

Lund University School of Economics and Management
Department of Economics



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Does trade explain the Environmental Kuznets Curve in Sweden?

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Author: Linda Nihlwing

Supervisors: Andreas Bergh, Pontus Hansson

Abstract

As climate change continues to escalate, the need for drastic changes is urgent. The world has agreed on a limit to global warming, and all countries are aware of the problem. The theory behind the Environmental Kuznets Curve is based on an inverted relationship between emissions and environmental impact and GDP growth. It could easily be interpreted as an easy way out of, which means that if a country focuses on growth the environmental problems will eventually solve themselves. This study has aimed to prove the existence of Environmental Kuznets Curves for a number of pollutants in Sweden. To further understand what has caused emissions to decrease at the same time as GDP has increased, trade-related variables were included in the second part of the analysis.

For carbon dioxide, nitrous oxides and methane, inverted U-shaped curves could be found. The data on carbon monoxide, sulfur oxides and volatile organic compounds covered a shorter time period, but they have all followed a steep downward-sloping curve during the last two decades, which indicates that the data showed part of the Environmental Kuznets Curve.

The manufacturing share of total GDP proved to have a large effect on emissions, whilst trade classified as dirty only had a very small impact on emissions in the long run. Thus, no pollution haven effects could be confirmed.

Keywords: Environmental Kuznets Curve, Sweden, cointegration, emissions, trade

Abbreviations

CO	Carbon monoxide
CO ₂	Carbon dioxide
COP	Conference of Parties
ECM	Error Correction Model
EKC	Environmental Kuznets Curve
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification
NAFTA	North American Free Trade Agreement
NO _x	Nitrous oxides
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
PHH	Pollution Haven Hypothesis
R&D	Research and Development
SITC	Standard International Trade Classification
SO _x	Sulfur oxides
UNFCCC	United Nations Framework Convention on Climate Change
VOCs	Volatile organic compounds

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1 Introduction

The urgent issues of global warming and changing climate in the world have gotten more and more attention during the last decades. After the COP21 summit in Paris in 2015, all participators agreed on a common goal and that they were determined to keep the levels of global warming below two degrees compared to pre-industrial levels (UNFCCC, 2016b). The agreement is a big step, and an acknowledgement of the seriousness of the problem. The global warming has been called the greatest market failure there has ever been (Stern, N., 2007, p.1), and to tackle the issue, actions have to be taken globally. This essay will discuss the problem when environmental problems are only seen to and treated within one single country. The negative environmental impact from emissions in one country will not be limited to that country alone. The emissions of greenhouse gases will ultimately affect everyone on the planet.

The theory behind the Environmental Kuznets Curve argues that emissions increase with increasing levels of GDP. However this relationship is only valid up until a certain turning point, after which the emissions will start to decrease even though the levels of income in the country continue to increase. This might lead to the interpretation that the environmental problems will eventually solve themselves, as long as the country aims to reach higher income levels. By including additional independent variables in my analysis of Environmental Kuznets Curves, my aim is to find and discuss if the decreasing levels of emissions once a country has passed the turning points can be explained by changes in trade patterns rather than just higher GDP.

Sweden is one of the industrialised countries that emits the least (Swedish Environmental Protection Agency, 2010), which is why I find it interesting to examine the emissions from a historical perspective, and see what has influenced the development. When a discussion of the impact of trade on the environment is included, it allows for an analysis on how our consumption patterns and demand for goods from other countries affect our overall environmental impact. In a world with finite resources, problems do not disappear just because the dirtiest production takes place elsewhere. As countries develop and become industrialised, the production structure changes and comparative advantages become more defined. When more countries reach higher standards of living and wish to move on to lighter industries and less polluting production, they would be unable to find other countries from which to import

resource-intensive products as they, themselves, become wealthy. When the poorer countries of today apply similar levels of environmental regulation they will face the more difficult task of abatement, rather than just outsource them to other countries (Arrow et al., 1995; Stern, Common & Barbier, 1996).

The aim of this essay is to examine whether Environmental Kuznets Curves can be observed in Sweden, and to further understand what has caused the environmental progress. Environmental progress can be measured in a number of different ways, however in this essay it refers to reduced levels of emissions.

In light of the issues discussed above, the following research questions will be the main focus of this essay:

Research question 1:

Are there Environmental Kuznets Curves in Sweden, for local and global pollutants?

Research question 2:

Can the potential environmental progress be explained by changing trade and production patterns? How do trade-related variables affect the potential Environmental Kuznets Curves?

This essay will be structured as follows: first a background on the Environmental Kuznets Curve and the reasoning behind the Pollution Haven Hypothesis will be provided, as well as a general discussion on the impact of trade on the environment. Thereafter follows a brief summary of previous research within the field, as well as criticism of the theories. I will then present my data and the methods that will be used to execute the study. This section is followed by the results, and then lastly, my conclusions.

2 Background

The second section of this essay will provide a background of some essential concepts. I will also explain the theoretical framework that my arguments are built upon.

In the influential Stern Review, Nicholas Stern argues that climate change is “the greatest example of market failure we have ever seen” (Stern, N., 2007, p.1). The enhanced greenhouse effect that causes global warming is a serious issue, which needs to be dealt with urgently. What choices we make have a significant impact on the future of our environment. The human impact on the environment is clear. According to the fifth assessment report by the IPCC “it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century” (IPCC, 2013, p. 17). The report also emphasises the importance of limiting emissions of greenhouse gases, since “continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions” (IPCC, 2013, p. 17). Climate change will affect the world economy in every possible way. Costs of future adaptation and mitigation are difficult to estimate, but these costs will accelerate as the temperature increases. Costs related to for example food security, water scarcity, human health, preserving ecosystems and handling extreme weather events will increase as the global mean temperature becomes higher (IPCC, 2013).

The environmental problems have been on the agenda for several decades. A critical point in acknowledging the seriousness of climate change was the adoption of the United Nations Framework Convention on Climate Change at the Rio Earth Summit in 1992. The Conference of Parties takes place every year in order to review the work within the UNFCCC, the conference includes all 195 parties of the framework. After the COP21 in Paris in 2015, the Paris Agreement states that the need to accelerate the environmental work is crucial. The world agreed on that the global warming should be kept below two degrees of warming compared to pre-industrial levels, and to preferably keep the levels of warming below 1.5 degrees (UNFCCC, 2016a).

The way air emissions affect human health and the environment differs depending on what type of pollutant it is and what the source of the emissions is. Greenhouse gases, like carbon

dioxide, methane and nitrous oxides, will contribute to the enhanced greenhouse effect. This is why emissions of such pollutants will cause global consequences (Kearsley & Riddell, 2010). Anthropogenic climate change can be described as an externality, because of the fact that the costs of emitting will not be imposed on the emitter, but rather on the rest of the world and on future generations. Mani and Wheeler (1998) describe pollutants as “...waste residuals - harmful by-products of industrial processes which are not profitable to recycle or resell at existing prices” (Mani & Wheeler, 1998, p. 6). Since the global climate system is slow to react to the changes in greenhouse gas concentrations, it means the costs of emitting greenhouse gases do not occur at once. Therefore, the incentives to abate such global pollutants are small (Stern, N., 2007). On the other hand, other pollutants such as carbon monoxide, sulfur oxides and volatile organic compounds cause environmental damage on a local level. Due to the fact that these local pollutants affect air quality and human health more directly than greenhouse gases, it creates greater incentives for policymakers to reduce the emissions and correct the market failures (Kearsley & Riddell, 2010).

2.1 Theoretical framework

In this section I will explain the theories the study is based on, and how they are related to the environmental problems and the greenhouse effect. The main focus will be on the theory behind the Environmental Kuznets Curve, and also how it can be related to the Pollution Haven Hypothesis. I will conclude the chapter by talking about the connection between trade and the environment, and put this in a Swedish context.

