally, a “good” ROA in asset-heavy industries is 5% or more (Emily Guy & Birken Benjamin Curry, 2021). The annual average ROA of companies operating in the transportation sector was 8.18% in 2015 and 1.18% in 2020.

Applying this as a benchmark to the sample, only Bucharest’s public transportation provider lies above 8.18% in 2015. However, Bucharest's ROA is 18.8% which is significantly higher than the industry average. A higher-than-average ROA might indicate that the firm is not investing enough in assets, which could lead to negative consequences in the long term.

This is true when comparing Bucharest's ROA in 2019 and 2020. It decreases over time to 2.5% in 2019 and -5.9% in 2020. The decrease implies that the corporation over-invested in assets that have failed to generate revenue growth, indicating that the company is unprofitable and mismanaged. In 2020, only public transportation providers in Bordeaux (1.86%), Gent (3.8%), and Kiel (3.06%) outperformed the benchmark. In 2015, 2019, and 2020, more than half of the companies had a negative ROA indicating an overall weak financial performance throughout the sample data.

Further, a negative ROA indicates the incapability to acquire or use assets sufficiently to create profitable returns. There is a substantial mismatch between the companies' assets and their generated return.

In conclusion, the ROA illustrates the unprofitable position of companies operating in the public transportation sector. The majority of companies have a low ROA regardless of the financial year. There is a mismatch in the efficient use of assets.

Under the assumption that the companies in this sample generate a credible picture of all companies operating in the European public transportation sector, it can be summarized that they need to be in a better financial position to make long-term sustainable investments on their own. The unprofitability of the companies indicates the missing capacity to generate profits from the assets and projects in which they invest.

Regarding the research question, these findings emphasize that the companies have difficulties in accelerating, financing, and managing sustainable infrastructure investments on their own. The unstable financial position indicates considerable risk factors, jeopardizing the success of a long-term project.

5.2. Development of European Co2 emissions

Figure 3 depicts the ratio of Europeans normalized cities' Co2 emission growth to the normalized GDP between 2010 (base year) and 2020.

In 2013 the Co2 emission significantly rose to over 1.12% compared to 2010. Co2 emissions were higher compared to the previous years. This is due to an abnormally cold winter leading to an exponential increase in fossil energies (Justin Grieser, 2013; Umweltbundesamt, 2014). Since 2014, the Co2 emission constantly reduces. The downswing until 2019 is mainly driven by prospering economic growth. The sharp drop in 2020 can be attributed to Covid. The overall economy was affected by Covid, resulting in a GDP decline as well as Co2 emissions reduction. This black swan effect is visualized in figure 3. Intermittent lockdowns and other political regulations restricted the global economy and reduced social life to a minimum. Consequently, the Co2 emissions attributed to the transportation sector and arising from trade or social consumption were reduced.

6. Empirical results

The central research question is whether or not the commitment to sustainable investments in the public transportation sector can support Co2 emission mitigation in European cities.

Regression 1

The empirical findings for H_1 are shown in table 1. The model measures the effect of the time of commitment on the cities' Co2 Emissions.

H_1 expects a negative relationship between a commitment and the Co2 emission. The coefficient β_1 indicates that the Co2 emission decreases with the number of years after the commitment. However, the coefficient is close to 0 and not statistically significant. Thus, the null hypothesis is not proven to be true. The empirical findings indicate that the length of the commitment has no significant influence on the cities' Co2 emission level. Based on this result, the time of a commitment does not matter. Regarding the overall reduction of Co2 emissions, companies that committed earlier have the same impact as companies that committed recently.

Furthermore, the findings challenge Wang et al. (2012) research. Their results reveal that the amount of urbanization, economic level, and industrial proportion all have a favorable impact on CO2 emissions. Other than in this paper, Wang et al. (2012) indicated the level of urbanization as a primary driver of CO2 emissions. This model shows that other variables like Co2 consumption, the percentage of urban population or GDP have no significant impact on the cities' Co2 emissions. However, the study supports Wang et al. (2012) results that rising per capita GDP increases CO2 emissions.

The key driver for Co2 emission in this model is Co2 emission arising from trade, which is significantly positive at a 95% confidence level. The majority of the sample operates in countries that are net importers, meaning that they import more Co2 in the form of traded goods than they export. However, the model shows an increase by 1 unit of Co2 embedded in trade, the cities' Co2 emissions decline by 0.001 tons.

This finding may indicate the effectiveness of global carbon markets or certificate trading as a market-based instrument for climate protection. Since 2005, the EU and other countries have established carbon markets as a means of increasing climate ambition and lowering Co2 levels in the atmosphere by giving a financial incentive to reduce emissions.

The strategy implies that if one nation pays for emissions to be reduced or absorbed in another country, such as by conducting sustainable investments. The reductions can be counted against the first country's own climate targets. The goal is that for every ton of CO2 emitted by production or trade at someplace, another ton is caught somewhere else, creating a circularity and reducing Co2 emissions.

There are multiple empirical studies evaluating the effects of emission trading schemes (ETS) or similar policies. In general, ETS can reduce Co2 emissions (Gao et al., 2020; Laing et al., 2014; Villoria-Sáez et al., 2016) which is emphasized by the findings of this paper.

