CO_2-emissions from domestic goods transport in countries with high income and high equality

A study of changes in BNP/capita, trade intensity and GINI-index relating to CO2-emissions

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Abstract

Transportation is one of the largest sectors contributing to CO_2-emissions, and has doubled its emissions in 30 years. Despite this, studies of the environmental Kuznets curve (”EKC”) often focus on stationary industry emissions.

Studies of the EKC have detected an N-shape, rather than an inverted U-curve, indicating that rich nation’s emissions, in fact, increase again after the downturn. Possibly, this could be explained by a trend for inhabitants of wealthy countries with high equality to purchase local products and potentially reverse a trend of dirty-industry emigration. Local production and movement of intermediate goods demand domestic goods transportation. To my knowledge, no previous research has studied how changes in GDP/capita, trade intensity and GINI-index are related to CO_2-emissions from domestic goods transportation in wealthy countries with high equality.

To study the relationship, mathematical tests using Panel data with Fixed Effects Regression were used. Five countries qualified for the tests, having both high equality (lowest GINI-index) and high GDP/capita, and were included in the study for the year interval 2000-2020.

Test results showed a significant correlation between the following: (1) wealth coincides positively with CO_2-emissions, (2) trade intensity coincides negatively with CO_2-emissions and (3) GINI-index coincides positively with CO_2-emissions.

Methodologically, this study contributes with the estimator GDP/GINI-index, rather than GDP solely, which could be a better estimator for the richness of a country’s population. The mathematical test results indicate that domestic goods transportation could be a reason for the increased CO_2-emissions from developed wealthy countries. This could be a development of the environmental Kuznets curve.

Key words: Environmental Kuznets Curve (EKC), Trade, Goods transport, GINI-index, GDP

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1. Introduction

1.1 CO_2-emissions from Freight Transport

The energy efficiency of the transport sector is increasing. However, this is dwarfed by the strong growth of the sector, resulting in increasing total emissions (Hoen et. al. 2014). As reported by Van Fan et al. (2018) electricity generation contribute with 29% of greenhouse gas (GHG) emissions followed by transportation at 27%, which puts transportation close to the largest contributor of GHG. 76% of overall GHG emissions are CO_2 and the transport sector plays an even larger role for that specific gas since it contributes with 32% of total CO_2-emissions (Van Fan 2018). Within the freight transport sector 93-95% of GHG emissions are CO_2 (McKinnon & Piecyk 2010). The above-mentioned facts have motivated this study to focus on CO_2-emissions from the freight transport sector, while omitting all other gases and sectors.

1.2 The N-shape of the Environmental Kuznets Curve

In 1991, Grossman and Krueger (1991) unearthed that the inverted U-curve advanced by economist Simon Kuznets, known as the "Kuznets curve", might be applicable for environmental degradation and ecologically detrimental emissions. Grossman & Krueger (1991) suggest that when a poor nation improves its GDP/capita its emissions increase along the environmental Kuznets curve ("EKC") until a peak is reached, then the nation's emissions begin to decrease as income reaches high levels of prosperity. Many studies, like Cole (2004), elaborate with a pollution haven hypothesis, testing if the decrease in emissions after the peak can be caused by dirty industries emigrating from developed nations with strict emission standards into developing regions with weak environmental regulations, thereby dumping emissions upon developing nations. If such dumping is the sole reason for the downturn in the EKC it would eliminate the chance for the last developing regions to realize a decrease in ecological deprivation on their own, since there will be no more nations to dump the dirty industries upon. Suri & Chapman (1998) and Cole (2004) do detect an inverted U-shape with economic progress, but also a mathematical upturn at income levels higher than had, at the time, been achieved by any nation. In other words, they actually detect an N-shape, however, a reason for the N-shape is yet unknown.

1.3 A trend for the upper middle class to purchase local products

Isenhour & Feng (2016) note that the carbon intensity of the Swedish economy has decreased over the last several decades, but significant growth in household disposable income has parallelly increased consumer demand, contributing to a 40% increase in imports between year 2000 and 2008 alone. As a producer of goods, Swedish GHG-emissions in 2010 were below 1990-levels but consumption-based accounting reveal that growing consumer demand had contributed to a 25% increase in emissions, “hidden” in imports (Isenhour & Feng 2016). The EU and the Swedish government have launched campaigns and voluntary programs to raise consumer awareness and improve the efficiency of contemporary consumption patterns (Isenhour & Feng 2016). Effects from the campaigns and programs appear to have come quickly, as in 2013, 81% of Swedes responded that climate change was the most serious problem facing the world, and in 2014, 100% of Swedes agreed that protecting the environment is important and 96% believe they can play a role (Isenhour & Feng 2016). The ability to choose what you consume is conditioned upon willingness to pay and ability to pay. A group that has willingness to pay and ability to pay is the educated upper middle class. The upper middle class has the potential to grow large in numbers and represent a very large portion of a country’s consumption. If it’s a trend for the upper middle class to purchase local products, then growth of the upper middle class could potentially reverse the trend of dirty industry-emigration, which could give rise to increased local CO_2-emissions and explain the N-shape of the EKC.

CO_2-emissions from goods transport is the “wild west” compared to high energy demanding stationary industry, which is under control of the European emissions trading scheme “ETS”, and also, McKinnon (2007) reports that the contribution of the freight sector to global warming has so far received less attention than CO_2-emissions from car traffic and aviation. With more products and services being produced and performed locally, domestic goods transportation will increase, as parts, tools, products and intermediate goods are moved between factories, distributors, shops and consumers, instead of imports simply entering ports and being forwarded directly to shops or individual consumers. No studies to my knowledge, has tested the relationship between the amount of CO_2-emissions from domestic goods transportation and the size of the upper middle class in order to explain the N-shape of the EKC.

1.4 Research question

How are changes in GDP/capita, trade intensity and GINI-index related to CO_2-emissions from domestic goods transport in countries with a large upper middle class?

Delimitations: All countries were not included, only the countries with highest GINI-index and GDP/capita. In this study only the systematic model is considered, not the random.

2. Background and Previous Research

2.1 The Greenhouse Effect

If the temperature of the earth's surface becomes warmer, storms, hurricanes and category-5 storms increase in numbers, wind speed and intensity (Anthes et al. 2006). Tropical cyclones form over warm oceans, where they gain their energy from the latent heat of condensation. So, a warmer world would most likely contain increased overall hurricane activity (Anthes et al. 2006). Warmer sea surface temperature has been found to be associated with more active seasons, such as longer droughts and heavier rainfalls, while rainfall fluctuations have been shown to be correlated with an increased number of hurricanes (Goldenberg & Shapiro 1996). The *characteristics* of rain are more apt to be affected by climate change than the actual *amount* of rain, and while steady moderate rain soaks into the ground and benefits plants, intense heavy rain is more likely to cause flooding and runoff, leaving the ground drier (Trenberth et al. 2003). Unnatural changes of the global mean temperature will cause some living species to become extinct (Hughes 2000). When some particular gases, referred to as greenhouse gases, "GHG", are released close to the earth's surface they can accumulate in the atmosphere and, with time, trap heat like a greenhouse and increase the temperature in the air and on the earth's surface (IPCC 1995). Gases most commonly referred to as GHGs are carbon dioxide, methane and CFCs (Hoen et. al. 2014). From the beginning of the industrial revolution in the late 18^{th} century and on, combustion processes have been a common characteristic of human industry and life (Schön 2014). Fuel combustion causes GHG emissions, which possibly has affected the temperature trend of 0.6°C increased global mean surface temperature since the late 19^{th} century (Hughes 2000). Climate models predict the mean global surface temperature to increase by 1-3.5°C by year 2100 (Hughes 2000). To curb the trend of increasing global GHG emissions, the IPCC (1995) report was used as a base when the Kyoto protocol was launched as an international agreement to lower the global release of GHGs (Hoen et. al. 2014). The EU has created an emission trading scheme for the European energy intensive industry (Hoen et. al. 2014), but until recently there was no general emissions limit or imposed cost on emissions for the transport sector. The GHG emissions from industry and power generation are in a decreasing trend while the transportation sector instead was (in 2014) on a path to double its emissions from 1990 to 2020 (Hoen et. al. 2014). This stresses the need for increasing our knowledge regarding the nature of evolution of the EKC.

