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Environmental quality related to economic growth: meta-analysis of environmental Kuznets curve hypothesis

Diploma thesis

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Vote of thanks

I am very thankful to my supervisor Ing. Šárka Stojarová, Ph.D., who was a great help and support. She has provided me with professional guidance and very helpful comments. And of course I have to give big thanks to my family and friends.

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Abstract

Petříková V. **Environmental quality related to economic growth: meta-analysis of environmental Kuznets curve hypothesis.**
Diploma thesis. Brno: Mendel University, 2017.

This diploma thesis examines scientific articles to determine if there is an agreement in literature on the topic of relationship between economic growth and environment. This investigation uses meta-analysis to explore the systematic variation across environmental Kuznets curve studies to better understand the specific factors that affect this relationship. Binomial and multinomial logit models are performed. Final results stimulate an ongoing discussion of not discovering any unity in this area.

Keywords

Meta-analysis, environmental Kuznets curve, multinomial logit model, environment, economic growth, binary logit model.

Abstrakt

Petříková V. **Vztah životního prostředí k růstu ekonomiky: meta-analýza environmentální Kuznětsovy křivky**.
Diplomová práce. Brno: Mendelova univerzita v Brně, 2017.

Diplomová práce se zabývá vědeckými články z oblasti environmentální Kuznětsovy křivky, z kterých bude díky kódování vybraných vlastností stanoveno, zda je v této oblasti možné dojít ke společnému závěru ve vztahu mezi ekonomickým růstem a životním prostředím. K výzkumu je využita meta-analýza, která umožňuje systematické prozkoumání všech faktorů ovlivňujících tento vztah. K dosažení výsledků jsou použity binominální a multinomální logitové modely. Konečné výsledky podporují již probíhající diskuzi, která nenachází shodu mezi články v této oblasti.

Klíčová slova

Meta-analýza, environmentální Kuznětsova křivka, multinomiální logit model, ekonomický růst, životní prostředí, binominální logit model.

Content

1 Introduction

Global public concern about the quality of our environment has sparked great efforts to find the determinants of environmental pollution. The environmental Kuznets Curve (EKC) hypothesis has become a controversial issue in recent years. This concept examines the relationship between per capita income and the level of environmental pollution in an economy. In early stages of economic growth, environmental degradation and pollution increase. At a certain level of per capita income, the trend reverses and the environmental deterioration decreases, leading to an improvement in the environment. This suggests that the relationship is an inverted U-shape. This relationship indicates that economic growth is necessary to maintain or improve the quality of the environment. After the first studies by Grossman and Krueger in 1991, which described the EKC for the first time, a deeper understanding of the empirical relationship between income and environmental quality has developed rapidly through further studies of the EKC hypothesis.

The presence and absence of the EKC in various empirical studies has led to a discussion of its relevance. The EKC literature includes many studies that use different methods, evaluate different environmental indicators, and use different data, leading to a wide range of findings that lead to conflicting interpretations. So far, there have been a limited number of attempts of systematically surveying the EKC literature using meta-analysis to discover the applicability of the curve.

Environmental pollution worldwide makes people worry about the link between economic growth and environmental degradation. Extensive literature on this subject, both theoretical and empirical, has grown in recent times. Among the majority of empirical studies is an important finding of the Environmental Kuznets Curve, namely the inverted U-shaped relationship between pollution and economic growth. The quality of the environment deteriorates first and improves with the economic development at a later stage. In most cases, literature has regarded the EKC as an empirical phenomenon. In order to strengthen the connection between theoretical and empirical analysis, models and stylized facts are needed.

Since the year 1991 the EKC has its place in environmental policy, although its application as an effective tool for political implementation has been seriously questioned. Policy makers could be able to rely on the EKC as a core instrument for managing environmental quality if economists were able to predict the types of datasets that would follow a real EKC. The uncertainty lies in the question of whether results from previous studies can be used in policy-making. Intuitively, if developed economies are polluting the environment less, policies that stimulate economic growth should lead to less environmental damage. However, this does not mean that developed economies are never exposed to environmental concerns in the future.

The focus of this work is to determine whether the addition of further EKC studies will provide deeper insight into what factors can influence the presence of an EKC relationship.

2 Objective

The aim of this thesis is to determine whether there is a consensus in the field of the Kuznets curve hypothesis, which shows an inverted U-shaped relationship between environmental degradation and economic development. The concept of the EKC originally began with data observation and has attracted considerable attention from many researchers concerning the existence of the EKC.

The thesis conducts a systematic review of the literature and estimates binomial and multinomial logit models. The econometric methods used, help to systematically review the empirical literature and to investigate the relationship with regards to the impact of chosen characteristics.