Regression 2

H_2 indicates that the positive impact of a commitment and accompanying sustainable investments or organizational restructuring measurements are delayed due to complex authorization, design, or funding processes. Especially in the context of public procurement, external factors, like macroeconomic circumstances (e.g., political decisions, legal requirements, and social demands), influence the time horizon of the investment. Thus, the reduction effect on Co2 emissions coming from a commitment rises with the years passed. Table 2 shows the empirical findings testing H_2.

Hypothesis 2 can be stated as partially true. On average, the commitment before 2010 (IIa) has a significant negative effect on the Co2 emission growth holding everything else constant. However, the effect in the following years' increases, as the dummy coefficient of the commitment between 2010-2014 and 2015-2021 indicates a stronger negative effect on the dependent variable. Commitments between 2010 and 2014 have a significantly strong negative effect on the cities' Co2 emissions at a 99% confidence level.

Coefficients β_0 of the first, second, and third models (IIa, IIb, IIc) are positive and significant at a 99.9% confidence level. This finding is contrary to the null hypothesis. The relationship between the commitment and the Co2 emission is positive. However, the slope coefficient γ_2, measuring the change, increases over time. Thus, commitments after 2010 have a stronger positive effect on Co2 emissions. This finding is aligned with the H_2.

Infrastructure investments are long-term, with a time horizon of up to ten years. This study is limited by considering only ten years. The positive impact of the commitments might be measurable after investigating a longer time horizon. This limitation can direct and motivate other researchers and practitioners to analyze the time horizon of the return after a filed commitment.

Regression 3

H_3 was formulated under the assumption that profitable companies benefit from solid financial power to implement sustainable investment or operational restructuring measurements faster and more efficiently than unprofitable companies. Table 3 shows the effect of a commitment coming from a profitable company on Co2 emissions.

The profitability measured by ROA has a negative on CO_2 emissions. On average, the CO_2 emissions decline by 0.005 tons, with an increase of the ROA by 1%, holding everything else equal. This is in line with hypothesis 3. However, the results are not statistically significant.

The empirical findings show a trend that companies with a positive ROA can reduce the cities' CO_2 emissions compared to companies with a negative ROA. Profitable companies can use their financial power to fund or maintain sustainable investments.

Moreover, the model measures the positive effect of CO_2 consumption on CO_2 emissions. This effect is significant at a 95% confidence level. An increase in the cities' consumption by 1 unit leads to an increase in the CO_2 emissions by 0.214 tons. Furthermore, cities' GDP has a significant positive effect on CO_2 emissions at a 90% confidence level. These findings support related literature stating the negative impact of economic growth on CO_2 emissions.

7. Conclusion

The empirical findings show that the length of commitment of the public transportation company has no significant effect on the CO_2 emission growth. Earlier commitments have the same impact as commitments that have been filed recently. The effect on the CO_2 emissions is close to zero. In general, the positive effect of infrastructure investments is often delayed due to macroeconomic circumstances or financial difficulties. However, even the companies that committed before 2010 have just a slight reduction effect on CO_2 emissions. The overall trend of the empirical results implies that the commitment is insufficient to support Europe's decarbonization goals. The weak effect of the commitment emphasizes that a firm portrays to the public an ecologically friendly and responsible image without a proper foundation for doing so. Sustainable measurements as a requirement of the commitment need strong financial resources to fund and later maintain the investments.

Evaluating the potential of European companies to fund sustainable investments, the study stresses the weak financial performance of the majority of companies operating in the public transportation sector. Looking only at profitability and ignoring subsidies from the government or other loans, companies are unable to make long-term investments or adopt necessary operational improvements.

The empirical study underlines the need for financial strength to support Co2 reduction. The study shows a trend that companies with a positive ROA can reduce the cities' Co2 emissions compared to companies with a ROA less than zero.

In conclusion, the majority of the observed public transportation providers are not able to support Europe's goal to reach carbon neutrality by 2050. Linking this fact to the companies' finances, the results imply an inefficient use of their sustainable assets. The public transportation provider and European cities have to create different approaches to improve a sustainable public transportation sector. Companies need external financial support to improve, renew or maintain their sustainable investments.

Coming back to Denmark's green e-ferry project as a motivational example. The consortium was formed as a PPP. Therefore, the public ferry providers were able to fund sustainable public transportation investments on their own because an efficient PPP can convert cost-heavy infrastructure projects into affordable, profitable, and sustainable investment cases.

This study proposes the use of partnerships between the public and the private sector or other joint ventures to support the reduction of Co2 emissions and reach the goal imposed by the Paris climate agreement.

Bibliography

AB Storstockholms Lokaltrafik Storstockholms Lokaltrafik Group. (2020). *Sustainability report 2019*. https://s3-us-west-2.amazonaws.com/ungc-production/attachments/cop_2020/487489/original/SL_Communication_on_progess_2019.pdf?1594797836

Awaworyi Churchill, S., Inekwe, J., Ivanovski, K., & Smyth, R. (2021). Transport infrastructure and CO2 emissions in the OECD over the long run. *Transportation Research Part D: Transport and Environment*, *95*, 102857. https://doi.org/10.1016/j.trd.2021.102857

Berliner Verkehrsbetriebe (BVG). (2022). *Sustainability report 2022*. https://unternehmen.bvg.de/wp-content/uploads/2021/07/Nachhaltigkeits-Fact-Sheets.pdf