2.2 Econometric model

Grossman & Krueger (1991) is an advisory report for the first North American Free Trade Agreement (NAFTA) which was pending at the time. They study three pollutants and the relationship between air quality and economic growth. Environmentalists feared that the NAFTA would deteriorate an already bad environmental situation in Mexico while also putting pressure on the USA to lower their environmental standards to help domestic industry to be internationally competitive. At the time of their report, little was known about a country's trade policies' or stage of economic development's relationship with its rate of environmental degradation and pollution. Grossman & Krueger (1991) uses level measures of three pollutants present at different times and places and apply a stringent test of the relationship between national income and pollution during a twelve-year time period. They find an up-side-down U-shape for SO_2 in terms of national income. At low levels of income, the SO_2 levels are low while it increases with higher income until a peak is reached and the levels go down again. At very high levels of income the curve levels out or possibly rises again. They conclude also that the levels of SO_2 have internationally trended downward along with better knowledge of detrimental effects. Dark matter and mass of suspended particles show similar curves as SO_2, except at somewhat different levels of income, where the peaks are located somewhere in the GDP/capita range from $4,000 to $5,000. This has been recognized to resemble the Kuznets curve, but in the shape of an *environmental* Kuznets curve (EKC) with environmental degradation or substance emissions on the y-axis instead of Kuznet's equality-y-axis. The curves of the relationships that Grossman & Krueger (1991) finds, turns back up again at $14,000, which has been difficult to explain (Suri & Chapman 1998). Grossman & Krueger (1991) write repeatedly that one of environmentalists' biggest worries about NAFTA is the goods transportation, handled by a trucking industry with few regulations, and that international trade is a large reason for concern since free trade can induce countries and corporations to dump environmentally degrading production upon less regulated countries. However, the report has omitted to include any tests involving goods transportation. Suri & Chapman (1998) develop the Grossman & Kruger (1991) model to quantify the interaction of trade in manufactured goods with the growth-environment relationship. They use energy consumption as the environment-variable in a pooled cross-country and time-series data analysis to examine growth-trade-environment linkages (Suri & Chapman 1998). The general model that was employed by Grossman & Krueger, and recycled by Suri & Chapman is:

Equation 1: $Y_{it} = a_i + t_{\gamma} + \beta_1 X_{it} + \beta_2 X^2_{it} + \beta_3 X^3_{it} + \beta_k Z_{kit} + e_{it}$ (1)

where, i is 1,...N countries or cities; t is 1,...T years or time intervals; Y_{it} is the environmental stress variable; a_i is the country or site specific effect; γ_t is the time specific effect; X_{it} is the real GDP/capita; Z_{kit} are the other variables that impact environmental quality (i.e. trade intensity) and e_{it} is an error term.

The model was initially used, in several studies, to analyse the impact of trade policy orientation on pollutant generation, which is a relevant and logical approach but it doesn't focus directly on the impact of trade through the actual flow of goods between countries (Suri & Chapman 1998). Suri & Chapman (1998) develop the model by adding import and export contra manufacturing variables to catch the effect of energy consumption hidden in imports. Suri & Chapman (1991) too, however, ignore to make a measure or identify any effects from the actual transportation of the goods in question.

Cole (2004) continues to explore the base formula from Grossman & Kruger (1991) and Suri & Chapman (1998), but with a slightly different focus, when he explores to which extent the EKC's inverted U relationship can be explained by trade, and specifically the migration of dirty industries. He calls the displacement of dirty industries from developed regions to developing regions the pollution haven hypothesis (PHH) (Cole 2004). An expansion of tests, performed by Cole (2004), is that he tests more industries than just the dirty or most energy demanding branches, as he puts geographical regions in trade pairs and compares net exports as a proportion of consumption. When he compensates the environmental impact for pollution haven behaviour, he finds that the inverted U-shape is still achieved, but the emissions' peak arrives at higher levels of GDP than if production emigration is ignored. After all, he finds compelling evidence of a positive relationship between trade openness and environmental quality for OECD countries, where, in most cases, trade openness results in a reduction of emissions (Cole 2004). As also Cole (2004) chooses to omit any effects on goods transportation and its emissions, this study has chosen to test the relationship between CO_2-emissions from domestic goods transportation and GDP/capita, GDP/capita^2, GDP/capita^3, GDP/capita over GINI-index, trade intensity and GINI-index.

2.3 GDP and GINI-index as a measure for wealth

It is well established that the income measure of GDP/capita isn't a perfect measure for how wealthy a country's middle class is, since it doesn't account for equality (cf. Ray 1998, p.23). As this study wishes to measure the size and/or growth of the upper middle class, an addition to GDP/capita is made in the GINI-index, based on the GINI coefficient. The GINI coefficient is all income differences in a country calculated in a formula, establishing the GINI-index, where index 100 means absolute inequality and index 0 means absolute equality, in terms of measurable income (cf. Ray 1998, pp.188-189). To avoid mistaking extreme wealth of a small upper class with a large influential middle class, this study divides each of the studied countries' GDP/capita with their GINI-index for each year. The resulting variable is "GDP/capita over GINI-index", which will be used as a proxy for the size of the upper middle class. As an example: country A has a GDP/capita of $30,000 and country B has $20,000 while A's GINI-index is 80 and B's GINI-index is 40. The calculation gives, A: 30,000/80=375 and B: 20,000/40=500. In a regular measure of GDP/capita, country A would be considered richer than country B. However, country A's income is highly concentrated to a small upper class and the remaining citizens struggle to make due, while country B most likely has a wealthier middle class. Since studies that test the effect of an affluent middle class on CO_2-emissions are lacking, the calculated variable of "GDP/capita over GINI-index" will be essential, with country B's quotient of 500 overtrumping A's 375. Several previous studies have put emphasis on a squared GDP-variable to represent aspects such as structural transformation in the composition of GDP and increasing environmental awareness and regulation (Suri & Chapman 1998). There are no studies that, instead, rely on the strength of the middle class to represent this impact. This could be a new point of view, especially since previous studies have struggled regarding CO_2 predictions. Many energy conservation efforts undertaken have largely been responses to energy prices, rather than environmental controls or regulations, incapacitating the squared GDP from picking up the effect of regulation (Suri & Chapman 1998). This study does, however, still include GDP squared and GDP cube in the analysis for comparative reason.

2.4 Trade

Behavior of replacing imports with domestically produced goods should show up in a country's trade intensity. The trade intensity data (World bank) is expressed in foreign trade as a percentage of GDP. A basic assumption of this study is that increased foreign trade will decrease the amount of CO_2-emissions from domestic goods transport. This does not imply that global CO_2-emissions from goods transport will decrease, but rather the contrary, when, for instance, long-haul container transports are replaced by purely domestic transportation.

3. Research methodology

The empirical analysis consisted of data collection and mathematical tests. The data collection consisted of literature search and searching well known economic databases. A Panel data sheet was constructed and regression analyses were conducted and plotted for each of the independent variables together with the dependent variable in Excel. Since the results showed interesting correlations, multiple regressions with fixed effects was conducted in the statistical computing and graphics environment “R”.

3.1 Data Collection

To find the data of interest, economic databases were searched. The CO_2-emissions for the countries’ coastal shipping freight transport, inland waterways freight transport, rail freight transport and road freight transport were found in “OECD.Stat”, by entering “https://stats.oecd.org/” (OECD.Stat. 2022a, 2022b, 2022c, 2022d). GDP/capita (GDPpC), GINI-index and trade intensity (Trade) were found by searching the World bank website (World bank, 2022a, 2022b). GDP/capita^2 (GDPpCsq), GDP/capita^3 (GDPpCcu) and GDP/capita over GINI-index (GDPpCoGINI) were calculated from GDP/capita and GINI-index. See Table 1 for details of the variables.

Table 1: Variables

Variable	Definition	Unit	Source
Trade	Trade is the sum of exports and imports of goods and services measured as a share of GDP.	%	World Bank national accounts data, and OECD National Accounts data files.
GINI_index	The GINI-index displays income differences.	Index 0 represents perfect equality, index 100 is absolute inequality.	Worldbank, World Development Indicators
GDPpC	Gross Domestic Product per Capita	Current international USD converted by purchasing power parity (PPP)	Worldbank, World Development Indicators
GDPpCsq	GDPpC x GDPpC		
GDPpCcu	GDPpCsq x GDPpC		
GDPpCoGINI	GDPpC divided by GINI-index	Current international USD converted by PPP/GINI-index	
Population	All residents, regardless of legal status or citizenship. The values are midyear estimates.	Humans	Worldbank, World Development Indicators
gCO2_Millions	Million gram tonnes-kilometres	Tonnes-kilometres, Millions	OECD. Statistics from transport ministries, statistical offices and institutions designated as official data sources.
gCO2population	Million gram tonnes-kilometres per capita	Tonnes-kilometres per capita, Millions	

3.2 Sample

To find populations with high wealth and high equality, the countries with lowest GINI-index, and highest GDP/capita, were identified. Out of the 27 countries with a GINI-index lower than 30 (World bank 2022b) and the 20 countries with a GDP/capita higher than $50,000 (World bank 2022a), five countries were on both lists. These were: Denmark, Iceland, The Netherlands, Norway and Sweden. The year interval 2000-2020 was chosen as this is a period when the likelihood of a late stage upturn of the EKC is strong.