2.1.1 The Environmental Kuznets Curve

The impact of anthropogenic emissions is undeniable, and it is necessary to reduce emissions in order to not cause irreversible damage. The industrialisation of the world is causing increasing levels of emissions and climate change, although the constant development of countries can be seen as a road towards environmental improvement. Galeotti, Manera and Lanza formulate the issue as “GDP [is] both the cause and cure of environmental problems” (Galeotti, Manera & Lanza, 2009. p 552). Their reasoning is in line with the theoretical framework of the Environmental Kuznets Curve. The theory of the Environmental Kuznets Curve reflects the relationship between environmental impact and GDP, and proposes that

economic growth will lead to decreasing levels of pollution. The concept of the EKC was originally an idea from Grossman and Krueger's (1991) study on the environmental impact and the effect on urban air pollution after the establishment of NAFTA. They proposed that sulfur and smoke tended to increase as GDP increased when a country was at a relatively low income level. However, when a country had reached higher levels of income pollution would decrease with increasing GDP. These findings would then result in the inverted U-shaped Environmental Kuznets Curve, similar to the curve showing a relationship between income inequality and economic growth (Kuznets, 1955).

In their study, Grossman and Krueger analyse how freer trade would affect the environment. They analysed the environmental impact through three different mechanisms that arise as consequences of trade liberalisation. Firstly, the scale effect explains that if economic activity expands due to increased trade flows, it will lead to more emissions given an unchanged production structure. Secondly, the composition effect shows how a change in the country's trade policy might lead to a specialisation in the sectors in which the country has a competitive advantage. Depending on whether the differences in competitive advantages are due to environmental regulations or not, this effect could be environmentally bad for the country. The third mechanism is described as the technique effect, where the trade liberalisation results in an increased inflow of new, and cleaner, technology from foreign producers. Within this effect they also talk about the fact that higher income levels following a trade liberalisation might increase the demand for a cleaner environment. Since the mechanisms affect the environment differently, the net effect depends on which mechanisms are triggered and to what extent.

Where countries are positioned on the curve, varies a lot, due to the very different stages of development. With the complex economic integration of today, national economic systems can be difficult to separate. Various economic cooperation and trade flows result in the interweaving of economies. Due to the fact that climate change and air emissions are not exclusively affecting one country, the issue of abatement and improvements must be seen in a global context. Studies of the EKC often present their outcomes of curves reflecting single countries or regions. If a country is shown to be on the downward-sloping side of the curve, such results could be misleading if the decreased emissions are due to a change in production structures and the movement of pollution-intensive industries to other countries. The emissions might decrease for the actual country, but no change occurs on a global scale (Kander & Lindmark, 2006).

2.1.2 The Pollution Haven Hypothesis

As the world develops, the structure of production industries changes. The displacement of industries due to differences in the stringency of environmental regulation is called the pollution haven hypothesis. The hypothesis relates to the shift of manufacturing industries from developed to developing countries. Over time, the costs for industries to meet the environmental requirements have increased a lot. Generally, such costs are lower in developing countries, which imply that they could develop comparative advantages in the production of pollution-intensive goods (Cole, 2004). There are several reasons to why countries on different development levels widely differ in the stringency of environmental policies. Environmental quality is considered to be a normal good, and the demand for it increases with income. Another reason is thought to be the fact that developed countries have more specialised and developed institutions that work with enforcement of environmental laws (Mani & Wheeler, 1998).

2.1.3 Trade and environment in a Swedish context

In light of the theory on the EKC, it has been suggested that the shape of the curve does not entirely depend on the increase in GDP, but might also be explained by trade. As Grossman and Krueger specified in their study, the scale, composition and technique effect may affect countries differently. Developing countries may benefit relatively more from a development of technology used in production industries. Developed countries are often considered to have a comparative advantage in capital-abundant production. Since trade liberalisation results in increasing specialisation in the goods produced in the sectors where a country has a comparative advantage, it depends how the environment is affected by a more open trade. If a country specialises in cleaner production, trade liberalisation will result in increased production in that sector and less production in other sectors. This in turn will lead to a lower environmental impact on a national level. The opposite goes for a country that specialises in dirty production (Onder, 2012). Sweden is considered to be relatively capital-abundant and as a result of this, many of the labour-intensive manufacturing industries moved abroad in the search for cheaper labour in the 1980s. This might be good from an efficiency-perspective, but not from an environmental perspective. The move of industries to other countries also led to the move of emissions related to the production. The Swedish Environmental Protection Agency (2010) assumes that the overall pressure on the global environment increased,

compared to what would be the case if the industries stayed in Sweden where regulations are relatively strict.

The environmental policy in Sweden is summarised in the generational goal, where the main intention is to leave a healthy environment to the next generation. In 2010 the Swedish Parliament adopted an amendment where the purpose was to take responsibility for the emissions Swedish consumption causes abroad. Reports on emissions today are based on production within the country, but counting in the fact that Sweden is a small trading economy, the actual emissions caused by consumption may deviate from the official emissions records. It is evident that Sweden's environmental impact is partly due to the fact that we import products to satisfy the national demand for consumption (Swedish Environmental Protection Agency, 2012). When emissions and environmental impact are measured, it can be done from the production or the consumption perspective. The production perspective is the most common way of measuring emissions, and it refers to emissions generated within a single country as a result of what is produced there. The advantage of this approach is the possibility for the government of the country to control the emissions as they arise within the own country. What this perspective does not take into account however, is the demand that causes the production and the emissions. With the alternative consumption-based approach, emissions are calculated based upon where the final product is consumed. This gives a clearer picture of the environmental impact of the lifestyle and standards living within countries, although this method is more difficult to measure and relatively new (Swedish Environmental Protection Agency, 2010)

Due to the fact that Sweden is a relatively small country, and therefore dependent on trade to meet all our needs, there is a difference between emissions measured from a consumption and from a production perspective. Statistical records from 2003 show that emissions are 25 per cent higher when measured from a consumption perspective. A majority of developed countries emits more when seen from a consumption perspective, although Sweden performs well overall. The latest available numbers on the different perspectives show that when measuring carbon dioxide emissions per capita from a consumption perspective, Sweden emitted 10 tonnes per capita. The average for other industrial countries at the same time was approximately 16 tonnes per capita (Swedish Environmental Protection Agency, 2010).

The environmental accounts in Sweden aim to report the connections between the environment and the economy. Since the statistics are mostly based on measures from a production-perspective, the environmental accounts might not show the full picture. To get a general overview of what the actual impact is, Statistics Sweden (2002) suggests that trade-adjusted environmental accounts should be included in the analyses. It has been shown that most imported products have been produced in more emission-intensive industries than products originating domestically. This work has started, but any extensive information is not yet to be found.

3 Previous research

This section will attempt to give an overview of the studies already done in the field, and how the theories have developed over the years. I will also briefly present some of the critique on the EKC theory.

Since the publishing of Grossman and Krueger's study, an extensive number of studies have been done on the EKC, and different conclusions have been drawn from its implications for future emissions, whether they can be predicted using the EKC or not. Many studies look for specific peak values of income when emissions start to decrease, however as turning points are outside the scope of this essay, there will not be any further focus on it in this section.

Since the concept of the EKC was founded in the early 1990s, a number of studies followed where researchers were inspired by Grossman and Krueger's findings. In a study done by Selden and Song (1994), the presence of EKC-shaped curves for SO₂, SPM (suspended particulate matter), NO_x and CO could be confirmed. They connect their findings to Grossman and Krueger's study (1991), when they conclude that the downturn of the curve can be related to the changes in consumption and production, what Grossman and Krueger called the composition effect. Selden and Song also explain the downturn with positive income elasticities for environmental quality, and the fact that with higher income levels, the levels of education and awareness of environmental issues increase. At higher levels of income, the stringency of environmental regulations also tends to increase. Copeland and Taylor (2004) found this to be a major explanation to the shape of the EKC.

Apart from the simpler EKC studies, where the target only was to establish the peak values of the curve, other studies have been made. There have been several attempts to include other dependent variables as a way of explaining the relationship between pollution and growth. The effect of trade patterns on pollutions has been a recurring theme. Suri and Chapman (1998) found that when trade effects were included in the EKC regression, it raised the turning points drastically. Their study includes ratios on manufacturing to GDP, a ratio of imported manufactured products to domestically manufactured products, as well as a ratio of exported manufactured products to domestically manufactured products. Suri and Chapman concluded that structural changes in the economies of industrialised countries as well as increasing

imports of manufactured products have resulted in the flatter upward-sloping curves in those countries than in industrialising countries. Cole (2004) confirms the appearance of relationships between emissions and GDP. The manufacturing share of GDP and the extent to how open the economy is to trade seem to matter more than the change in dirty trade. Although he finds significant results for small effects on emissions from dirty imports and exports. Additionally, Cole concludes his findings, that if trade effects are not controlled separately in the analysis, the effect of trade tends to be captured by the income effect in the GDP-variable.