Berrone, P., Ricart, J. E., Duch, A. I., Bernardo, V., Salvador, J., Peña, J. P., & Planas, M. R. (2019). EASIER: An evaluation model for public-private partnerships contributing to the sustainable development goals. *Sustainability (Switzerland)*, *11*(8). https://doi.org/10.3390/su11082339

Brundtland World Commission on Environment and Development. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Cazan, R., Stoica, M., Brooks, H., Mathieu, L., Calvo Ambel, C., Mestre, C., Kenny, S., & Earl, T. (2018). *Transport & Environment (2018) Emission Reduction Strategies for the Transport Sector in Romania*. www.transportenvironment.org

de Lijn. (2021). *Duurzaamheidsverslag 2020-2021*. https://assets.ctfassets.net/32fmeyn9t08i/1aj5yBKfKm4rY0Apn6stdw/4486cbc376143b74c2d55146c56894e7/Duurzaamheidsverslag_2020_2021_def.pdf

Department of Economic and Social Affairs Population Division. (2022). *2022 Revision of World Population Prospects*. https://population.un.org/wpp/

EDGAR/JRC; al., C. et. (2021). *Transportation emissions worldwide*.

Emily Guy, & Birken Benjamin Curry. (2021). *Understanding Return On Assets (ROA)*. https://www.forbes.com/advisor/investing/roa-return-on-assets/

Environment Team, G. L. A. (GLA). (2022). *London Energy and Greenhouse Gas Inventory (LEGGI)*. https://data.london.gov.uk/dataset/leggi

European Environment Agency. (2022). *Greenhouse gas emissions from transport in Europe*. https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-transport

Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Gregor, L., Hauck, J., le Quéré, C., Luijkx, I. T., Olsen, A., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Alkama, R., … Zheng, B. (2022). Global Carbon Budget 2022. *Earth System Science Data*, *14*(11), 4811–4900. https://doi.org/10.5194/essd-14-4811-2022

Gao, Y., Li, M., Xue, J., & Liu, Y. (2020). Evaluation of effectiveness of China's carbon emissions trading scheme in carbon mitigation. *Energy Economics*, *90*, 104872. https://doi.org/10.1016/j.eneco.2020.104872

Gherghina, Ş., Onofrei, M., Vintilă, G., & Armeanu, D. (2018). Empirical Evidence from EU-28 Countries on Resilient Transport Infrastructure Systems and Sustainable Economic Growth. *Sustainability*, *10*(8), 2900. https://doi.org/10.3390/su10082900

Groupe Keolis. (2021). *Financial Report*. www.keolis.com

Grupo Transtejo. (2014). *Relatório de Sustentabilidade 2014*. https://ttsl.pt/wp-content/uploads/2018/01/rs_2014_min.pdf

Gupta, R., Morris, J. W. F., & David Espinoza, R. (2016). Financial Sustainability as a Metric for Infrastructure Projects. *Geo-Chicago 2016*, 653–662. https://doi.org/10.1061/9780784480120.066

Hannah Ritchie, Max Roser, & Pablo Rosado. (2020). CO_2 and Greenhouse Gas Emissions. *Https://Ourworldindata.Org/Co2-and-Other-Greenhouse-Gas-Emissions*.

Hochbahn Hamburg AG. (2022). *Corporate and sustainability report*. https://www.hochbahn.de/resource/blob/17268/b906060e356b83bd4a8c28fa1d2dedab/finanz-englisch-data.pdf

IMF. (2022a). *Hungary: Inflation rate from 1987 to 2027*. https://www.statista.com/statistics/339881/inflation-rate-in-hungary/

IMF. (2022b). *Hungary: Inflation rate from 1987 to 2027 (compared to the previous year)*. https://www.statista.com/statistics/339881/inflation-rate-in-hungary/

IMF. (2022c). *Latvia: Inflation rate from 1997 to 2027 (compared to the previous year)*. https://www.statista.com/statistics/375251/inflation-rate-in-latvia/

IMF. (2022d). *Norway: Inflation rate from 1987 to 2027 (compared to the previous year)*. https://www.statista.com/statistics/327359/inflation-rate-in-norway/

IMF. (2022e). *Portugal: Inflation rate from 1987 to 2027 (compared to the previous year)*. https://www.statista.com/statistics/372347/inflation-rate-in-portugal/

IMF. (2022f). *Sweden: Inflation rate from 1987 to 2027 (compared to the previous year)*. https://www.statista.com/statistics/375283/inflation-rate-in-sweden/

IMF. (2022g). *United Kingdom: Inflation rate from 1987 to 2027 (compared to the previous year)*. https://www.statista.com/statistics/270384/inflation-rate-in-the-united-kingdom/

IMF. (2022h). *Germany: Inflation rate from 1987 to 2027 (compared to the previous year)*. https://www.statista.com/statistics/375207/inflation-rate-in-germany/

IMF. (2022i). *Czech Republic: Inflation rate from 1989 to 2027*. https://www.statista.com/statistics/369876/inflation-rate-in-czech-republic/

IMF. (2022j). *Denmark: Inflation rate from 1987 to 2027 (compared to the previous year)*. https://www.statista.com/statistics/318356/inflation-rate-in-denmark/

IMF. (2022k). *France: Inflation rate from 1980 until 2021 and forecast until 2027 (compared to the previous year)*. https://www.statista.com/statistics/270353/inflation-rate-in-france/