The issue of the EKC hypothesis has become the standard topic for technical discussions on environmental policy. The EKC has revealed a surprising result. The early estimates showed that some important indicators of environmental quality such as the level of carbon or sulphur-dioxide and particles in the air actually improved as income and consumption levels rose. But there can be found contradictory results on the evidence of the EKC which suggests that a meta-analysis should be performed to statistically summarize the literature in order to find out which factors can lead to the presence or absence of the curve.

The main goal of this work is to look for the nature of the relationship between the income level and the environmental degradation and to find out which is the predominant type of this relationship and whether it corresponds to the environmental Kuznets curve hypothesis. The goal is achieved using econometric methods. The analysis uses the binomial and multinomial logit models. In addition, the thesis focuses on examining the influence of other characteristics.

Partial goal of this thesis is to investigate the influence of trade on environmental Kuznets curve. Specifically, in those countries which will confirm the hypothesis of inverted U-shape. Environmental Kuznets Curve provides a framework with which it is possible to see the role of trade in the economic growth and environment relationship as well.

The theoretical basis of this work will allow creating of relatively unconstrained model structure. Studies of environmental Kuznets curve hypothesis may practice different methods, evaluate different environmental indicators, and use different data, resulting in a broad spectrum of findings and leading to sometimes conflicting interpretations. The purpose of this diploma thesis is to synthesize the results of existing environmental Kuznets curve findings by conducting a statistical meta-analysis. Environmental Kuznets curve studies usually solve the empirical validity of the expected relationship type inverted-U between pollutants and economic levels. However, there is a specific complaint in the area of Environmental Kuznets Curve, that is that in the present there can not be said any definite conclusion regarding the most appropriate method of modelling (e.g. The choice and specification of variables). For this situation it appears to be particularly suitable to use the compositions of meta-analysis. The ambition is to provide a complete review of the relevant literature.

3 Methodology

The investigation of the relationship will be performed using econometrics methods regarding the impact of study characteristics and of the systematic review of scientific articles. The first step towards meta-analysis is to create a database. This involves three main activities, which are quite time consuming: the investigation of studies, the selection of applicable articles, and classifying of study attributes to construct a dataset. For the purposes of the analysis, two types of datasets were created. By classifying of individual observations in the study then the disaggregated data set was initiated, which is the basis for the meta-analysis. In addition, an aggregated dataset focusing on single individual studies as a whole was prepared.

The dataset was created within the collaboration on IGA project PEF_TP_2016009 „Využití meta-analýzy v kauzálně-vazební literatuře z oblasti energetické a environmentální ekonomie“ lead by Vladimír Hajko and is used here with a permission. Scientific articles were searched for on the Scopus web database, www.scopus.com. The used link was: TITLE-ABS-KEY (ekc OR "environmental kuznets") AND SUBJAREA (mult OR arts OR busi OR deci OR econ OR psyc OR soci) AND PUBYEAR > 1999.

It is needed to set keywords for searching for studies in this database. The keywords used in this study are: EKC or environmental Kuznets curve. This meta-analysis aims on the most recent articles published since 2000, so the year of publication was limited to year more than 1999. The studies were also restricted by the subject area. Subjects were selected by relevance to the selected topic. When further exploration of the topic, which means later expansion of the work, the subject should not be limited to studying an even wider range of articles. But for this thesis, this relevant limitation has been applied. Studies were also ranked according to the number of citations in descending order. For practical reasons, the survey of studies was limited to the 100 most cited studies.

The next step in creating of a dataset is the choice of relevant studies from the already set study overview. In the beginning it was tested whether the key variables of this study include the relationship between GDP/income and pollutants/environmental pollution. Papers containing other key variables other than these were removed from the list. Papers, which contained some other key variables besides these which were mentioned, stayed named in the list of suitable literature. Articles which did not supply the needed information were removed. The final number of relevant studies in the survey is 69.

In a few fields, there is a confirmation that interesting results are distributed more rapidly or frequently than the not positive ones. This is named production predisposition. Meta-analysis can be bounced over by representing critical positive discoveries but the ones which are negative will most likely be distributed later on –after the meta-analysis was done, or not at all (Card, 2012). However, if a sample of articles which was chosen for review is biased, then the validity of the outcome of the meta-analysis is in danger, with no regard on how systematic it is in other

respects. But in other words, publication bias should not be seen as a disagreement against the use of a meta-analysis (Rothstein, Sutton, Borenstein, 2006).