What Cole tries to capture in his analysis is the pollution haven effect, when pollution-intensive production shift from developed countries to developing. A large number of studies have been done in this field, with a wide variety of results. The Pollution Haven Hypothesis can be described as the case when trade barriers are being reduced, and thus results in a shift of industries with pollution-intensive production shifts from a country with stringent environmental regulations, to a country with weaker environmental regulations (Copeland & Taylor, 2004). Copeland and Taylor distinguish the PHH from the Pollution Haven Effect. Where the latter describes the case when tighter pollution regulations affect the decisions of plants' locations and trade flows. In their study they find strong evidence for the Pollution Haven Effect, but quite weak evidence for the PHH.

In a study with Latin American focus, Birdsall and Wheeler (1993) find that increased trade openness actually leads to cleaner industries in developing countries, due to adoption of pollution standards from developed countries. They conclude that pollution havens instead tend to emerge in protectionist, developing economies.

Mani and Wheeler (1998) do find evidence for production structures in developing and developed countries that bear similarities to the PHH. During their period of study, they could see the share of manufacturing in the economy of OECD countries decreasing, at the same time as the same share increased in developing countries. In line with the hypothesis, when the costs of pollution abatement increased the most in developed countries, the share of manufacturing in developing economies grew the most. Although, they point out that their findings show that the pollution havens have not had any major impact, since the positive counter-effect of higher incomes puts the producers under pressure. Also Lucas, Wheeler and Hettige (1992) found that the pollution-intensive industries in low-income countries grew the most, when the OECD

economies strengthened their environmental regulations. They can then see significant proof for displacement of pollution-intensive industries following these policy changes.

3.1 Critique against the Environmental Kuznets Curve

The studies on the EKC have been disputable, and the theoretical framework, the econometric foundations as well as the interpretations of the outcomes have been thoroughly criticised.

Regarding the criticism on the theoretical foundation of the EKC, one point of view that was expressed early in the history of the EKC, was the lack of feedback on the economy from the environmental damage. Is it reasonable to assume that no matter how badly affected the emissions and the environment get, it will not affect the economic production (Arrow et al., 1996)? It has also been argued if the downturn of the EKC really can be related to an environmental improvement and a decrease of emissions, or if it is a consequence of changed trade patterns (Arrow et al., 1996; Stern, Common & Barbier, 1996). This could be caused by either differences in comparative advantages, in line with the Heckscher-Ohlin theorem, or differences in environmental regulations. These differences would enhance the effect of what might appear as a decrease of pollution in developing countries, as they normally specialise in cleaner industries (Stern, D, 2004).

When it comes to the econometric framework, several areas are criticised. One of the issues that has gotten the most attention, is the statistical properties of the variables. Many EKC results are based on shaky econometric methods, which mean the results should be interpreted with care (Galeotti, Manera & Lanza, 2009). David Stern (2004) is critical to the fact that very few studies on the EKC report any test statistics for cointegration. If the regressions do not cointegrate, they might show spurious results which make it impossible to draw any conclusions from the outcomes. If there is no cointegration in the regression, the nonstationarity makes the significance testing misleading, and it is not possible to see if the variables are significant or not.

Stern, Common and Barbier (1996) criticise several aspects of the EKC studies that were performed up until the point of their study. They concluded that the use of OLS in many of the studies, did not consider the fact of simultaneity and thus resulted in inconsistent and biased

results. They were also critical regarding the choice of data, and conclude that tests for heteroskedasticity need to be performed, and if present, the problem of heteroskedasticity must be corrected in order to get efficient estimates.

3.2 Contribution of a new perspective

The contribution of this essay to previous studies is to try to explain the role of trade in relation to the EKC in Sweden. The thesis aim to study what Sweden's environmental progress depend on. Many other studies have been based on a panel data set, where a number of different countries in different stages of development have been included. To focus on one country makes it easier to connect results to certain events in the history of the country. It also makes it possible to study the country's development and future possibilities more in depth.

4 Data

This section will explain what variables are used in this study, and how they have been chosen. The data concerning GDP and emissions are mainly collected from the World Bank database, the World Development Indicators. Some of the emissions data is collected from the OECD database. Additionally, data concerning trade sorted into different commodity groups are collected from the OECD database.

4.1 Sectors of production classified as dirty

To determine if changes in trade patterns are valid as explanations to changes in emissions of air pollutants, dirty trade variables will be included in the analysis. In this study I have chosen to define fourteen sectors in the SITC system as dirty. The classification of dirty sectors is based on a number of studies, where they have come to similar conclusions (Harris, Kónya & Mátyás, 2002; Low & Yeats, 1992). Due to availability of data for Sweden's trade with OECD and non-OECD countries, some adjustments have been made. Much of the previous research on the subject used ISIC classification, whilst the available data for Swedish trade used the SITC revision 3 classification system. However, the main categories on a 2-digit level are categorised in a very similar way, with similar description of the sectors. Therefore the following categories are included in this study, as listed in the OECD trade database:

- 25 Pulp and waste paper
- 27 Crude fertilisers other than division 56, and crude minerals
- 28 Metalliferous ores and metal scrap
- 33 Petroleum, petroleum products and related materials
- 51 Organic chemicals
- 52 Inorganic chemicals
- 56 Fertilisers other than group 27
- 59 Chemical materials and products not elsewhere specified
- 60 Cork and wood manufactures (excluding furniture)
- 64 Paper and paper manufactures
- 66 Non-metallic mineral products not elsewhere specified

67 Iron and steel

68 Non-ferrous metals

69 Manufactures of metal not elsewhere specified

The choice of dirty sectors is based on previous empirical work. Lucas, Wheeler and Hettige (1992) point out the fact that most of the empirical studies in the field assume constant pollution-intensity across countries when conducting similar studies. The dirty classification is based on costs for abatement and controls, as well as pollution-intensities for air and water pollutants. Mani and Wheeler (1998) mention that similarities can be observed for the dirty sectors. Most of them are intensive in energy and land, as well as inputs of raw materials. As can be seen from the sectors listed above, many of them are transformation processes that produce primary inputs for industries from raw materials.

Since a part of one of the research questions is focused on pollution haven effects, I want to look at the impact of the dirty exports and imports on the levels of emissions in Sweden. A problem however, is the existing statistics. Approximately 85 per cent of the Swedish imports come from Europe, according to a report by the Swedish Environmental Protection Agency (2010). This may in fact be misleading, since only the last country a product was shipped from is represented in the statistical records. Production chains are usually fragmented and all the different countries a good has passed through in the making are not mentioned. This means that if a good is mainly produced in China, finished in Germany and then shipped to Sweden, the statistics will only show that the good is imported from Germany (Swedish Environmental Protection Agency, 2010).

Since data on dirty trade is only available from 1990 to 2015, it will be assumed that no technological change has made the production significantly cleaner. A deeper analysis of what industries pollute the most in Sweden, and how their emissions might have changed over time, is outside the scope of this thesis. It can however be assumed that changes in environmental regulation has resulted in decreasing levels of air pollution. The Swedish Environmental Protection Agency (2016) mentions stricter regulations on cars and the control of exhaust emissions as a reason for lower levels of nitrous oxides and carbon monoxide. As earlier mentioned, a discussion on the role of industrial standards and environmental regulations will not be the focus of this essay.

4.2 Sample and data

The global pollutants chosen in this study are all included in the overall group of greenhouse gases. The emissions of gases such as carbon dioxide, nitrous oxides and methane cause global damage by stopping infrared radiation to leave the atmosphere, and thus help to create an enhanced greenhouse effect which heats up the atmosphere (Kearsley & Riddell, 2010; IPCC, 2013). I have chosen to study both global and local pollutants since previous studies have shown different results depending on if the pollutant is considered local or not. The local pollutants have been more prone to follow an inverted U-shaped relationship. Stern (2004) states that these findings are in line with environmental economics theory. He points out that the impact from emissions locally are internalised in the country's economy, and can more easily be corrected with environmental policies. When it comes to global pollutants, it is much more difficult to internalise the externality on a global scale, which reduces the incentives to abate the emissions. Pollutants such as carbon monoxide, sulfur oxides and volatile organic compounds are all considered to be local pollutants, and the effect of the emissions will mostly be recognised locally. The emissions of carbon monoxide are mostly caused by fossil-fuel combustion in vehicles. Emissions of VOCs are also mainly coming from fossil-fuel combustion, but with additional sources like fires, industrial processes and solvents. Sulfur oxides are known to cause acid rains, which is causing great damage on buildings, water and forests (Kearsley & Riddell, 2010).