International Energy Agency (IEA). (2021). *Net Zero by 2050 - A Roadmap for the Global Energy Sector*. www.iea.org/t&c/

Justin Grieser. (2013, March 29). Freezing cold March sets records across Europe. *The Washington Post*. https://www.washingtonpost.com/news/capital-weather-gang/wp/2013/03/29/cold-march-sets-records-across-europe/

Kölner Verkehrsbetriebe. (2021). *Umweltpolitik der KVB*. https://www.kvb.koeln/unternehmen/zukunftsfahren/umwelt/umweltpolitik.html

Laing, T., Sato, M., Grubb, M., & Comberti, C. (2014). The effects and side-effects of the emissions trading scheme. *WIREs Climate Change*, *5*(4), 509–519. https://doi.org/10.1002/wcc.283

Littlewood, D., Decelis, R., Hillenbrand, C., & Holt, D. (2018). Examining the drivers and outcomes of corporate commitment to climate change action in European high emitting industry. *Business Strategy and the Environment*, *27*(8), 1437–1449. https://doi.org/10.1002/bse.2194

Metro do Porto. (2010). *Sustainability Report 2009*. https://en.metrodoporto.pt/metrodoporto/uploads/document/file/270/Sustainability_Report_2009.pdf

Metroselskabet I/S. (2022). *Metroselskabet I/S Annual Report 2021*. https://m.dk/media/4823/en-ms-årsrapport-2021.pdf

Mihyeon Jeon, C., & Amekudzi, A. (2005). Addressing Sustainability in Transportation Systems: Definitions, Indicators, and Metrics. *Journal of Infrastructure Systems*, *11*(1), 31–50. https://doi.org/10.1061/(asce)1076-0342(2005)11:1(31)

Miller, P., de Barros, A. G., Kattan, L., & Wirasinghe, S. C. (2016). Public transportation and sustainability: A review. *KSCE Journal of Civil Engineering*, *20*(3), 1076–1083. https://doi.org/10.1007/s12205-016-0705-0

Moran, D., Kanemoto, K., Jiborn, M., Wood, R., Többen, J., & Seto, K. C. (2018). Carbon footprints of 13 000 cities. *Environmental Research Letters*, *13*(6), 064041. https://doi.org/10.1088/1748-9326/aac72a

Morelli, J. (2011). Environmental Sustainability: A Definition for Environmental Professionals. *Journal of Environmental Sustainability*, *1*(1), 1–10. https://doi.org/10.14448/jes.01.0002

Nantes Metropole. (2019). *Nantes European Green Capital 5 years report*. https://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2019/05/2019_05_24_rapport_EGC_5ans_EN_EXE3.pdf

National Research Council (U.S.). Toward Sustainable Critical Infrastructure Systems: Framing the Challenges Workshop Committee., & National Research Council (U.S.). Board on Infrastructure and the Constructed Environment. (2009). *Sustainable critical infrastructure systems : a framework for meeting 21st century imperatives : report of a workshop*. National Academies Press.

Pei, Y. L., Amekudzi, A. A., Meyer, M. D., Barrella, E. M., & Ross, C. L. (2010). Performance Measurement Frameworks and Development of Effective Sustainable Transport Strategies and Indicators. *Transportation Research Record: Journal of the Transportation Research Board*, *2163*(1), 73–80. https://doi.org/10.3141/2163-08

Plötz, P., Wachsmuth, J., Gnann, T., Neuner, F., Speth, D., & Link, S. (n.d.). *Net-zero-carbon transport in Europe until 2050 – targets, technologies and policies for a long-term EU strategy*.

Régie autonome des transports parisiens. (2018). *Activity and Sustainable Development Report 2018*. https://www.ratp.fr/en/annualreport

Rheinbahn. (2021). *Unternehmensbericht 2021*. https://cdn0.scrvt.com/c05c43da411abd1b674666ad73487c28/f4c3fb83c6e725a9/a7031971c0a1/Geschaeftsbericht.pdf

Rīgas satiksme. (2019). *Operation Report 2019*. https://www.rigassatiksme.lv/files/operativais_parskats_2019-ar_rd_paradu_(1)_a7370.pdf

Roseland M, Cureton M, & & Wornell H. (1998). *Toward Sustainable Communities: Resources for Citizens and Their Governments. (Completely rev. and updated): Vol. New Society.*

Rostocker Straßenbahn AG. (2021). *Nachhaltigkeitsbericht 2021*. https://www.rsag-online.de/fileadmin/media/PDF/PDF_Nachhaltigkeitsbericht-2021.pdf

Ruter. (2020). *Sustainable Development Goals*. https://aarsrapport2020.ruter.no/en/ruters-malbilde/baerekraftsmal/

Senate Department for Environment, C. and T. (2010). *Sustainable Urban Mobility Plan Bremen 2025*.