One good thing about logistic regression is that it is very close to regular linear regression analysis, but some of the more negative properties of linear regression also can apply to logistic regression. One is multicollinearity, which shows up when there are big linear dependencies between explanatory variables. The basic sign is that two or more variables are highly correlated, it can become difficult to get right estimates of their effect on the dependent variable. Multicolliniarity makes coefficients less stable. Standard errors can become large and individual variables that have quite a weak effects, when in groups. It is fortunate that the consequences are only here for the collinear variables (Allison, 2012).

In the appendices are described all attributes and the way they are coded is explained. Also there are explained the binary and multinomial logit models.

4 Theoretical part

This section focuses on the convergence of the terms and opinions that are relevant to the theme of this thesis. These conditions will then be the basis for practical part of this work. The main source of information is acquired from scientific literature.

4.1 Meta-analysis

Meta-analysis is a statistical method that focuses on the aggregation of results from independent studies, especially in cases where different studies deliver different results. The method is particularly popular in the field of medical research and areas that do experiments which are under control. It should be said that this involves these studies to be similarly modelled. As a research methodology, meta-analysis has benefits and limitations that must be acknowledged in its application (Card, 2012).

The benefits of meta-analysis include the ability to improve the power of small or inconclusive studies to answer questions and the ability to identify sources of diversity across various types of studies. Conceptually, a meta-analysis uses a statistical approach to combine the results from multiple studies in an effort to increase power (over individual studies), improve estimates of the size of the effect and to resolve uncertainty when reports disagree. A meta-analysis is a statistical overview of the results from one or more systematic review. Basically, it produces a weighted average of the included study results and this approach has several advantages:

- Hypothesis testing can be applied on summary estimates
- The precision and accuracy of estimates can be improved as more data is used. This, in turn, may increase the statistical power to detect an effect.
- Inconsistency of results across studies can be quantified and analysed.
- Results can be generalized to a larger population,
- Moderators can be included to explain variation between studies,
- The presence of publication bias can be investigated (Ioannidis, 1999).

Meta-analysis cannot improve the quality or reporting of the original studies. Other limitations come from misapplications of the method, such as when study diversity is ignored or mishandled in the analysis. In the past, most researchers have prepared summaries of empirical studies in a narrative way. Large numbers of studies which examined the same subjects were collected, individual studies were characterized and thanks to the interpretation, the research results were summarized. However, this research synthesis was criticized. Critics of this traditional method warned that their process and their results are inaccurate. As Cooper (2016) explained, the main drawbacks were poor proofing methods, lack of

systematic procedures, limited search for studies, lack of measures to assess the reliability of the descriptions, or the use of post-hoc criteria.

The first step to conducting a meta-analysis is to decide what specific variables will be collected and used from past studies in order to formulate a complete database. The list of variables must be relative to the theory within the meta-analysis and also be present in the studies being analysed.

The next step is to identify what literature will be used in relation to the topic of the meta-analysis. When the list of variables to look for is done and the collection of literature is complete, it is time to identify individual observations in each of the studies. The unit of observation is "a study." Each of the studies produces values for the variables defined. After identifying each individual observation, the data collected from every study must be assigned a value and coded into the dataset. The last step of the meta-analysis process is taking the formulated dataset and applying a statistical model to it. No meta-analyses are restricted to any one given model just as any other research topic is not limited to taking a specific statistical approach.

Overall, a meta-study allows a much wider and diverse net to be cast than a traditional literature review. Because it uses econometric techniques, meta-analysis is excellent for highlighting correlations and links between studies that may not be readily evident as well as ensuring that the researcher does not subconsciously infer correlations that may not exist. Rather than relying on descriptive literature or individual results of a single study, a meta-analysis has the capability of "analysing the analysis," thus controlling for a large variety of factors and potentially resulting in an improved statistical interpretation of the results of multiple pieces of literature. (Goldman, 2012)

Systematic reviews and meta-analyses began to be used by the researchers in the mid-1980s and were rooted in the 1990s. These types of verifications use explicit criteria that later determine what is, or will be, included in the analysis. Due to the subjectivity of the rules, the systematic review cannot be considered completely objective. Meta-analysis is the major part of the most systematic investigations (Borenstein, Hedges, Higgins, Rothstein, 2011).