In order to answer the first research question on whether there is an Environmental Kuznets Curve relationship between emissions and GDP growth in Sweden, separate regressions will be run for each pollutant chosen in the study, which is why there are several dependent variables that will be used separately.

The length of the time series will vary, due to availability of data (see table 1). For CO₂, data are available from 1967. For NO_x and Methane, data are available from 1970. For the three pollutants classified as local (CO, SO_x and VOCs), data are only available from 1990 and onwards.

Global pollutants:

CO ₂	1967-2013
NO _x	1970-2012
Methane	1970-2012

Local pollutants:

CO	1990-2014
SO _x	1990-2014
VOCs	1990-2014

(Table 1, length of time series)

4.2.1 Dependent variables

There are several different ways to measure and report emissions. In this essay I have chosen to report actual emissions, and not the emission intensity. The latter measures the volume of emissions that is emitted per unit of GDP. This measurement could be misleading since a reduction of the emissions intensity could still indicate an increase in total emissions following a higher GDP (Climate Council, 2015).

CO₂/capita - Carbon dioxide is considered to be a global pollutant. Measured in tonnes of emitted carbon dioxide per capita. Data are retrieved from the World Bank database, the World Development Indicators.

NO_x/capita - Nitrous oxides are considered to be global pollutants. Measured in tonnes of CO₂ equivalent. Data are retrieved from the World Bank database, the World Development Indicators.

Methane/capita - Methane is considered to be a global pollutant. Measured in tonnes of CO₂ equivalent. Data are retrieved from the World Bank database, the World Development Indicators.

CO/capita - carbon monoxide is considered to be a local pollutant. Measured in kilograms per capita. Data on emissions are retrieved from the OECD database within the section for Air and GHG emissions.

SO_x/capita - sulfur oxides are considered to be local pollutants. Measured in kilograms per capita. Data on emissions are retrieved from the OECD database within the section for Air and GHG emissions.

VOCs/capita - Volatile Organic Compounds are considered to be local pollutants. Measured in kilograms per capita. Data on emissions are retrieved from the OECD database within the section for Air and GHG emissions.

4.2.2 Independent variables for research question 1

GDP/capita - Data are retrieved from the World Bank database, World Development Indicators. Expressed in 2010 US dollars.

4.2.3 Additional independent variables for research question 2

To add the following explanatory variables to the models, is inspired by Cole's (2004) and Kearsley and Riddell's (2010) studies on the EKC in relation to the Pollution Haven Hypothesis.

M - Manufacturing as a part of total GDP. Reported as a percentage rate. It measures how an economy transforms structurally as development proceeds. For developing countries this share is generally rapidly increasing, whereas the opposite usually can be observed for developed countries (Suri & Chapman, 1998).

DX - Dirty exports to non-OECD countries. Expressed as a ratio of dirty exports (classification groups of dirty products are listed above) to non-OECD countries to total exports to non-OECD countries.

DM - Dirty imports from non-OECD countries. Expressed as a ratio of dirty imports (classification groups of dirty products are listed above) to non-OECD countries to total imports from non-OECD countries.

T - Trade intensity. Sum of imports and exports divided by GDP. Reported as a percentage rate. This variable should catch the effects of increasing or decreasing trade in Sweden.

4.2.4 Expected behaviour of variables

The change of significance in the GDP-variable when trade variables are included in the analysis could indicate that the significance GDP first held was explained by the trade-related variables and that the pure income rise has no impact on the emissions. To answer my research question number two, and to generate outcomes in line with the EKC and PHH theories, I expect the coefficients for manufacturing share of GDP (M) and dirty exports (X) to have a positive correlation with the dependent variable. Since I expect the emissions to increase if the share of manufacturing in GDP increases, and also if the share of dirty exports increases which might imply an increase of dirty production.

It is hypothesised that the parameters for dirty imports (DM) and trade openness (T) have negative relationships with the dependent variable. The coefficients for trade openness are expected to turn out negative due to the fact that Sweden is an economy with a focus on services and R&D, and in line with trade theory it can be assumed that when trade increases, a country will specialise in the sectors where it has a comparative advantage. As was discussed in section 2.1.3, it is also assumed that increased trade results in specialisation and that the production technique is made more efficient. If the coefficient for dirty imports is negative, it implies that a greater part of our pollution-intensive consumption is produced abroad.

5 Methodology

This section will explain the different regression models that will be used to conduct the study and answer my research questions. I will also explain the different problems that might occur when using time series data and how I will correct for any issues I might come across.

5.1 Regression models

In order to answer the first research question, I will conduct a multiple regression analysis for each of the pollutants. Due to data availability, some regressions will be run on shorter time periods.

The standard regression model for estimating the EKC is written as follows (Stern, D, 2004):

$$\ln(E/\text{capita})_{it} = \alpha_i + \gamma_t + \beta_1 \ln(\text{GDP}/\text{capita})_{it} + \beta_2 (\ln(\text{GDP}/\text{capita}))_{it}^2 + \varepsilon_{it} \quad (1)$$

This format of the regression is appropriate when using panel data, but since this study focuses on Sweden the model will be slightly adjusted, as time series data will be used instead. The variables will be used in their logged form in order to fit the model into an OLS model. It is also a useful method, in order to be able to interpret the coefficients as elasticities.

E in this setting stands for emissions, and will be substituted with each of the pollutants described in section 4.2.1.

$$\ln(E/\text{capita})_t = \alpha_t + \beta_1 \ln(\text{GDP}/\text{capita})_t + \beta_2 (\ln(\text{GDP}/\text{capita}))_t^2 + \varepsilon_t \quad (2)$$

To investigate research hypothesis 2, the same type of regression analysis will be performed, but with additional independent variables. Including the additional variables will test for the significance of trade effects on emissions. To test for the impact of changed trade patterns and production structure on the Swedish emissions, I will add the variables for dirty imports and exports, as well as the variables that reflect the manufacturing and trade as parts of GDP. The model is inspired by Cole's (2004) study on the Pollution Haven Hypothesis and

Environmental Kuznets Curve. Again, E in this model means emissions, and the dependent variable will be the different pollutants listed in section 4.2.1.

The model will be adjusted to suit time series data, which gives it following design:

$$\ln(E/\text{capita})_t = \alpha + \beta_1 \ln(\text{GDP}/\text{capita})_t + \beta_2 (\ln(\text{GDP}/\text{capita}))^2_t + \beta_3 T_t + \beta_4 M_t + \beta_5 DM_t + \beta_6 DX_t + \varepsilon_t \quad (3)$$

The variables trade openness (T), manufacturing as a share of GDP (M), dirty imports (DM) and dirty exports (DX) will not be estimated in their logged form, since they already express a percentage rate and that could result in misleading interpretations of the effect on the dependent variable.

5.2 Estimation techniques and issues

When using time series data it is important to check for stationarity. A time series process is considered to be stationary if the mean and variance of the distribution are independent over time, and if the covariance between two values at different points of time does not depend on time either (Dougherty, 2011).

In case the data are stationary a normal OLS estimation can be carried out, and the results can be analysed in relation to the research questions. In case data are nonstationary, and the regressions are run without further measures, it could result in spurious regression outcomes. That means the outcome could show strong, but false relationships (Dougherty, 2011). To test for stationarity, I will use the augmented Dickey-Fuller test for unit root. If the data are nonstationary, there are ways to correct for it, and avoid the spurious regressions. Two common methods to solve the problem are differencing the variables and to construct error correction models.

If the data turn out to be nonstationary when tested for it, it is necessary to check for cointegration. In order for two nonstationary time series to develop together and influence each other, some sort of stationary process that keeps them together must exist. This process is often called the long-run equilibrium relationship. If there is such a relationship, the time series are

said to be cointegrated. The long-run relationship will prevent the time series to drift too far away from each other, and to follow a common trend. In case cointegration is present, the estimated coefficients in the regression model are generally superconsistent (Dougherty, 2011; Verbeek, 2012). Galeotti, Manera and Lanza (2009) point out, that one of the main issues of previous EKC studies has been the lack of cointegration and unit root tests. To be able to interpret the results of the regressions as EKCs, it is necessary to confirm that a cointegrating relationship between the dependent and independent variables exists.