3.3 Mathematical tests

The econometric model used in this study for expressing the relation between the dependent and independent variables is;

Equation 2: $Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_N X_{Kit} + e_{it}$ (2)

For i = 1, 2, ..., N and t = 1, 2, ..., T. e = random.

As i = country and t = year.

This is a common way of expressing a multiple regression model when panel data (both series of time and cross-sectional data) is used (Stock & Watson 2020, p.367), and it is consistent with previous studies about the EKC.

McKinnon & Piecyk (2010) have summarized the CO_2-emission rates for road, sea, rail and air transport (see their results in Table A1 in Appendix A), and they show that road transport emits 62 gCO_2 per tonne-km transported, rail transport emits 22 gCO_2 per tonne-km while short sea transport emits 16 gCO_2/tonne-km. OECD data (https://stats.oecd.org/) on the amount of domestic goods transportation with the different modes is multiplied with the CO_2-emission rates from Table A1, which yields the total CO_2-emissions from domestic goods transport for each year between 2000 and 2020. The total CO_2-emissions for each year divided by each country's population each year result in the dependent variable gCO_2-emissions per capita, which can be seen in Tables B1, B2 and B3 in Appendix B (column gCO2population). The independent variable GDP/capita was divided by GINI-index to form another independent variable, called GDP/capita over GINI-index, as a measure of a country's middle class' purchasing power (for more detail see chapter 2.3). For the purpose of displaying the data clearly, two plots and one regression are shown with the mean values for each year across the included countries. The mean values are listed at the bottom of Table B3 with the pseudo name "Mean".

Two different equations are tested. Equation 3 resembles previous studies, and equation 4 incorporates the equality input of this study. Adding variables to the equations, the econometric models are:

Equation 3: $CO_2 = \beta_0 + \beta_1(GDP/c)_{it} + \beta_2(GDP/c)^2_{it} + \beta_3(GDP/c)^3_{it} + \beta_4 TRADE_{it} + e_{it}$ (3)

Equation 4: $CO_2 = \beta_0 + \beta_1((GDP/c)/GINI)_{it} + \beta_2 TRADE_{it} + \beta_3 GINI_{it} + e_{it}$ (4)

3.4 Panel Data

To investigate if and how the changes in GDP/capita, trade intensity and GINI-index are related to CO_2-emissions for several countries, regression with panel data is required. Panel data means that each entity, in this case country, is observed for at least two time periods (Stock & Watson 2020, p.361). The change over time of a dependent variable is studied and the effect of omitted variables is possible to eliminate (Stock & Watson 2020, p.361). A panel that has some missing data is called an unbalanced panel (Stock & Watson 2020, p.362). For this study, 20 time periods are used, from 2000-2020, for five entities (countries) and six independent variables (GDP/capita, $(GDP/capita)^2$, $(GDP/capita)^3$, "GDP/capita over GINI-index", trade intensity and GINI-index).

3.5 Fixed Effects Regression

In this study Fixed Effects regression was used. If two or more time periods are studied it is possible to eliminate the effect of omitted variables (Stock & Watson 2020, p.367), for example in this case; size of population. The method of fixed effects regression controls for omitted variables when the omitted variables vary across entities but not over time (Stock & Watson 2020, p.367).

3.6 Least Squares Assumptions

For Multiple regression, upon which Panel Data and Fixed Effects regressions are based, there are four least square assumptions for causal inference (Stock & Watson 2020, p.225).

Assumption 1; *Linear relationship*. For each value of x, there are corresponding y values. The y values follow the normal distribution, which is normally assumed when observations exceed 30 in numbers. The means of these normal distributions lie on the regression line (Lind et al. 2018, p.467). Since the number of observations exceeded 30 in this study, a linear relationship was assumed.

Assumption 2; *Multivariate normality*, when the marginals (residuals) are normally distributed (Stock & Watson 2020, p.79), and *correctly specified functional form*. A Ramsey Reset Test for panel data regression PD4 (see Appendix C) shows that the hypothesis of correct functional form cannot be rejected.

Assumption 3; *Multicollinearity*, is when a regressor is a linear function of another regressor (Stock & Watson 2020, p.226), meaning that independent variables are correlated with each other. In this study, the multicollinearity was checked by conducting a correlation test of the independent variables. Multicollinearity was clearly detected between GDP/capita, GDP/capita^2, GDP/capita^3 and GDP/capita over GINI-index (see Appendix D), instigating the decision to never test GDP/capita over GINI-index in the same regression as the other GDP-variables.

Assumption 4; *Homoscedasticity*, is when the variance of error terms are similar for all values of the independent variables (Stock & Watson 2020, p.219). Heteroscedasticity is when the curve's confidence interval can resemble a tilted hourglass, potentially impossible to detect within our sample range, but quite possibly existing outside the range studied in this paper.

4. Results

The first aim of this chapter is to display the data at hand, beginning with Table 2. As recommended by Stock & Watson (2020, p.555), the empirical analysis starts, in section 4.1, by plotting the data for maximum clarity. Section 4.2 shows regressions and 4.3 shows the Panel Data analyses.

Table 2. Summary statistics.

	Trade	GINI_index	GDPpC	GDPpCoGINI	Population	gCO2population
Denmark						
Mean	96,57238095	26,87222222	43058,37714	1609,940736	5561354,952	141374,3233
Median	100,17	27,25	43003,05	1619,075517	5547683	138690,5051
Standard deviation	9,291239909	1,483559137	9986,088628	260,5570241	160592,2144	14052,41976
Minimum	80,88	23,8	28658,12	1203,921484	5339616	119033,9837
Maximum	110,61	28,7	60229,91	2119,168592	5831404	176981,7068
N	21	18	21	18	21	19
Iceland						
Mean	83,79333333	27,80666667	43200,84571	1552,184034	318171,8095	168145,7126
Median	84,09	27,2	41864,19	1518,141221	318499	161124,5247
Standard deviation	11,81110636	1,742521435	8650,801998	269,3779512	24659,5377	20240,22764
Minimum	68,2	25,4	29779,09	1220,120896	281205	148273,3555
Maximum	104,09	31,8	58290,1	2131,742912	366463	209332,5886
N	21	15	21	15	21	19
Netherlands						
Mean	136,3095238	28,60625	45436,50048	1666,504009	16643035,71	253249,7021
Median	131,52	28,35	46420,2	1694,490494	16615394	251968,5682
Standard deviation	15,9545039	0,775	8619,558542	244,9340608	434568,9201	8906,991618
Minimum	111,92	27,6	31870,83	1201,670805	15925513	238366,2822
Maximum	158,82	30	59266,91	2057,887189	17441500	270668,3791
N	21	16	21	16	21	21
Norway						
Mean	69,82285714	27,33888889	55695,77143	2110,609812	4909850	309841,4681
Median	69,16	27,05	58939,91	2224,458167	4889252	310551,0771
Standard deviation	2,628598758	1,601520927	10946,43109	418,7400368	307275,4409	14112,4776
Minimum	65,33	25,3	36936,49	1346,517089	4490967	283101,6126
Maximum	74,89	31,6	69808,33	2542,987549	5379475	333878,2442
N	21	18	21	18	21	21
Sweden						
Mean	83,97333333	27,88823529	42469,75476	1567,037404	9459610,571	321575,7989
Median	83,75	27,7	42223,92	1608,069097	9378126	318307,459
Standard deviation	4,445756778	1,31190813	8413,321601	182,2285218	483874,8183	14217,57713
Minimum	75,25	25,3	29618,28	1257,504348	8872109	293075,8047
Maximum	92,56	30	55037,72	1863,43959	10353442	353936,0606
N	21	17	21	17	21	21
Total						
Mean	94,09428571	27,675	45972,2499	1709,004409	7378404,61	242167,1983
Median	85,79	27,7	44803,97	1638,783782	5547683	252445,2241
Standard deviation	24,89307256	1,507481343	10459,62757	354,018257	5502119,936	74084,13687
Minimum	65,33	23,8	28658,12	1201,670805	281205	119033,9837
Maximum	158,82	31,8	69808,33	2542,987549	17441500	353936,0606
N	105	84	105	84	105	101

4.1 Correlation plots

Figure 1 plots the mean values of all countries included in this study for each year 2000 to 2020. An N-shape is somewhat visible, when a CO_2-emissions rise with GDP/capita between $30k and $40k is followed by a cluster of lower points between $40k and $50k, leading into a steady rise again over $50k.