Statistik Austria. (2022). *Inflation rate in Austria from 2011 until 2021*. https://de.statista.com/statistik/daten/studie/217415/umfrage/inflationsrate-in-oesterreich/

Statistisches Bundesamt. (2021). *Einwohnerzahl der größten Städte in Deutschland am 31. Dezember 2020*. https://de.statista.com/statistik/daten/studie/1353/umfrage/einwohnerzahlen-der-grossstaedte-deutschlands/

Sun, C., Luo, Y., & Li, J. (2018). Urban traffic infrastructure investment and air pollution: Evidence from the 83 cities in China. *Journal of Cleaner Production*, *172*, 488–496. https://doi.org/10.1016/j.jclepro.2017.10.194

Sustainable Bus. (2019, January 16). *KVG Kiel (Germany) calls for tender to buy 36 electric articulated buses*. https://www.sustainable-bus.com/news/kvg-kiel-germany-calls-a-tender-for-36-electric-articulated-buses-procurement/

Sustainable Bus. (2021, July 8). *GVB Amsterdam to provide zero emission transport from 2025 onwards. 44 further VDL Citea Electric ordered*. https://www.sustainable-bus.com/news/gvb-amsterdam-zero-emission-transport-2025-44-vdl/

Transport for London. (2021). *Sustainability Report 2021*. https://content.tfl.gov.uk/tfl-sustainability-report-29-september-2021-acc.pdf

Transportation Department of Prague City Hall. (2015). *The sustainable mobility plan for prague and its suburbs*. https://poladprahu.cz/wp-content/uploads/2019/11/Mobility_Plan-Brochure_EN.pdf

Transports Metropolitans de Barcelona. (2022). *Social responsibility and sustainability plan*. https://www.tmb.cat/documents/20182/111197/Pla+RS+i+Sostenibiliat+2022+-+EN/ddd2bc77-7f92-4892-998d-1c4d958fed84

Umweltbundesamt. (2014). *Greenhouse gas emissions rise again slightly in 2013, by 1.2 per cent*. https://www.umweltbundesamt.de/en/press/pressinformation/greenhouse-gas-emissions-rise-again-slightly-in

Västtrafik. (2022). *Environment and public transport*. https://www.vasttrafik.se/en/about-vasttrafik/miljo/

Vicente, P., Sampaio, A., & Reis, E. (2020). Factors influencing passenger loyalty towards public transport services: Does public transport providers' commitment to environmental sustainability matter? *Case Studies on Transport Policy*, *8*(2), 627–638. https://doi.org/10.1016/j.cstp.2020.02.004

Victoria Masterson. (2022, September 29). *The European Union has cut greenhouse gas emissions in every sector - except this one*. https://www.weforum.org/agenda/2022/09/eu-greenhouse-gas-emissions-transport/

Villoria-Sáez, P., Tam, V. W. Y., Río Merino, M. del, Viñas Arrebola, C., & Wang, X. (2016). Effectiveness of greenhouse-gas Emission Trading Schemes implementation: a review on legislations. *Journal of Cleaner Production*, *127*, 49–58. https://doi.org/10.1016/j.jclepro.2016.03.148

Wang, Z., Yin, F., Zhang, Y., & Zhang, X. (2012). An empirical research on the influencing factors of regional CO2 emissions: Evidence from Beijing city, China. *Applied Energy*, *100*, 277–284. https://doi.org/10.1016/j.apenergy.2012.05.038

Wiener Lienen GmbH & Co KG. (2022, September 22). *Wir leben Klimaschutz. Wir sind Greener Linien.* https://www.wienerlinien.at/greener-linien

Würzburger Verkehrsverbund. (2020). *Unsere Nachhaltigkeitskampagne*. https://www.wvv.de/nachhaltigkeit/wuerzburg.html#bild_text_combo_3

Xie, R., Fang, J., & Liu, C. (2017). The effects of transportation infrastructure on urban carbon emissions. *Applied Energy*, *196*, 199–207. https://doi.org/10.1016/j.apenergy.2017.01.020