In case there is a cointegrating relationship, that works in the long run, it will also affect the variables in the short run. In order for the long-run relationship to hold, some sort of mechanism must exist that drives the variables towards their long-run equilibrating relationship. It is called the error correction mechanism, and can be estimated using the error correction model. The model assumes the variables are integrated at first order, and cointegrated (Verbeek, 2012).

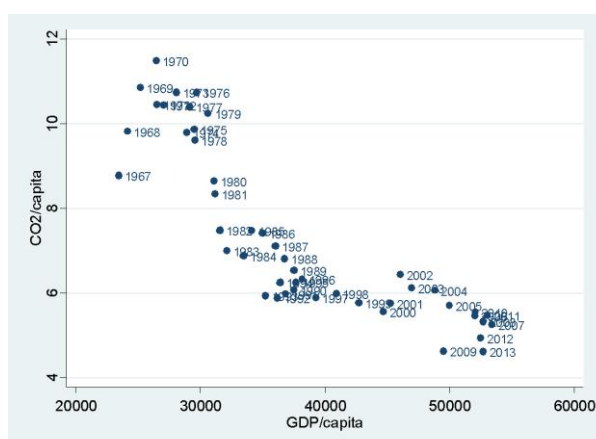
6 Results and discussion

In this section I will present the results from my research. In order to answer the research questions, the study was divided into two parts. To answer the first research question on whether any Environmental Kuznets Curves exist in Sweden, I first ran the basic EKC regressions with the shorter model. To answer the second research question and examine if the EKCs could be explained by changing trade patterns, additional trade-related independent variables were added in order to see if there was a significant difference.

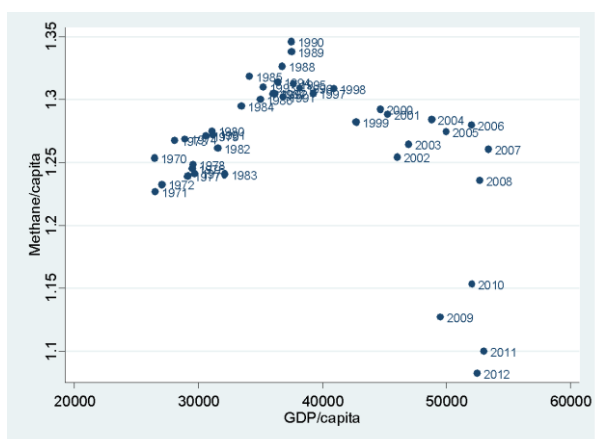
6.1 Research question 1

Are there Environmental Kuznets Curves for Sweden, for local and global pollutants?

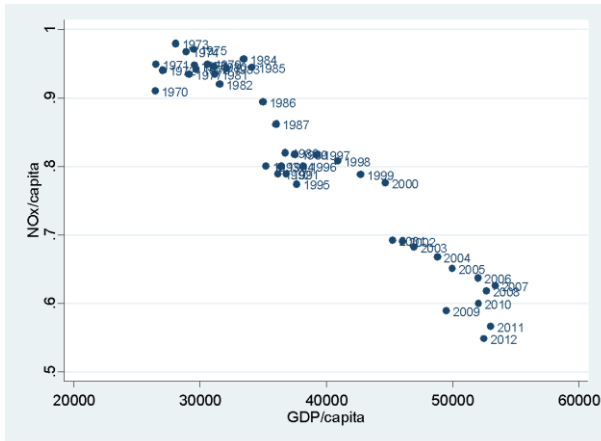
I started by creating scatter plots for all pollutants, as this would make it easier to graphically examine any potential Environmental Kuznets Curves.



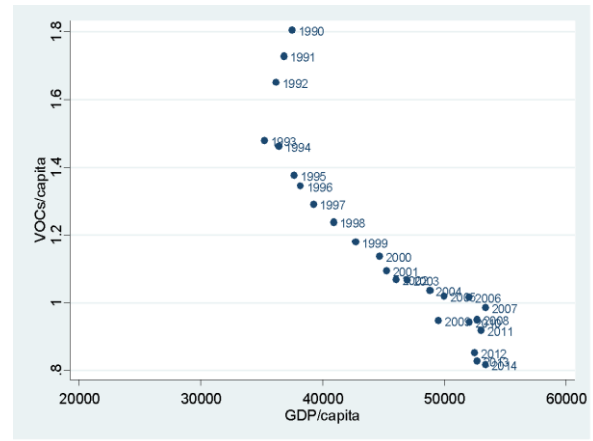
(Fig. 1, scatterplot, CO₂/capita and GDP)



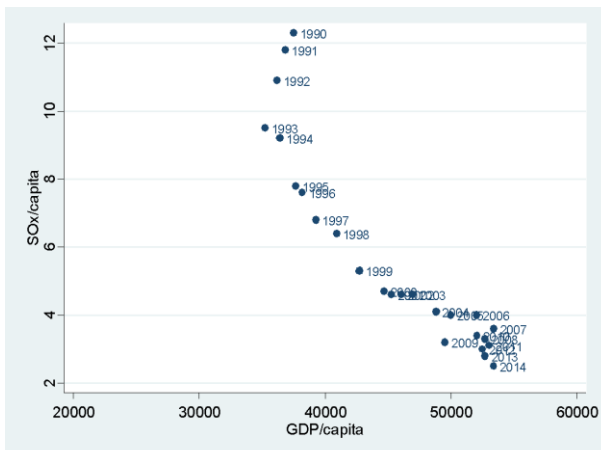
(Fig. 2, scatterplot, Methane/capita and GDP)



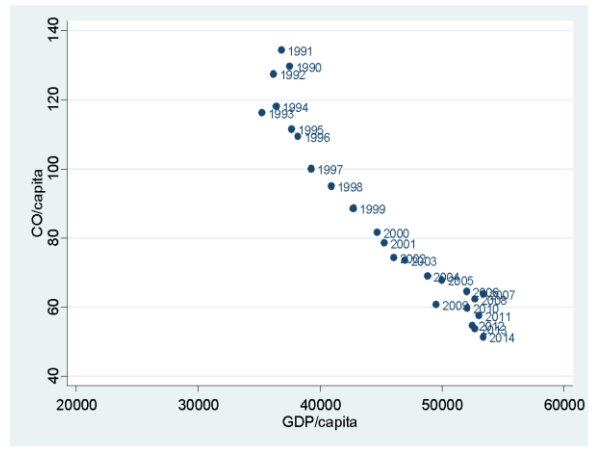
(Fig. 3, scatterplot, NO_x/capita and GDP)



(Fig. 4, scatterplot, CO/capita and GDP)



(Fig. 5, scatterplot, SO_x/capita and GDP)



(Fig. 6, scatterplot, VOCs/capita and GDP)

When looking at the graphical outputs, it is important to remember that the data available for CO, SO_x and VOCs (figures 4, 5 and 6) covered much shorter time periods. It can be seen that they all follow a downward trend, which implies that emissions of all pollutants have decreased over time, at the same time as GDP/capita has increased. When looking at the scatter plots for CO₂ and Methane (figures 1 and 2), clear bell-shaped curves appear. These results are in line with the EKC theory. A similar result can be found in the scatter plot for NO_x emissions (figure 3), although there is a bigger cluster of observations around the turning points, which makes it more difficult to see a clear turning point. What it looked like in the years before cannot be interpreted since there were no data available, but based on historical development it can be assumed that the trends before these observations were upward-sloping. Regarding the scatter plots for CO, SO_x and VOCs (figures 4, 5 and 6), it can be assumed that the graphs depict the

downward-sloping part of the curve. Just drawing on the graphical signs, it can be shown that there are clear signs of EKC's in Sweden for local and global pollutants.