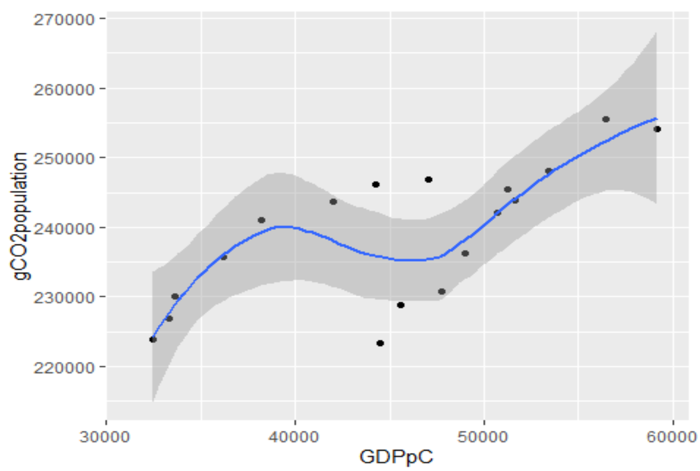


Figure 1. Mean values of GDP/capita's relation to gCO2-emissions/capita from domestic goods transport.

Figure 2 shows the mean values of GDP/capita over GINI-index and CO_2-emissions for all countries included in this study for each year 2000 to 2020. An N-shape is somewhat visible, when a CO_2-emissions rise with GDP/capita over GINI-index between ~1280 and 1600 is followed by a cluster of lower points between 1600 and 1800, leading into a steady rise again over 1800.

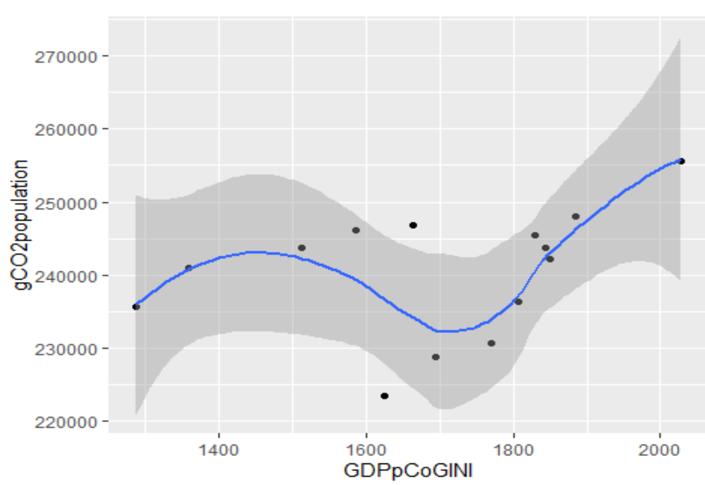


Figure 2. Mean values of GDP/capita over GINI-index' (unit: $/GINI-index) relation to gCO_2-emissions/capita from domestic goods transport.

Figure 3 shows GDP/capita over GINI-index' relation to CO_2-emissions in Sweden. An up-side-down U-shape is somewhat visible, when a CO_2-emissions rise with GDP/capita over GINI-index between 1200 and 1450 is followed by points scattered seemingly random between 1450 and 1630, leading into a steady slow decline over 1630.

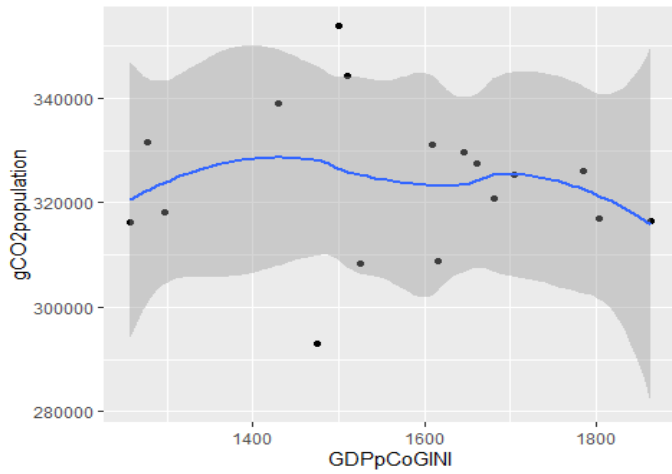


Figure 3. The data points for GDP/capita over GINI-index' relation to gCO2-emissions/capita from domestic goods transport in Sweden for each year between 2000 and 2020.

Figure 4 shows GDP/capita over GINI-index' relation to CO_2-emissions in Iceland. An N-shape is quite clearly visible, when a CO_2-emissions rise with GDP/capita over GINI-index between ~1200 and 1400 is followed by a downturn between 1400 and 1600, leading into a steady rise again over 1600.

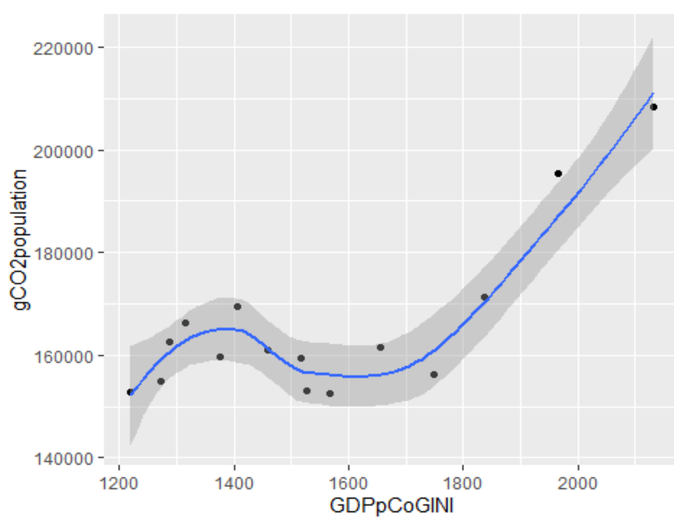


Figure 4. The data points for GDP/capita over GINI-index' relation to gCO_2-emissions/capita from domestic goods transport in Iceland for each year between 2000 and 2020.

Figure 5 shows GDP/capita over GINI-index' relation to CO_2-emissions in Denmark. A shift is clearly visible, with a flat line between 1200 and 1600, followed by a steady rise over 1600.

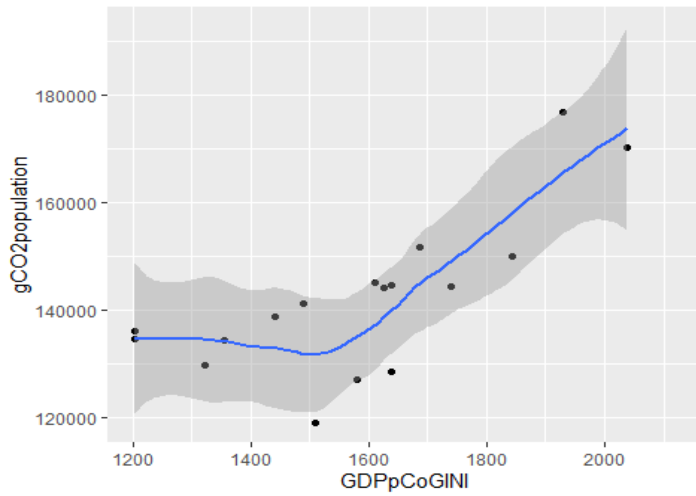


Figure 5. The data points for GDP/capita over GINI-index' relation to gCO₂-emissions/capita from domestic goods transport in Denmark for each year between 2000 and 2020.

Figure 6 shows GDP/capita over GINI-index' relation to CO_2-emissions in the Netherlands. A declining wave-shape is somewhat visible, when a (relatively) high level of CO_2-emissions is steady between 1200 and 1600, followed by a sharp drop and then continues at a lower level between 1600 and 2100.

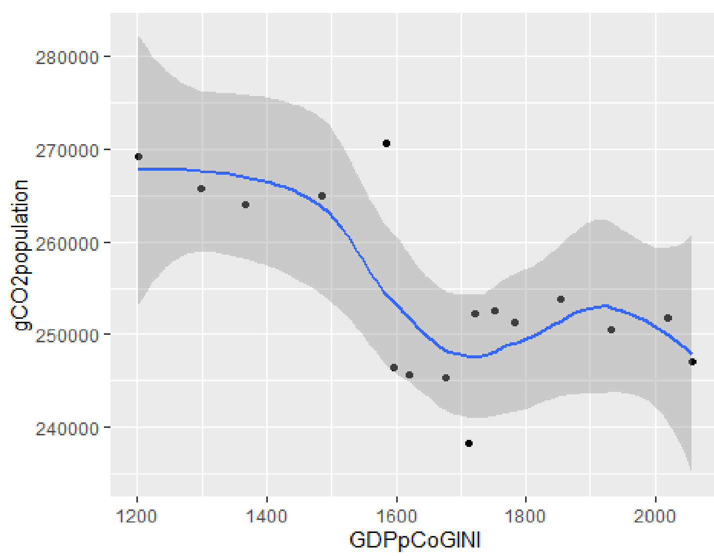


Figure 6. The data points for GDP/capita over GINI-index' realtion to gCO_2-emissions/capita from domestic goods transport in the Netherlands for each year between 2000 and 2020.