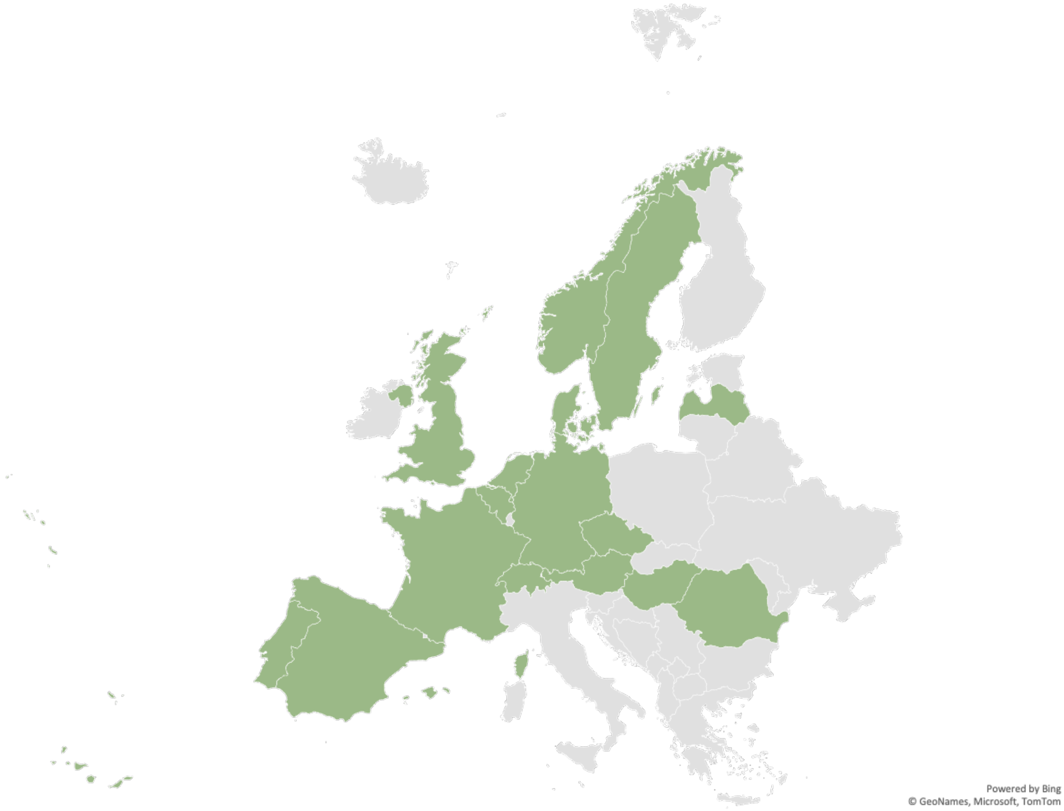

Figure 1: **Country allocation**. The figure highlights all countries observed in this study.

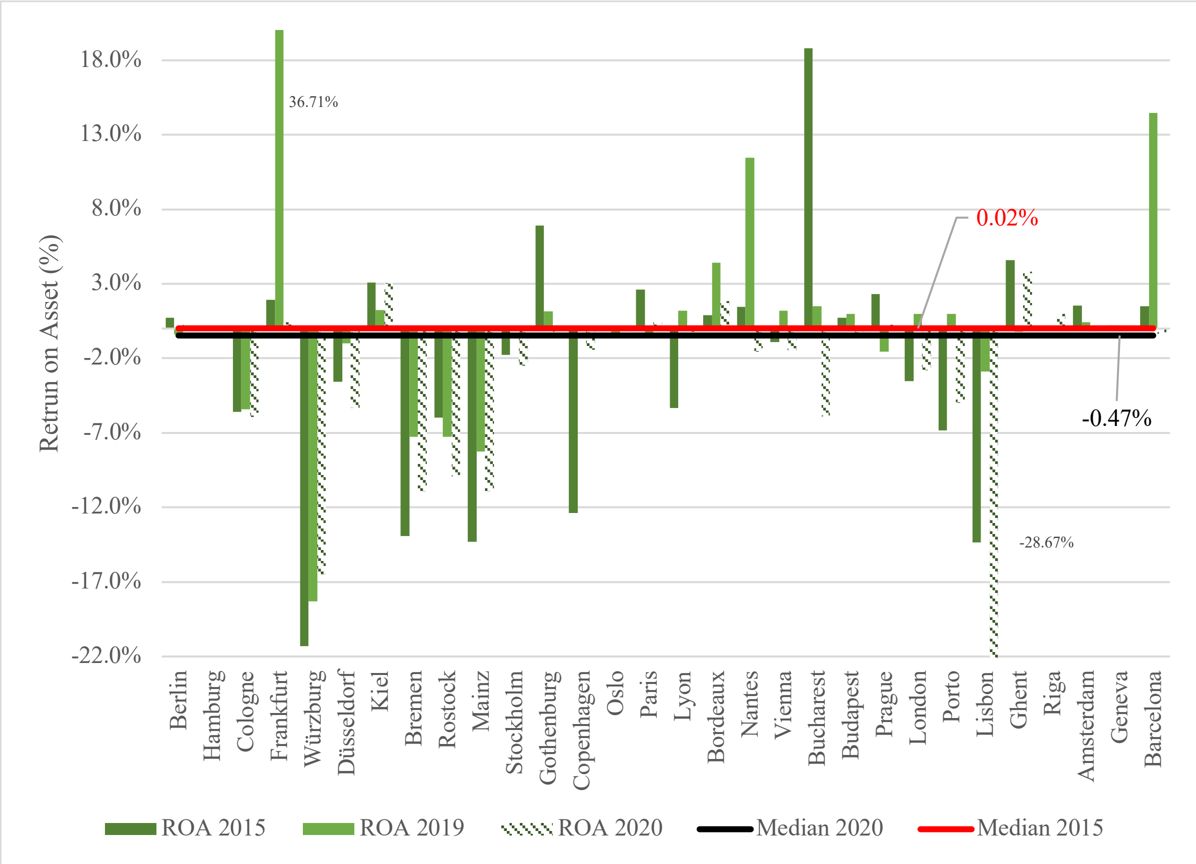

Figure 2: **Comparison of ROA from public transport companies in 2015,2019 and 2020**. The figure illustrates the different ROA in 2015, 2019, and 2020 of 30 European public transportation providers. The city in which the entity operates is displayed. A list of all entities and their respective city is shown in section C in the appendix. Further, the median in 2015 and 2020 is displayed.