It can clearly be seen graphically, that the data are not showing any signs of stationarity. In order to confirm this, the data were tested for stationarity using the Augmented Dickey-Fuller unit root test. All the pollutants, as well as the logged version of GDP/capita and the same variable but squared, turned out to be nonstationary (see appendix 1). If the regressions would have been run on them, the results might not have been accurate. The normal way to treat nonstationary data, is to use the first differences of the variables. To take the first differences of all the nonstationary variables would be a simple and quick solution. If variables are stationary after having their first difference tested, they are said to be integrated of the first order I(1) (Dougherty, 2011), and this turns out to be the case for the variables used in my study (see appendix 2). Theoretically, I could run my regressions on the first differences with OLS and interpret the results, however, this creates problems. The long run information on the relationship between the variables will be lost. If running a regression where the dependent variable is the first difference of CO₂/capita, and the independent variable would be GDP/capita, then the outcome would only be possible to interpret as how much the change in GDP/capita from one year to another affects the change in emissions from one year to another. The method when first differences are used cannot help me in answering my research questions and will thus not be used.

The complete model used was the following, where I substituted E with the different pollutants (CO₂, NO_x, Methane, CO, SO_x and VOCs):

$$\ln(E/capita)_t = \alpha_t + \beta_1 \ln(GDP/capita)_t + \beta_2 (\ln(GDP/capita))_t^2 + \epsilon_t \quad (4)$$

All models were tested for cointegration to see if any long-run relationship existed between them. If the models cointegrated, interpretations could be done, even though the variables were nonstationary. To test the models for cointegration, I used the Engle-Granger two-step approach, and noteworthy is, that when the squared GDP-term is included, only the model for Methane was cointegrated at 10 % significance level. When the squared GDP-term was excluded to see if it made any difference, none of the models were cointegrated (see appendix 3). This is problematic since it implies there is no long-run relationship between the variables. Even though the scatter plots (figures 1-6) showed seemingly obvious curves and relationships

between GDP and emissions, it cannot be confirmed by the data. Since I could not find any long-run relationships in any of the models, I chose not to do any further tests on the data or move forward with the regression analyses. Even though the data could not be used to confirm the hypothesis, the scatter plots proved useful in order to understand the relationships between the different pollutants that were used in the study and the GDP per capita in Sweden.

6.2 Research question 2

Can the potential environmental progress be explained by changing trade and production patterns? How do trade-related variables affect the potential Environmental Kuznets Curves?

In order to answer the second research question, the same OLS regression model was estimated as for the first research question, but with the additional dependent variables included.

$$\ln(E/\text{capita})_t = \alpha + \beta_1 \ln(\text{GDP}/\text{capita})_t + \beta_2 (\ln(\text{GDP}/\text{capita}))^2_t + \beta_3 T_t + \beta_4 M_t + \beta_5 DM_t + \beta_6 DX_t + \varepsilon_t \quad (5)$$

I could already establish the nonstationarity of some of the variables, from the tests related to the first research question. When the trade-related dependent variables were tested for stationarity, they turned out to be nonstationary as well (see appendix 1). However, they were stationary when tested in their first differences, which makes them integrated of the first order, I(1) (see appendix 2). The first differences could be used to estimate the regressions, but the same problems arise as with the first research question. Important long-run information will be lost, since only the differences between each year will matter, and not the long-run relationship that is needed to answer the questions. To find out if any long-run relationships existed, the extended models were tested for cointegration using the Engle-Granger approach (see appendix 3). Noteworthy here is, that all models are cointegrated, except for Methane. Hence no further conclusions can be drawn from the Methane model.

Regarding the rest of the emissions, cointegration makes it possible to work with the models even though the variables are nonstationary. The models were run in an OLS estimation to find the cointegrating relationships, and how the dependent variables affect the level of emissions in the long run. Since variables that are cointegrated share a trend, it is possible to estimate

coefficients from an OLS regression (Verbeek, 2012). Since the problem of nonstationarity is still present in the regressions, that problem overshadows and dominates the other problems that could occur, such as autocorrelation, omitted variables and endogeneity of X-variables. The OLS estimator is generally not normally distributed when using nonstationary data, which is why the t-statistics are not trustworthy (Verbeek, 2012). When all these issues are taken into consideration, it proves that is not necessary to test for heteroscedasticity and autocorrelation as normally would be done. Since the tests would generate skewed and misleading results, they were not performed. The only thing that could be interpreted from the regressions, was the estimations of the coefficients which will show the long-run relationships.

6.2.1 Global pollutants

The global pollutants CO₂, Methane and NO_x were all tested for cointegration, but it showed that the model for Methane was not cointegrated. The following results will thus only concern CO₂ and NO_x.

	CO ₂	NO _x
ln(GDP/capita)	8,313162	15,47085
(ln(GDP/capita)) ²	-0,3993628	-0,7612316
Manufacturing/GDP	-0,0119028	-0,0000749
Trade/GDP	-0,002789	0,0023194
Dirty exports	-0,0086645	0,0044124
Dirty imports	-0,001429	-0,0063074

(Table 2, regression outputs CO₂ and NO_x)

It is noteworthy that no levels of significance are shown in table 2. Due to the fact that the data are nonstationary, any p-values and t-statistics in the regression outputs are not accurate.

As can be seen in the table of the regression outcomes (table 2), the results vary between the different pollutants. For both pollutants the coefficient for the GDP variable is positive. This

might seem strange, and could suggest that emissions increase with increasing levels of income. In line with EKC theory, the GDP variable should be positive and the squared GDP variable should be negative to allow for the EKC to appear, though this is only valid if the data actually show a curve with a turning point (Cole, 2004; Kearsley & Riddell, 2010). As it could be seen in section 6.1, when inspecting the relationships between emissions and GDP graphically (fig. 1 and 3), turning points were visible for CO₂ and NO_x around the year 1970.

Concerning the CO₂ model, the negative sign for the trade intensity variable is in line with the expectations that increased trade leads to less emissions. The negative long-run relationship between CO₂ emissions and dirty imports is also what was assumed. However, the negative coefficient for dirty exports indicates that emissions will decrease as the share of dirty export increases. The manufacturing share of GDP proved to have a larger impact on CO₂ emissions than the trade-related variables, which indicates that CO₂ emissions are in the long run more affected by a structural change in the economy than dirty trade shares.

Two variables behave differently in the model for NO_x emissions compared to the CO₂ regression. Trade and dirty exports have positive coefficients. In this case it seems like in the long run; emissions will increase as a result of increased trade. The positive coefficient for dirty exports coincides with what I expected; emissions will increase as a result of bigger shares of dirty exports. Compared to the results from the CO₂ regression, the impact on emissions from structural changes in the manufacturing industry is much smaller in the NO_x regression. A one percent increase of the manufacturing share would result in a 0,007 percent decrease of NO_x emissions.

6.2.2 Local pollutants

All models for local pollutants, CO, SO_x and VOCs, were tested for cointegration and they all turned out to be cointegrated (see appendix 3). It is important to remember that the data for the local pollutants only cover a period of 25 years. The estimated coefficients from the OLS estimation are interpreted as the cointegrating relationships that are valid in the long run. Since p-values and t-statistics are misleading due to the nonstationarity, they are not included in the results or analyses.

	CO	SO _x	VOCs
ln(GDP/capita)	-53,86566	-102,2816	-47,71171
(ln(GDP/capita)) ²	2,475501	4,739529	2,219977
Manufacturing/GDP	0,0535167	0,1055671	0,0549559
Trade/GDP	-0,0128285	-0,0286351	-0,0156152
Dirty exports	-0,0055039	-0,0052078	-0,0025497
Dirty imports	0,0060198	0,0157272	0,0075197

(Table 3, regression outputs CO, SO_x and VOCs)

Note that no levels of significance are shown in table 3. Due to the fact that the data are nonstationary, any p-values and t-statistics in the regression outputs are inaccurate.

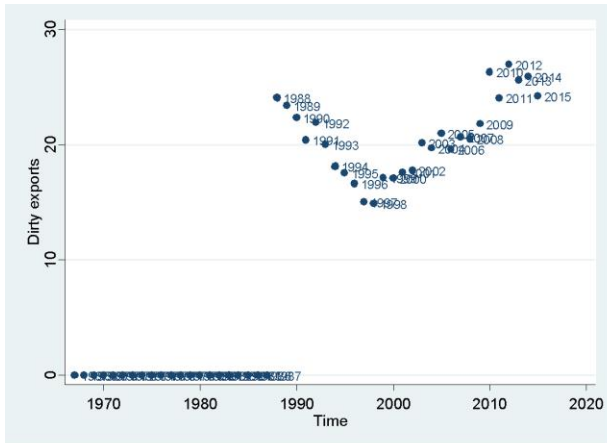
As the coefficients show in table 2, the patterns for all the local pollutants look somewhat similar. The logged GDP/capita variable is negative for all the different pollutants, whereas the squared GDP variable is positive for all pollutants. This result implies that there is a negative relationship between emissions and GDP, meaning that, in the long run emissions will decrease as GDP increases. The positive signs of the squared GDP-variables indicate that emissions are reduced at a diminishing speed, which is visible in figures 3-6.