Cavlovic et al. (2000) conducted the first meta-analysis of the EKC hypothesis, using a compilation of EKC studies from the early 1990s. They analysed 25 studies using 155 observations and considered 11 different environmental degradation measures. A second meta-analysis has since been conducted by Li et al., (2007) adding 52 studies to the original Cavlovic et al. (2000) dataset, providing a total of 588 observations. Li et al. (2007) ultimately found no statistically significant evidence that supports the EKC for anthropogenic activity-related gases, but they did find that longer time periods, panel data, and global data all significantly increase the probability of finding a significant EKC pattern. Goldman in 2012 enlarged the exploration of determining the factors influencing the presence or absence of an EKC. He chose to replicate the variables used in Li et. al, 2007. Studies he used must be after the year 2005 in order to prevent overlapping data with Li's past meta-analysis. He used a total of 20 studies published between the years 2006 and

2011. In his conclusion he states that the resulting relationship is not going to look like the EKC type.

4.2 Environmental Kuznets curve

The environmental Kuznets curve is just hypothetical. It studies the relationship between environmental degradation's indicators and income per capita. The early stages of the economical growth go together with the increase of pollution and degradation. But over a certain amount of income per capita (which varies for different indicators), the trend reverses, economic growth goes to an improvement in the environment at higher income levels. This says that the environmental impact indicator is an U-shaped function which is inverted of income per capita. The EKC is named after Kuznets (1955), which firstly increases income inequality and then decreases as economic development progresses. It is quite easy to slip to do wrong econometrics and the history of the EKC clarifies what could go wrong. The EKC idea came to the fore, as only a few had adequately taken into account the econometric diagnostic statistics. The properties of the statistical data used for example the serial dependency or stochastic trends in time series were little or not considered, and few tests of the model adequacy were carried out or presented. One of the main features of econometrics is to examine which apparent relationships are valid and which are incorrect correlations. When we consider these statistics and apply appropriate techniques, we notice that the environmental Kuznets curve does not exist. Instead of that, we receive more real view of the impacts of economic growth and technological change on environmental quality. (Perman and Stern 2003). It looks like that most indexes of environmental pollution monotonically rise in income, although the "elasticity" of income is less than one and is not an easy function of income by itself. Time-related effects reduce environmental impact in countries with income being at all levels. However, we can find in rapidly growing countries with middle income, the scale effect, which enhances pollution and other deterioration, overcomes the time effect. In rich countries, growth is slower, and measures to reduce environmental pollution could overcome the scale effect. (Stern, 2003)

4.2.1 Theoretical background

Environmental Kuznets Curve is named according to the economist Simon Kuznets born in Russia, who later lived in the United States. Simon Kuznets was born in 1901, at age 21 he decided to emigrate from Russia to the United States, where he lived the rest of his live. Between 1922-1926 he studied at Columbia University in New York. Later he taught economics at the University of Pennsylvania, John Hopkins University in Baltimore and at Harvard University in Cambridge. His main economic branch of all were the macroeconomic aggregates headed by empirical studies on GDP. A great contribution was his methodology. Kuznets argued, that it can be very complicated to pronounce the general conclusions about certain relations in the field of economic development. He often referred to incomplete models

and warned about boundless confidence in these models. In 1971, this author has received the Nobel Prize for economics.

In 1955 Simon Kuznets introduced a revolutionary idea[1] in the field of economic development. The core point of Kuznets theory is the argument that individual economies, while they are in the phase of economic development, show an increase in inequality in society (especially inequalities of income), and also a widening of the social scissors between rich and poor up to a certain point, after which the thread comes in a twist and takes the opposite trend (equitable distribution of income). Fig. No.1 shows a graphical representation of this idea. The EKC is inherently based on this theory and it applies it to include an environmental issue of pollution in relation to the degree of economic development[2]. The shape of the EKC and its validity as such lead to a rich discussion. The simplest possible graphical presentation of the environmental degradation and economic progress is shown in Fig. No.2.