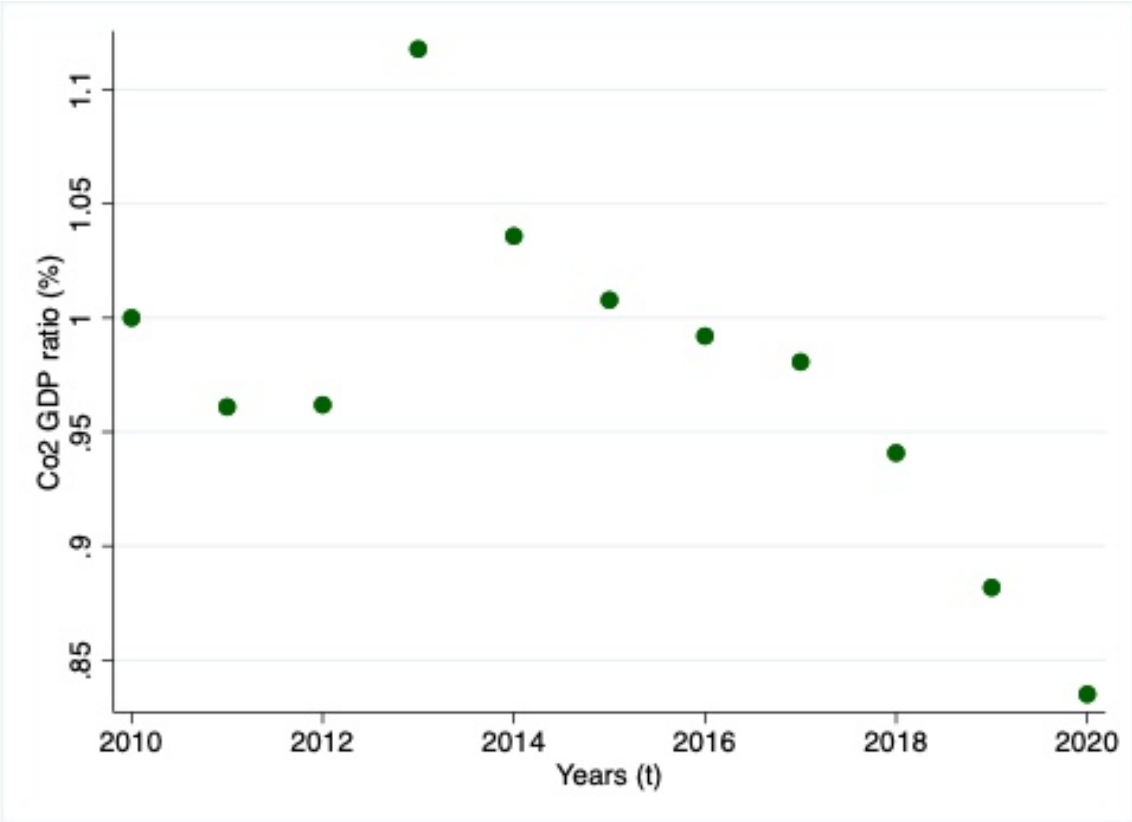

Figure 3: **Co2 emissions in relation to GDP over time**. The figure plots the ratio of the normalized Co2 emission and the normalized GDP of each city over ten years. The year 2010 is the base year and standardized to 100%. The annual average inflation rate further adjusts the cities' normalized GDP. The ratio is calculated by dividing the Co2 emission by the cities' GDP.

Table 1: **Length of commitment and Co2 emissions (testing hypothesis 1)**

This table shows the output of the first regression. The model regresses the length of commitment on the cities' Co2 emissions. The model includes time-fixed effects. All variables are defined in section B in the appendix. The t-statistics are reported in parentheses and are based on standard errors that are clustered at the company level.

	I
Lenght of Commitment	-0.000
	(-0.03)
GDP (normalized)	0.118
	(-1.57)
Consumption (per capita)	0.114
	(-1.51)
Energy (per capita)	0.012
	(-0.16)
Change in land used	0.000
	(-0.79)
Trade Co2	-0.001*
	(-2.56)
Urban Population	0.000
	(-0.09)
Time fixed effects	Yes
Observations	330
R2 within	0.63
R2 overall	0.029
R2 between	0.016
* p<0.05, ** p<0.01, *** p<0.001	

Table 2: **Time of commitment and Co2 emissions (testing hypothesis 2)**

This table reports the output by regressing the cities' Co2 emissions on different commitment dates. All commitment dates are divided into three-time ranges. The time ranges are dummy variables and equal to one for each commitment within the respective period and zero for every commitment outside the time range. The coefficient Commitment x Co2 emissions measures the difference to the base case. The model includes time-fixed effects. All variables are defined in section B in the appendix. The t-statistics are reported in parentheses and are based on standard errors that are clustered at the company level.

	IIa	IIb	IIc
Commitment before 2010	-0.333**		
	(-2.98)		
Commitment before 2010 x Co2 Emissions	0.362***		
	(-4.84)		
GDP (normalized)	0.115	0.008	0.162
	(-1.54)	(-0.26)	(-1.81)
Consumption (per capita)	0.104	0.04	0.075
	(-1.45)	(-0.95)	(-1.28)
Energy (per capita)	0.024	-0.01	-0.008
	(-0.33)	(-0.22)	(-0.19)
Change in land used	0.000	0.000	0.000
	(-0.9)	(-0.55)	(-0.77)
Trade Co2	-0.001*	-0.001***	0.000
	(-2.24)	(-4.09)	(-0.93)
Urban Population	0.000	0.001	-0.001
	(-0.08)	(-0.65)	(-1.03)
Commitment between 2010 and 2014		-0.809***	
		(-9.93)	
Commitment 2010-2014 x Co2 Emissions		0.827***	
		(-9.61)	
Commitment between 2015 and 2020			-0.783***
			(-9.03)
Commitment 2015-2020 x Co2 Emissions			0.790***
			(-10.39)
Time effects	Yes	Yes	Yes
Observations	330	330	330
R2 within	0.636	0.75	0.651
R2 overall	0.038	0.294	0.377
R2 between	0.009	0.008	0.185
* p<0.05, ** p<0.01,*** p<0.001			

Table 3: **Profitability and Co2 emissions (testing hypothesis 3)**

Table 3 reports the output by regressing the cities' Co2 emissions on companies' ROA. The indicator is equal to one if the company has a positive ROA and zero otherwise. The model includes time-fixed effects. All variables are defined in section B in the appendix. The t-statistics are reported in parentheses and are based on standard errors that are clustered at the company level.