Figure 7 shows GDP/capita over GINI-index' relation to CO_2-emissions in Norway. A continuous increase of gCO_2/capita is somewhat visible with increasing GDP/capita over GINI-index. There is a data gap between 1600 and 2030 which causes uncertainty in the shape of the trend.

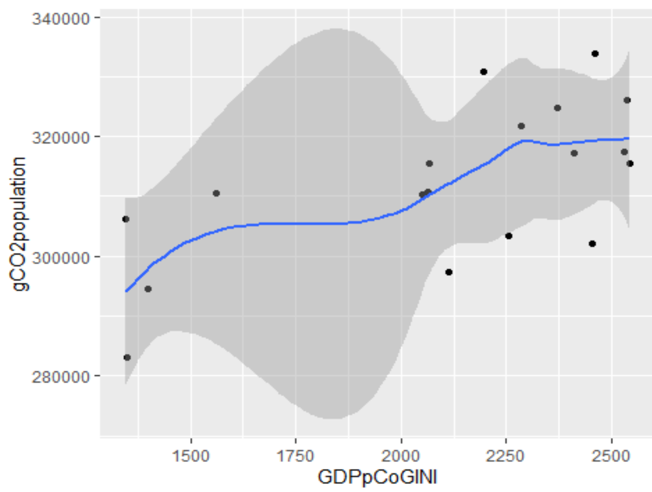


Figure 7. The data points for GDP/capita over GINI-index' connection to gCO_2-emissions/capita from domestic goods transport in Norway for each year between 2000 and 2020.

4.2 Regressions

Regressions R1 and R2, displayed in Table 3, tests this study's assumption regarding trade intensity's relation with CO^2-emissions from domestic goods transport. R1 tests the mean values while R2 includes all countries' data points. The entire confidence interval in R1 shows a positive relationship between trade intensity and CO_2-emissions. The probability value shows significance at the 99% level. The adjusted R^2 is 0.35. The confidence interval in R2 runs from negative to positive regarding the relationship between trade intensity and CO_2-emissions. The probability value is insignificant. The adjusted R^2 is 0.96.

Table 3. Results from regressions R1 and R2.

	R1	**R2**
Trade	840.384 **	164.533
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.		

The plots for regressions R1 and R2, in Figures 8 and 9, show large differences between each other. The data points indicate a random scatter and R2 displays potential clustering problems.

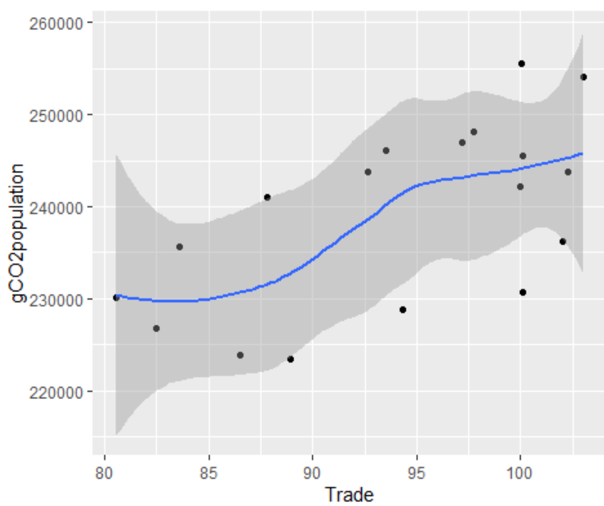


Figure 8. Plot of regression R1. Trade intensity's relation with gCO_2/capita for the mean values of all countries for each year.

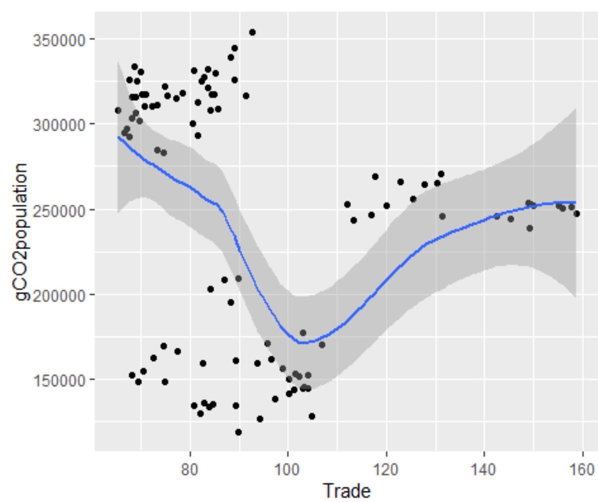


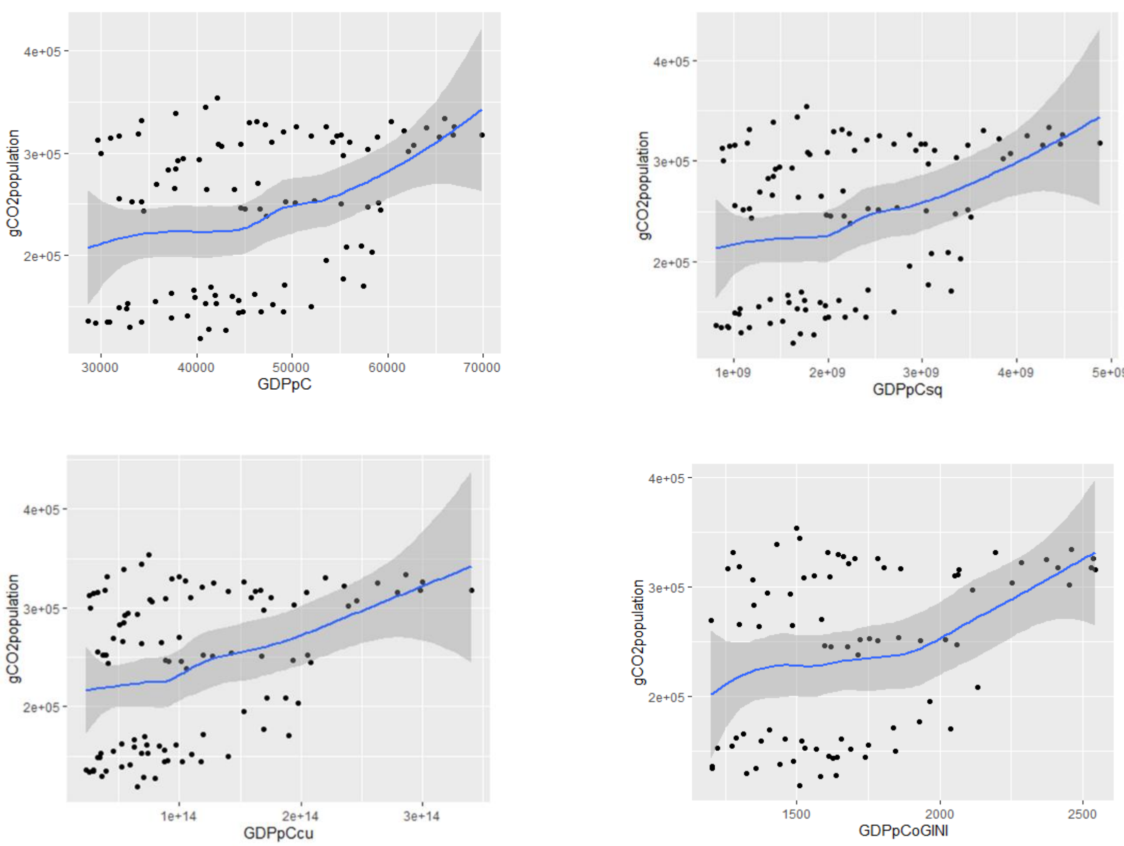
Figure 9. Plot of regression R2. Trade intensity's relation with gCO_2/capita for all countries for each year.

Table 4 shows the results from Regressions R3-R6. All GDP-variables (GDP/capita, GDP/capita^2, GDP/capita^3, GDP/capita over GINI-index) are highly significant when tested individually towards CO_2-emissions from domestic goods transport. They all show a positive correlation which indicates that higher GDP/capita coincides with higher CO_2-emissions from domestic goods transport.