As was described in section 6.2.1 regarding the global pollutants, the theory on EKC says the coefficient for GDP should be positive, whereas the coefficient for the squared GDP variable should be negative. The outcomes in the analyses of the local pollutants are completely different, although this could probably be explained by the fact that data only cover part of the curves. When inspected graphically, all the local pollutants have downward-sloping relationships. The turning points might have occurred earlier, which results in the negative relationship between emissions and growth. As data were not available for that time period, no further examinations of EKC patterns for the local pollutants could be done.

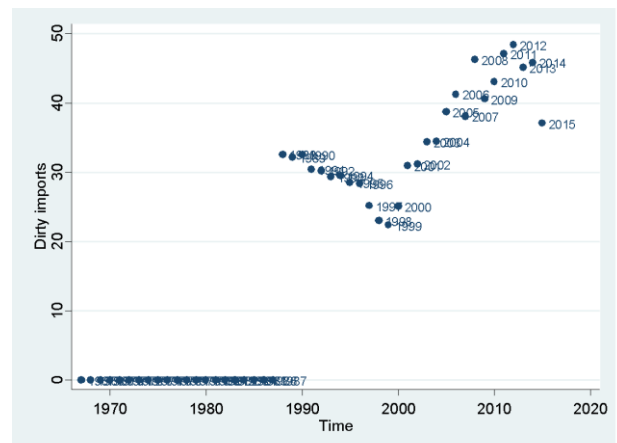
The positive signs of the manufacturing variables implicate that an increase of the manufacturing share of GDP, also leads to increasing emissions. In all three models, this coefficient turns out to affect emissions more in the long run than the three other trade-related variables. For both CO and VOCs a one percent increase in the manufacturing share of GDP results in a 5 percent decrease in emissions, and for SO_x the same result is a 10 percent decrease in emissions when the manufacturing share increases with one percent. Trade as a percent of GDP turned out negative in all the models for local pollutants, which is in line with the expectations.

Two surprising results are the coefficients for dirty imports and exports. In all the three models, these variables have the opposite sign as they were expected to have in line with the theory and previous research. The negative coefficients for dirty exports imply that, in the long run, increasing shares of dirty exports in the total exported amount of goods to non-OECD countries, will lead to decreasing emissions in the local environment. The opposite result is indicated for dirty imports. The positive sign of the coefficients in all three models implies that as the share of dirty imports increase, the levels of emissions in Sweden increases as well. The dirty trade ratios turned out to have a relatively low impact on emissions compared to manufacturing shares of GDP.

In order to correctly interpret the results from the cointegration relationships, some of the dependent variables were analysed more in depth. To confirm the assumptions of pollution haven effects, dirty imports to Sweden would increase at the same time as dirty exports would decrease. When the dirty trade data was plotted separately over time (figures 7 and 8) it could be seen that they simultaneously increase. This fact makes it difficult to draw any conclusions regarding the presence of pollution haven effects in Sweden.

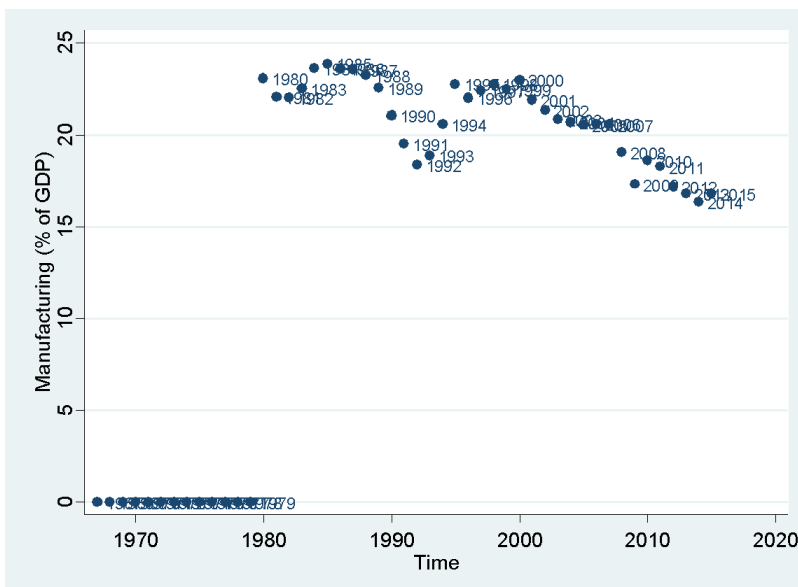


(Fig. 7, dirty exports over time)



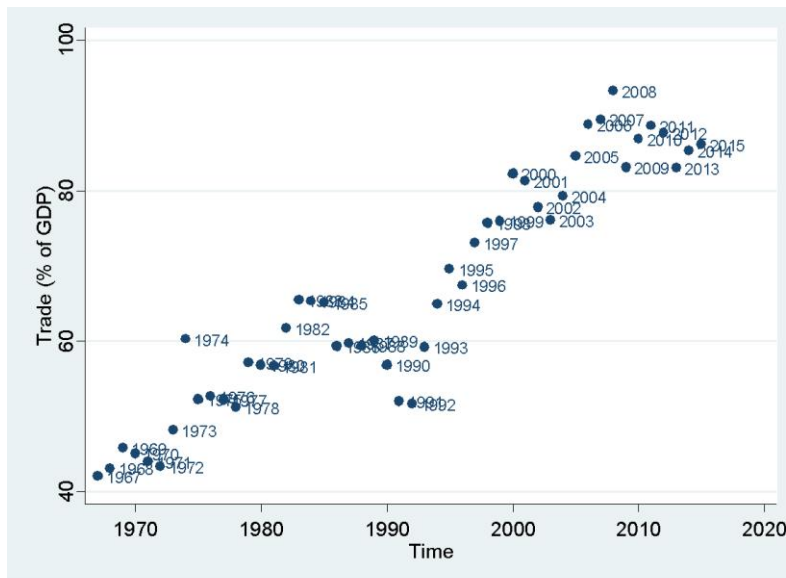
(Fig. 8, dirty imports over time)

In my regression outputs for the extended EKC-models (table 1 and 2), it was shown that in a majority of the regressions the manufacturing share of GDP had a bigger impact on emissions than dirty trade shares. To understand this structural change a bit better, the manufacturing variable was plotted over time (figure 9). It is clear that from the mid-90s, the manufacturing share of GDP has followed a downward-sloping trend.



(Fig. 9, manufacturing share of GDP over time)

Trade intensity turned out to have a negative relationship with emissions of local pollutants (table 3). It is shown graphically in figure 10 that trade intensity has increased steadily from the 1970s except for a decline in the early 1990s when Sweden experienced a financial crisis.



(Fig. 10, trade as % of GDP over time)

6.2.3 Error Correction Models

When cointegration analyses are performed, the natural next step is to construct Error Correction Models. This will allow for an analysis of the short-run mechanisms that drive the variables in the cointegrated models to their long-run relationship. To study those mechanisms is not the main focus of this essay, but in order to gain an understanding of how the variables in the models interact, a brief study of Error Correction Models will be included in the study. I constructed an Error Correction Model for one global pollutant (NO_x) and one local pollutant (SO_x). Not all the pollutants were included since the scope of the task would be too big and the results too complicated to get an overview, besides, all models are assumed to behave relatively similarly.

The model estimates error correction terms for all endogenous variables. These error correction terms are also called the speed of adjustment, because they measure how quickly the adjustment back to long-run equilibrium happens. If the error correction term is positive, it means the adjustment is away from the equilibrium relationship. If it is negative instead, it implies that the adjustment parameters move the variables back towards the long-run equilibrating relationship (Enders, 2015).