	III
Postive ROA	-0.005
	(-0.73)
GDP (normalized)	0.409**
	(-3.06)
Consumption (per capita)	0.214*
	(-2.11)
Energy (per capita)	-0.045
	(-0.46)
Change in land used	0.000
	(-1.54)
Trade Co2	-0.002**
	(-2.97)
Urban Population	-0.004
	(-0.99)
Time fixed effects	Yes
Observations	179
R2 within	0.893
R2 overall	0.072
R2 between	0.002
* p<0.05, ** p<0.01,	*** p<0.001

Appendix

A. Abbreviations

Co2	Carbon Oxygen
EUR	Euro
ETS	Emission Trading Schemes
GDP	Gross Domestic Product
GDPC	Gross Domestic Product per Capita
GHG	Green House Gas
IMF	International Monetary Fund
OECD	The Organisation for Economic Co-operation and Development
PPP	Public Private Partnerships
ROA	Return on Assets
U.S.	United States
UK	United Kingdom

B. Variable specification

Control Variable	**Description**
Return on asset (ROA)	Return on assets (ROA) is a financial statistic that measures how profitable a firm is in comparison to its total assets. It is the ratio of the companies net income and its total assets.
Co2 consumption per capita (Consumption)	The logarithm of the consumption-based Co2 emissions (million tons) represents the country's population's consumption and lifestyle choices.
Energy use per capita (Energy)	The logarithm of Co2 emissions per unit of energy per capita is used to assess a country's energy mix's carbon footprint.
Change in land used per capita (LUC)	"Land-use change" refers to any method that humans influence the general terrain. The variable indicates the sum of land use change and fossil CO2 emissions (million tons).

Continued on next page

Control Variable	Description
Trade Co2 per country (Trade)	Annual Co2 emissions (million tons) embedded in trading activities. Net importing countries have a positive value, and net exporters a negative value.
Urban population (UP)	Countries urban population as a percentage share the total population
Time (T)	Linear time trend measured in years
Length of commitment	Length of the individual commitment measured in years

C. Data specification

Company	City	Country	Year of Commitment
GVB Holding B.V.	Amsterdam	Netherlands	2010
Transports Metropolitans de Barcelona	Barcelona	Spain	2017
Berliner Verkehrsbetriebe	Berlin	Germany	2014
Keolis Bordeaux Métropole	Bordeaux	France	2018
Bremer Straßenbahn Aktiengesellschaft	Bremen	Germany	2009
Serviciul Transport Voluntari S.a.	Bucharest	Romania	2018
BKK Budapesti Közlekedési Központ Zártkörűen Működő Részvénytársaság	Budapest	Hungary	2018
Kölner Verkehrs-Betriebe Aktiengesellschaft	Cologne	Germany	2015
Metroselskabet I/S	Copenhagen	Denmark	2015
Rheinbahn AG (Düsseldorf)	Düsseldorf	Germany	2006
Rhein-Main-Verkehrsverbund GmbH	Frankfurt	Germany	2012
Transports publics genevois	Geneva	Switzerland	2017
De Lijn - Vsn Eesv	Gent	Belgium	2015

Continued on next page

Company	City	Country	Year of Commitment
Västtrafik AB	Gothenburg	Sweden	2006
HVV Hamburger Verkehrsverbund GmbH	Hamburg	Germany	2017
KVG Kieler Verkehrsgesellschaft mbH	Kiel	Germany	2017
Transtejo	Lisbon	Portugal	2014
Transport for London	London	United Kingdom	2018
Keolis Lyon	Lyon	France	2012
Mainzer Verkehrsgesellschaft mbH	Mainz	Germany	2018
Transport de l'Agglomération Nantaise	Nantes	France	2010
Ruter AS	Oslo	Norway	2016
Régie autonome des transports parisiens	Paris	France	2007
Sociedade de Transportes Coletivos do Porto	Porto	Portugal	2014
Prague Public Transit Co, Inc.	Prague	Czech Republic	2021
RP SIA Rīgas satiksme	Riga	Latvia	2014
Rostocker Straßenbahn AG	Rostock	Germany	2008
AB Storstockholms Lokaltrafik	Stockholm	Sweden	2016
Wiener Linien GmbH & Co KG	Vienna	Austria	2013
Würzburger Straßenbahn Gesellschaft mit Beschränkter Haftung	Würzburg	Germany	2018

Years	Average exchange rate US$ to EUR
2010	0.7611
2011	0.71815
2012	0.77834
2013	0.7531
2014	0.7541
2015	0.9015
2016	0.904
2017	0.8865
2018	0.848
2019	0.893
2020	0.877
2021	0.8458