Table 4. Regressions R3-R6, testing all GDP-variables' relations to CO2-emissions from domestic goods transport.

	R3	R4	R5	R6
GDPpC	0.848 ***			
GDPpCsq		9.237e-06 ***		
GDPpCcu			1.260e-10 ***	
GDPpCoGINI				19.136 **

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.



Figures 10-13. The GDP-variables' individual relations to CO_2-emissions.

4.3 Panel Data regressions

Panel Data regressions PD1-PD4 feature data for all countries and all years. Their results are shown in Table 5. PD1 is the test for Equation 3. None of the variables are significant in PD1, possibly due to multicollinearity issues (see Table D1 in Appendix D). PD2 is a test to eliminate multicollinearity by excluding all GDP-variables except GDP/capita. The multiple regression in PD2 of GDP/capita's and trade intensity's correlation with CO_2-emissions from domestic goods transport show that GDP/capita and trade intensity are significant with probability values above the 95% level. A test was made to also include the GINI-index in PD2, but because of insignificance, the GINI-index was excluded. Adjusted R^2 is 0.97 in PD2. The positive relationship between GDP/capita and CO_2-emissions indicate that increases in GDP/capita coincide with increased CO_2-emissions. Trade intensity displays a negative relationship with CO_2-emissions indicating that increased imports & exports coincide with a lower level of CO_2-emissions from domestic goods transport. A regression is run with independent variables GDP/capita^2, trade intensity and GINI-index, but GINI-index comes up insignificant (similarly to the procedure in PD2), so GINI-index is excluded, resulting in PD3. GDP/capita^2 has positive correlation and trade intensity has negative correlation with CO_2-emissions in PD3. Both trade intensity and GINI-index are insignificant when tested together with GDP/capita^3, rendering that regression's exclusion from Table 5 (see regression R5 in Table 4 for test of GDP/capita^3's sole correlation with CO_2-emissions). PD4 is the test for Equation 4. PD4 is a multiple regression of GDP/capita over GINI-index', trade intensity's and GINI-index' correlation with CO_2-emissions from domestic goods transport. All the independent variables are significant at the 95% level. Adjusted R^2 is 0.97. GDP/capita over GINI-index displays a positive relationship with CO_2-emissions indicating that increases in GDP/capita over GINI-index coincide with increased CO_2-emissions from domestic goods transport. Trade intensity displays a negative relationship with CO_2-emissions indicating that increased imports & exports coincide with a lower level of CO_2-emissions from domestic goods transport. GINI-index displays a positive relationship with CO_2-emissions indicating that more inequality coincides with more CO_2-emissions from domestic goods transport.

Table 5. Results from Panel Data regressions PD1-PD4.

	PD1	PD2	PD3	PD4
GDPpC	-7.762	1.074 ***		
GDPpCsq	1.636e-04		1.107e-05 ***	
GDPpCcu	-9.880e-10			
Trade	-253.229	-374.888 **	-310.494 *	-338.231 *
GINI_index	1653.708			2404.006 **
GDPpCoGINI				26.355 ***

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

5. Discussion

5.1 Results discussion

The scatter plot of GDP/capita and CO_2-emissions/capita are shown in Figure 1. These variables are close to the fundamentals in the regular EKC. The mean values for all the countries included in this study show a wave-shape, reminding of an N-shape. The shape could indicate support for waves of shifting consumption between home produce and imports, depending on consumer wealth. In order to get a clearer view of consumer wealth, this study tests GDP/capita over GINI-index, as an identification of high wealth for the middle class, featured in Figure 2, by the mean values for all countries for each year. It shows a similar shape as Figure 1 but with a slightly more accentuated dip between the waves and a sharp rising wave as GDP/capita over GINI-index goes very high, indicating that a situation with high GDP/capita and low GINI-index (wealthy middle class) coincides with very high CO_2-emissions from domestic goods transport.

Figures 3-7 are scatter plots for GDP/capita over GINI-index and CO_2-emissions/capita for all five individual countries included in the study. The data points in Figure 3 for Sweden appear to be scattered almost randomly, but a "classic" EKC inverted U can be detected. Figure 4 for Iceland has, on the contrary, a narrow confidence interval, showing a clear N-shape with higher CO_2-emissions from domestic goods transport with a wealthier middle class, potentially preferring home produce over imports. Figure 5 for Denmark also displays a shape of high CO_2-emissions with high GDP/capita over GINI-index, possibly indicating support for waves of shifting between home produce and imports, depending on the size of the upper middle class, or alternatively, a continuous rise over a certain level of wealth. Figure 6 for the Netherlands shows lower figures for CO_2-emissions from domestic goods transport with higher GDP/capita over GINI-index. This shape could indicate support for waves of shifting between home produce and imports, depending on the size of the upper middle class. The shape differs compared to the other countries, both as the CO_2-emissions per capita are relatively high at the low levels of GDP/capita over GINI-index and that the emissions' decline continues all the way to the top of the GDP/capita over GINI-index. Possibly, the Netherlands are in a different phase of development compared to the other countries in the study, or perhaps the data is pseudo-tainted by the fact that the Netherlands are home to the largest sea-port in Europe (Rotterdam), transiting goods from ocean going bulk- and container-carriers from around the world to many large markets on the European continent. The graph could nonetheless indicate that the Dutch upper middle class prefers to import their emissions. Figure 7 for Norway has a gap in the middle of GDP/capita over GINI-index making it difficult to interpret the shape of its correlations. There appears, however, to be a positive correlation between GDP/capita over GINI-index and CO_2-emissions from domestic transport. This shape could indicate support for waves of shifting between home produce and imports, depending on the size of the upper middle class. The available shape (with these data) indicates a continuous rise in CO_2-emissions from domestic goods transport with a growing upper middle class.

One of the central assumptions of this study is the correlation between trade intensity (imports' & exports' percentage to GDP) and CO_2-emissions from domestic goods transport. This study hypothesises there to be a negative correlation between the two. The negative correlation might indicate that producing goods for domestic use domestically instead of importing them will increase domestic CO_2-emissions from domestic goods transport. If this assumption is incorrect, it is difficult to motivate CO_2-emissions from domestic goods transport as the dependent variable. Regression R1 in Table 3 tests correlation between the mean values of trade intensity and CO_2-emissions from domestic goods transport for all the countries in the study. It establishes a significant positive relationship at the 99% level, possibly undermining the choice of dependent variable. However, the plot in Figure 8 displays a randomly scattered board of data combined with the low adjusted R^2-value of 0.35. The low R^2-value indicates that the sole trade intensity variable doesn't explain much, and that the nature of correlation between these variables might be reversed once more independent variables are included as explanatory variables. Moreover, there are only 16 degrees of freedom in R1, which motivates regression R2 (Table 3), with all countries' individual data for each year, expanding to 95 degrees of freedom. The correlation is still positive, however, with a smaller coefficient, a 95% confidence interval spanning from minus to plus and significant only at the 80% level. The scatter plot displays clusters. With an R^2-value of 0.96, this regression is more complete than R1 and the insignificant correlation insinuates that R1 should be disregarded, as R1 features the means of these values. The trade intensity variable will be further evaluated below.

Table 4 shows the results from Regressions R3-R6, where all the GDP-variables are tested individually toward CO_2-emissions. All countries' datapoints are included and all the regressions are highly significant. R3 features GDP/capita's positive correlation with CO_2-emissions. The scatter plot in Figure 10 shows no sign of an inverted U-shape, nor is there an N-shape. It is a steady increase of CO_2-emissions with increasing values of GDP/capita, as there are no datapoints in this study where relatively high GDP/capita coincides with relatively low values of CO_2-emissions. Regressions R4-R6 are all similar to R3, but feature GDP/capita^2, GDP/capita^3 and GDP/capita over GINI-index, respectively, instead of GDP/capita. There are no signs of inverted U-shapes, nor are there N-shapes in their scatter plots of Figures 11-13. They are all steady increases of CO_2-emissions with their increasing respective GDP-values. The high CO_2-emissions at high levels of GDP/capita over GINI-index in Figure 13 could indicate that a large upper middle class prefers to shop local/domestic produce over imports, inducing more domestic goods transport instead of importing emissions from abroad. Potentially, this could be the upturn at the end of the N-shape of the EKC, assuming that the positive correlation between trade intensity and CO_2-emissions are false.