Error Correction Model, NO_x		
Variable	Error correction term, _ce1	P-value
$\Delta \ln \text{Emissions of NO}_x$	0,1866096	0,018
$\Delta \ln(\text{GDP/capita})$	-0,0070207	0,919
$\Delta(\ln(\text{GDP/capita}))^2$	-0,1739427	0,906
$\Delta(\text{Manufacturing/GDP})$	-17,9367	0,119
$\Delta(\text{Trade/GDP})$	-17,23961	0,185
$\Delta \text{Dirty exports}$	-42,54609	0,000
$\Delta \text{Dirty imports}$	-64,86622	0,000

(Table 4, ECM for NO_x)

The significant error correction terms in this model (table 3), are the ones for the differenced emissions variable and the differenced variables for dirty exports and imports. However, the size of the adjustment parameters of dirty exports and imports makes it difficult to interpret the outcome. Normally, a small parameter would indicate a slow adjustment and a parameter with higher value would mean a fast adjustment, although, the size of these parameters are a bit extreme. The negative signs of the parameters imply that if a positive deviation takes place, an adjustment back to the equilibrium will take place next period. The positive sign of the error correction term for GDP implies that a positive deviation from the long-run equilibrium results in another deviation the following period. This will destabilise the relationship.

Error Correction Model, SO_x		
Variable	Error correction term, _ce1	P-value
$\Delta \ln \text{Emissions of SO}_x$	-0,0876368	0,000
$\Delta \ln(\text{GDP/capita})$	-0,0146739	0,237
$\Delta(\ln(\text{GDP/capita}))^2$	omitted due to collinearity	-
$\Delta(\text{Manufacturing/GDP})$	0,5953921	0,160
$\Delta(\text{Trade/GDP})$	1,583742	0,410
$\Delta \text{Dirty exports}$	-0,7130445	0,349
$\Delta \text{Dirty imports}$	-3,695059	0,003

(Table 5, ECM for SO_x)

In the ECM for SO_x (table 4), the only error correction terms that are significant are the ones for emissions of SO_x and dirty imports. They both have negative signs which indicate that following a deviation from the long-run equilibrium, they will both adjust back to long-run path in the following period. The size of the dirty imports parameter indicates a very fast readjustment to the long-run relationship following a deviation.

7 Summary and conclusions

This essay has aimed to answer the question on whether Environmental Kuznets Curves can be found in Sweden for a group of local and global pollutants. Additionally I have tried to examine whether the environmental progress in Sweden could be described by structural changes or trade patterns.

The questions were answered by empirically studying six pollutants in Sweden and how they were affected by changing GDP levels, manufacturing shares of GDP, trade openness and dirty exports and imports to and from non-OECD countries. In order to produce interpretable results the regression models were estimated using OLS. All the data that were used proved to be nonstationary. The nonstationarity was confirmed both graphically and by using unit root tests. After having tested for cointegration, the trade-extended models could be used for further tests. The outcomes of the OLS estimations could due to the nonstationarity only be used to interpret the long-run cointegrating relationships.

I found that the long-run relationships between GDP and emissions for CO₂ and NO_x resembled EKC patterns. These results were confirmed with a graphical analysis of the scatter plots (figures 1-6). I found that global as well as local pollutants have declined over the last decades at the same time as GDP has steadily increased. These findings are in line with the Environmental Kuznets Curve theory.

When it came to the local pollutants CO, SO_x and VOCs, only part of the curve could be analysed due to data availability. The results from the cointegration relationships implied a negative relationship between GDP and emissions which could be interpreted as the downward-sloping part of the EKC. When analysing the extended models where trade-variables were included, the dirty trade-variables proved in most cases to have a relatively low impact on emissions in the long run. This could be explained by several different scenarios. One reason could be, that no pollution haven effects can be found in Sweden. Another reason that is more likely, is the lack of detailed trade data. If goods pass through other EU countries on their way to Sweden, the country of origin is registered as the last country it passed through. This makes it difficult to see if Sweden's trade with non-OECD countries has increased or decreased, and the effect on emissions was difficult to distinguish in my analysis.

The pollutants that were used in the study were divided into groups of local and global pollutants since they were expected to behave differently. After the scatterplots and the cointegration relationships were analysed, no larger difference between the groups could be confirmed.

To gain a deeper understanding of the impact trade flows have on the environment in Sweden, as well as globally, more detailed trade data is needed. My suggestions for further research would be to include a more detailed dataset on the underlying trade details, where the countries of origin can be more clearly specified. This would also have implications for trade policy, to gain a deeper knowledge of the environmental impact from Sweden's consumption and production. Ultimately, this would also make it easier for the Swedish population to gain knowledge of the global scale of climate change.

To summarise, the findings in this essay support the EKC hypothesis for at least the global pollutants CO₂, Methane and NO_x where sufficiently long time series were available. The essay can also show that for SO_x, CO and VOCs, Sweden can be assumed to be on the later, downward-sloping part of the EKC. Dirty trade with non-OECD countries was shown to have a relatively low impact on emissions, and the presence of pollution haven effects could not be confirmed. Manufacturing proved to have a greater impact on emissions. The simultaneous decline of manufacturing as a part of GDP and pollutants emitted in Sweden, implies that the production structure has a great effect on the environmental impact. When seen from a production perspective, Sweden has succeeded in reducing its emissions of the pollutants that are examined in this essay. To draw any further conclusions on the impact globally of Swedish standards of living, all aspects of our environmental impact need to be included. To be able to create a sustainable future, a greater focus on the consumption perspective of emissions is needed.

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Appendix 1

ADF unit root test, stationarity. Variables in levels.				
Variable	Critical value 5 %	Observed t-stat	P-value	Result
lnCO ₂ , level	-2,941	-0,338	0,9199	Nonstationary
lnMethane, level	-2,952	0,437	0,9828	Nonstationary
lnNO _x , level	-2,952	1,579	0,9978	Nonstationary
lnCO, level	-3,000	-0,595	0,8721	Nonstationary
lnSO _x , level	-3,000	-1,387	0,5885	Nonstationary
lnVOCs, level	-3,000	-2,519	0,3939	Nonstationary
lnGDP/capita, level	-2,936	-1,237	0,6577	Nonstationary
(lnGDP/capita) ² , level	-2,936	-1,092	0,7184	Nonstationary
Manufacturing, level	-2,972	-0,599	0,8712	Nonstationary
Trade, level	-2,936	-1,161	0,6902	Nonstationary
Dirty exports, level	-2,936	-1,172	0,6856	Nonstationary
Dirty Imports, level	-2,936	-1,088	0,7230	Nonstationary

Appendix 2

ADF unit root test, stationarity. Variables in first differences.				
Variable	Critical value 5 %	Observed t-stat	P-value	Result
CO ₂ , 1st difference	-2,944	-7,033	0,0000	Stationary
Methane, 1st difference	-2,955	-6,537	0,0000	Stationary
NO _x , 1st difference	-2,955	-6,182	0,0000	Stationary
CO, 1st difference	-3,000	-5,889	0,0000	Stationary
SO _x , 1st difference	-3,000	-3,735	0,0036	Stationary
VOCs, 1st difference	-3,000	-3,759	0,0034	Stationary
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GDP/capita, 1st difference	-2,938	-5,377	0,0000	Stationary
(GDP/capita) ² , 1st difference	-2,938	-5,529	0,0000	Stationary
Manufacturing, 1st difference	-2,938	-6,954	0,0000	Stationary
Trade, 1st difference	-2,938	-6,98	0,0000	Stationary
Dirty exports, 1st difference	-2,938	-7,198	0,0000	Stationary
Dirty Imports, 1st difference	-2,938	-7,038	0,0000	Stationary

Appendix 3

Engle-Granger test for cointegration				
Model	Critical value 5 %	Observed t-stat	P-value	Result
Basic model CO ₂	-3,528	-2,126	0,5312	Not cointegrated
Basic model Methane	-3,544	-2,572	0,2932	Not cointegrated
Basic model NO _x	-3,544	-2,420	0,3690	Not cointegrated
Basic model CO	-3,600	-0,760	0,9689	Not cointegrated
Basic model SO _x	-3,600	-0,564	0,9807	Not cointegrated
Basic model VOCs	-3,600	-0,496	0,9836	Not cointegrated
Extended model CO ₂	-3,532	-3,84	0,0146	Cointegrated
Extended model Methane	-3,548	-2,873	0,1713	Not Cointegrated
Extended model NO _x	-3,548	-3,725	0,0208	Cointegrated
Extended model CO	-3,600	-4,279	0,0034	Cointegrated
Extended model SO _x	-3,600	-4,252	0,0037	Cointegrated
Extended model VOCs	-3,600	-5,563	0,0000	Cointegrated