The panel data regressions in Table 5, with multiple independent variables, should provide an accurate view of existing correlations and their nature. Panel data regression PD1, featuring the variables from Equation 3, is a test of the math used in the previous research of Suri & Chapman (1998) and Cole (2004). PD1 results in the same correlation directions as obtained by Cole (2004) for CO-emissions, with negative coefficients for GDP/capita, GDP/capita^3 and trade intensity while GDP/capita^2 has a positive coefficient. This study, however, fails to show any significance in this regression, possibly due to the high multicollinearity between the three GDP-variables, shown in Table D1 in Appendix D and visualized by the likeness of Figures 10, 11 and 12. The values from PD1 are not presented inserted into Equation 3 due to the lack of significance. PD2 was first regressed with the independent variable GINI-index included, but since GINI-index lacked significance it was excluded from the regression. After the exclusion of GINI-index, PD2 shows significance for both GDP/capita and trade intensity, where GDP/capita is positively correlated while trade intensity is negatively correlated with CO_2-emission. With a higher R^2 (0.97), the PD2 result opposes the result in R1 (for mean values) in regards to trade intensity’s correlation with CO_2-emissions. Both are significant but the R^2-value is remarkably higher in PD2, indicating that this result is far more reliable because the regression is much more complete, featuring more variables that explain the results. This negative relationship matches the assumption made in this study. The results from PD3 resemble the ones from PD2, only with GDP/capita replaced by GDP/capita^2. Trade intensity has a significant negative coefficient, also in PD3. Tests with

GDP/capita^3, trade intensity and GINI-index as independent variables failed to show significance for trade intensity and GINI-index and was therefore excluded from Table 5 (see regression R5 for GDP/capita^3's lone correlation with CO_2-emissions). Regression PD4 is similar to PD1, except that GDP/capita, GDP/capita^2 and GDP/capita^3 are replaced by GDP/capita over GINI-index. All independent variables featured in this regression are significant at the 95% level or above, indicating that wealth coincides positively with CO_2-emissions, trade intensity coincides negatively with CO_2-emissions and, in addition, that GINI-index coincides positively with CO_2-emissions. The positive slope for GDP/capita over GINI-index matches Figure 13, showing that more equality induces less CO_2-emissions from domestic goods transport. The negative slope of trade intensity matches the assumption made in this study. The significance of GINI-index, enables the inclusion of GINI-index in the final evaluation, therefore making this regression suitable for analysis. Regression PD4 put into Equation 4 becomes:

$$CO_2 = \beta_0 + 26{,}355((BNP/c)/GINI)_{it} – 338{,}231TRADE_{it} + 2404{,}006GINI_{it} + e_{it}.$$

5.2 Methodological Considerations

A strength with this study is the choice of outcome variable. Rather than choosing the total CO_2-emissions for a country, including stationary industries and personal transport emissions, this study focuses on domestic goods transport; road, shipping (inland waterways) and rail transport. An uncertainty in the data could be the exclusion of containers. The OECD data base has a category of containers that include goods, as well as passengers (OECD.Stat. 2022a), and was therefore excluded from the data set. Nor was air freight included. Another uncertainty is the presence of thoroughfares. Due to Sweden's, Norway's and Iceland's placements, the number of thoroughfares are limited, while Denmark, and above all, the Netherlands, may have a larger extent of thoroughfares. Domestic transport via air was considered too small to be included in this study. Moreover, as with most data, the reporting from the authorities from each country may have a certain degree of uncertainty, as they are all estimates. Nevertheless, investigating change can still be valid.

Next, there are a number of advantages using panel data for multiple regression analysis. For example, panel data has greater capacity for capturing the complexity of economic behaviours than time series or cross-sectional data separately (Hsiao 2005). However, a challenge putting together a panel data set could be lack of data (Hsiao 2005). In this study the data availability of GINI-index before 2000 was missing. With a longer time frame, going back to the 19th and 20th centuries, an earlier picture of the EKC would have been possible to examine. For example, it would have been possible to look into countries going from poor to wealthier economies. Nevertheless, as pointed out in the introduction, the focus of interest in this study is the latest part of the EKC, hence the selection of countries, and the time frame of 20 years is therefore sufficient.

The emissions per transport mode are taken from the list in McKinnon & Piecyk (2010). It can be argued that the list in McKinnon & Piecyk (2010) is especially measured for the chemical industry and not representative as a summary of all freight transport, but the chemical industry appears to be one of the most progressive sectors in its measurement of transport-related emissions (McKinnon & Piecyk 2010) and therefore suitable as the most proper fact base.

Regarding the sample of countries; they were not a random sample, but rather a very specific group of countries with high GDP/capita and low GINI-index. There may be sample bias that can have led to inconsistent estimators, possibly because transit traffic is very different in different countries which can cause very different numbers for domestic goods transport.

5.3 Further research

A larger scope is needed for testing what happens with the CO_2-emissions in other countries when they increase or decrease their GDP/capita over GINI-index. Will the total CO_2-emissions be reduced or are they moved to other countries? For example, are they increasing both in Sweden and China at the same time? With higher awareness of environmental dumping, do the countries with high GDP/capita over GINI-index take back the industries and reduce the global CO_2-emissions through technical development? The technical development of trucks, boats and trains, and other transport modes, may, however, in the future lower CO_2-emissions from transport, which may question the reliability of a repeated measure of this study's research design. Nevertheless, checking the market and production of eco-friendly goods would be interesting as further research.

Moreover, although the five wealthiest countries with highest equality have been investigated in this study, in a few years, more countries may have reached these numbers and could be included in further research. Hence, more countries could be included in future research, confirming or contradicting the results from this study. Additional variables, such as the countries' areal sizes, distances, and distances between large cities may also be included into further studies.

Furthermore, although CO_2-emissions from stationary industry are deliberately excluded as they are commonly focused on, as for example Akashi (2011) and Bains et al. (2017), a meta study is suggested to check whether or not those industries' CO_2-emissions are following the same curve as domestic goods transport. Alternatively, does it increase when the domestic goods transport decreases? Furthermore, a possible threat to the assumption of increasing CO_2-emissions from domestic goods transport with decreasing trade intensity, might be that a buzzing economy always creates increased long-haul transportation as well as short-haul transportation simultaneously. There is a gap in knowledge of examining the division of emissions from domestic transit of import and export goods versus emissions from domestic transport of domestically consumed goods in the total domestic goods transport sector.

6. Conclusions

This study has explored the contribution of domestic goods transportation to global warming and the N-shape of the environmental Kuznets curve in countries with a large upper middle class, by investigating changes in GDP/capita, trade intensity and GINI-index in relation to CO_2-emissions from domestic goods transport. Previous research has focused on GDP per capita, while this study contributes with the estimator GDP/GINI-index, which could be a better estimator for the richness of a country's population. Moreover, most studies on CO_2-emissions focus on environmentally degrading emissions from stationary industries, while this study focuses on domestic goods transport. Results from this study indicate that domestic goods transportation could be a reason for the increased CO_2-emissions from developed wealthy countries. This could be a development of the environmental Kuznets curve.

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Appendix A

Table A1. CO2-emissions per goods transportation mode.
Source: McKinnon & Piecyk 2010.

Transport mode	gCO_2/tonne-km
Road transport	62
Rail transport	22
Barge transport	31
Short sea	16

Appendix B

Table B1. Data for Denmark and Iceland.

Country	Year	gCO2population	GDPpC	GDPpCoGINI	Trade	GINI_index
Denmark	2000	136067,84	28658,12	1204,12	82,98	23,80
Denmark	2001	134011,02	29437,31		83,97	
Denmark	2002	135319,07	30640,35		84,56	
Denmark	2003	134756,34	30820,39	1203,92	80,88	25,60
Denmark	2004	129641,78	32938,69	1322,84	82,21	24,90
Denmark	2005	134491,95	34150,16	1355,17	89,40	25,20
Denmark	2006	138690,51	37334,39	1441,48	97,37	25,90
Denmark	2007	141111,55	39006,20	1488,79	100,07	26,20
Denmark	2008	128422,04	41278,33	1638,03	104,83	25,20
Denmark	2009	119033,98	40331,41	1510,54	89,76	26,70
Denmark	2010	127045,11	43003,05	1580,99	94,10	27,20
Denmark	2011	144160,78	44403,38	1626,50	101,25	27,30
Denmark	2012	145257,90	44803,97	1611,65	103,24	27,80
Denmark	2013	144546,72	46726,85	1639,54	103,05	28,50
Denmark	2014	151830,43	47901,45	1686,67	102,26	28,40
Denmark	2015	144520,69	49045,34	1739,20	104,05	28,20
Denmark	2016	149987,65	51976,01	1843,12	100,17	28,20
Denmark	2017	176981,71	55356,68	1928,80	102,98	28,70
Denmark	2018	170235,06	57482,96	2038,40	106,97	28,20
Denmark	2019		58700,97	2119,17	110,61	27,70
Denmark	2020		60229,91		103,31	
Iceland	2000		29779,09		71,14	
Iceland	2001	148606,16	31876,03		74,73	
Iceland	2002	148273,36	32607,11		69,43	
Iceland	2003	152700,49	32699,24	1220,12	68,20	26,80
Iceland	2004	154844,32	35616,20	1272,01	70,43	28,00
Iceland	2005	162643,98	37322,74	1286,99	72,45	29,00
Iceland	2006	166421,97	39700,33	1314,58	77,54	30,20
Iceland	2007	169562,79	41463,43	1405,54	74,67	29,50
Iceland	2008	159658,99	43728,11	1375,10	82,69	31,80
Iceland	2009	161124,52	41864,19	1458,68	89,39	28,70
Iceland	2010	159488,87	39775,30	1518,14	93,65	26,20
Iceland	2011	153165,69	40936,87	1527,50	101,41	26,80
Iceland	2012	152546,18	42004,45	1567,33	104,09	26,80
Iceland	2013	156311,39	44409,67	1748,41	98,79	25,40
Iceland	2014	161607,40	45996,97	1654,57	96,67	27,80
Iceland	2015	171437,21	49201,06	1835,86	95,82	26,80
Iceland	2016	195540,77	53480,40	1966,19	88,33	27,20
Iceland	2017	208375,07	55638,49	2131,74	86,98	26,10
Iceland	2018	209332,59	57211,30		89,95	
Iceland	2019	203126,78	58290,10		84,09	
Iceland	2020		53616,68		69,21	

Table B2. Data for the Netherlands and Norway.

Country	Year	gCO2population	GDPpC	GDPpCoGINI	Trade	GINI_index
Netherlands	2000	255767,77	31870,83		125,52	
Netherlands	2001	251968,57	33180,18		120,04	
Netherlands	2002	243482,15	34447,21		113,46	
Netherlands	2003	252445,22	34149,62		111,92	
Netherlands	2004	269204,31	35809,79	1201,67	117,61	29,80
Netherlands	2005	265775,92	37625,56	1297,43	122,81	29,00
Netherlands	2006	264012,62	41013,79	1367,13	127,77	30,00
Netherlands	2007	264937,46	43939,15	1484,43	130,46	29,60
Netherlands	2008	270668,38	46420,20	1584,31	131,06	29,30
Netherlands	2009	246419,99	44556,92	1597,02	116,89	27,90
Netherlands	2010	245738,14	45043,90	1620,28	131,52	27,80
Netherlands	2011	245386,62	46599,02	1676,22	142,47	27,80
Netherlands	2012	238366,28	47272,10	1712,76	149,27	27,60
Netherlands	2013	252574,92	49241,52	1752,37	149,55	28,10
Netherlands	2014	252339,70	49233,22	1721,44	150,05	28,60
Netherlands	2015	251386,33	50288,59	1783,28	157,82	28,20
Netherlands	2016	253827,56	52288,42	1854,20	148,86	28,20
Netherlands	2017	250618,63	55088,63	1932,93	156,03	28,50
Netherlands	2018	247084,66	57826,63	2057,89	158,82	28,10
Netherlands	2019	251743,48	59004,32	2020,70	155,27	29,20
Netherlands	2020	244495,03	59266,91		145,30	
Norway	2000	283101,61	36936,49	1348,05	74,65	27,40
Norway	2001	284953,25	37764,31		73,28	
Norway	2002	292367,01	37980,35		67,61	
Norway	2003	294515,82	38593,71	1398,32	66,55	27,60
Norway	2004	306285,18	42549,94	1346,52	69,01	31,60
Norway	2005	310551,08	47797,53	1562,01	70,81	30,60
Norway	2006	310392,25	54160,48	2051,53	72,36	26,40
Norway	2007	310716,60	55930,53	2063,86	73,18	27,10
Norway	2008	321796,93	61716,60	2285,80	74,89	27,00
Norway	2009	297403,91	55364,22	2113,14	67,05	26,20
Norway	2010	303375,65	57919,65	2253,68	68,25	25,70
Norway	2011	302009,17	62076,74	2453,63	69,67	25,30
Norway	2012	315444,25	65354,78	2542,99	68,22	25,70
Norway	2013	326157,67	66961,25	2536,41	67,55	26,40
Norway	2014	333878,24	65892,69	2458,68	68,66	26,80
Norway	2015	330901,53	60368,92	2195,23	69,86	27,50
Norway	2016	315530,42	58939,91	2068,07	68,94	28,50
Norway	2017	324767,18	64050,76	2372,25	69,16	27,00
Norway	2018	317502,01	69808,33	2529,29	70,21	27,60
Norway	2019	317337,14	66799,16	2411,52	71,04	27,70
Norway	2020	307683,93	62644,85		65,33	

Table B3. Data for Sweden and the calculated mean.

Country	Year	gCO2population	GDPpC	GDPpCoGINI	Trade	GINI_index
Sweden	2000	312896,07	29618,28		81,48	
Sweden	2001	300055,31	29927,60		80,59	
Sweden	2002	314589,94	30926,51		77,22	
Sweden	2003	316181,02	31814,86	1257,50	75,25	25,30
Sweden	2004	318307,46	33858,61	1297,26	78,59	26,10
Sweden	2005	331723,59	34244,47	1277,78	83,75	26,80
Sweden	2006	339052,95	37730,16	1429,17	88,20	26,40
Sweden	2007	344323,82	40905,15	1509,42	89,16	27,10
Sweden	2008	353936,06	42158,30	1500,30	92,56	28,10
Sweden	2009	293075,80	40279,46	1475,44	81,51	27,30
Sweden	2010	308244,87	42223,92	1524,33	84,25	27,70
Sweden	2011	308847,94	44608,58	1616,25	85,79	27,60
Sweden	2012	329633,02	45432,43	1646,10	85,28	27,60
Sweden	2013	331147,76	46312,39	1608,07	80,82	28,80
Sweden	2014	327594,47	47184,67	1661,43	82,93	28,40
Sweden	2015	320821,40	49103,13	1681,61	83,72	29,20
Sweden	2016	325446,80	50430,25	1703,72	82,32	29,60
Sweden	2017	317096,64	51947,95	1803,75	84,93	28,80
Sweden	2018	326085,13	53521,63	1784,05	89,13	30,00
Sweden	2019	316579,19	54598,78	1863,44	91,43	29,30
Sweden	2020	317452,55	55037,72		84,53	
Mean	2000		31372,56		87,15	
Mean	2001	223918,86	32437,09		86,52	
Mean	2002	226806,31	33320,30		82,46	
Mean	2003	230119,78	33615,56		80,56	
Mean	2004	235656,61	36154,65	1287,56	83,57	28,08
Mean	2005	241037,31	38228,09	1359,46	87,84	28,12
Mean	2006	243714,06	41987,83	1511,44	92,65	27,78
Mean	2007	246130,45	44248,89	1585,98	93,51	27,90
Mean	2008	246896,48	47060,31	1664,08	97,21	28,28
Mean	2009	223411,64	44479,24	1625,70	88,92	27,36
Mean	2010	228778,53	45593,17	1693,65	94,35	26,92
Mean	2011	230714,04	47724,92	1770,21	100,12	26,96
Mean	2012	236249,53	48973,55	1807,14	102,02	27,10
Mean	2013	242147,69	50730,34	1848,77	99,95	27,44
Mean	2014	245450,05	51241,80	1830,06	100,12	28,00
Mean	2015	243813,43	51601,41	1844,22	102,25	27,98
Mean	2016	248066,64	53423,00	1885,07	97,72	28,34
Mean	2017	255567,85	56416,50	2027,91	100,02	27,82
Mean	2018	254047,89	59170,17		103,02	
Mean	2019		59478,67		102,49	
Mean	2020		58159,22		93,54	

Appendix C

Table C1. Ramsey Reset Test for panel data regression PD4 (Equation 4).

Ramsey Reset Test for Panel Data Regression PD6
H_0 = The regression has correct functional form.
H_1 = The model suffers from misspecification.
Power = 2:3, type = regressor, data = Lot.
Reset = 2.2162, df1 = 6, df2 = 73, p-value = 0.0509.
Result: With a p-value above 0.05 the null hypothesis of correct functional form cannot be rejected.

Appendix D

Table D1. Multicollinearity test for the variables.

	GDPpC	GDPpCsq	GDPpCcu	GDPpCoGINI	Trade	GINI_index
GDPpC	1					
GDPpCsq	0,993604439	1				
GDPpCcu	0,975895323	0,99422724	1			
GDPpCoGINI	0,969284066	0,976147232	0,97111683	1		
Trade	0,03361137	-0,007820533	-0,048526587	-0,081181856	1	
GINI_index	0,09974249	0,045583437	-0,001639296	-0,143098457	0,229701556	1