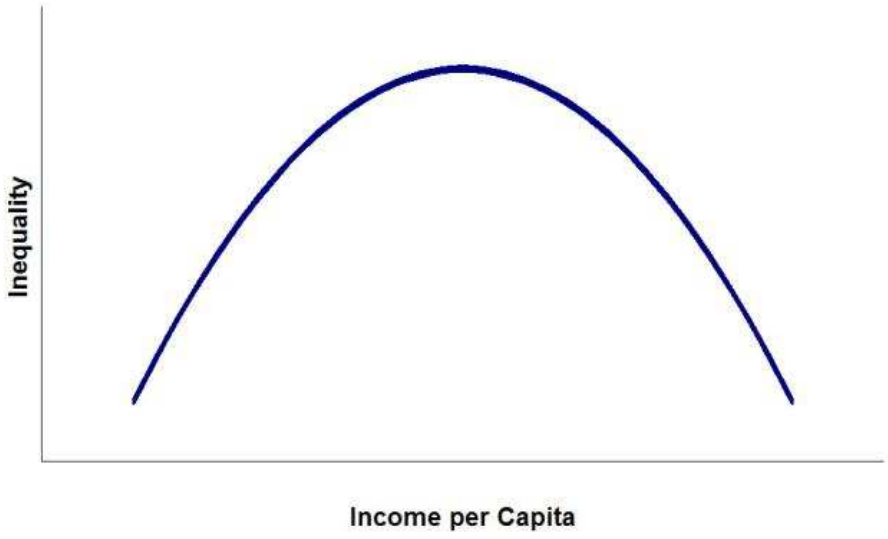

Fig. 1 **Kuznets curve**
Source: *LearnEconomicsOnline.com (2013)*

[1] Article related to long-term distribution of income among individuals is called "Economic Growth and Income Inequality".

[2] The origin of the idea of the environmental Kuznets curve is possible to attribute to more authors who published simultaneously but independently of this idea in their studies. The main authors popularizing the idea of EKC can be considered the World Bank Development Report and later in 1993-1995 the scientific duo Grossman and Krueger (1991).

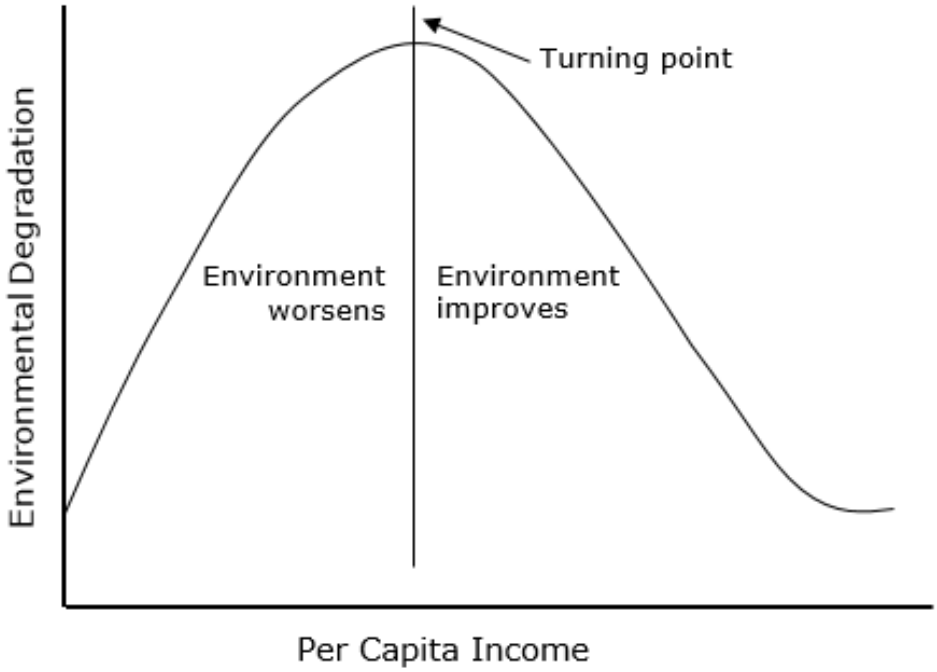

Fig. 2 **Environmental Kuznets curve**
Source: *Ferrini (2012)*

The EKC concept was then brought up in the early 1990s with the ground-breaking study by Grossman and Krueger in 1991. The thought that economic increase is needed to develop the obtaining or improving environmental quality, is an essential part of the sustainable development's argument. The EKC topic was known after the World Bank in the year 1992 published World Development Report, which says that the aspect which points out that the bigger economic activity is, damages the environment because of different assumptions about technological innovations, or investment in environment. The environmental Kuznets curve has never been presented for all of the pollutants or impacts on environment (Dasgupta et al., 2002) This assumption also goes with the thoughts of Perman and Stern (2003). The common view that economic growth and environment are contradictory goals, shows the scale effect. Supporters of the EKC hypotheses are arguing that at a high development level can be seen structural change going towards information-intensive industries or services. "(Panayotou, 1993).

If these conditions apply, then the EKC concept can be valids:

a) Marginal utility of consumption is declining or constant with increasing consumption.
b) Total degradation of pollution is increasing.
c) Marginal damage from pollution increases.
d) Marginal cost for reduction of pollution are growing.

(Dasgupta, 2002, p. 149)

4.2.2 Phases of the EKC

As explained above, the EKC is essentially a function of concave shape, which looks like an "Inverted U". On the vertical Y-axis, the factor is arbitrarily chosen by the author but it must include an environmental deterioration factor per capita. The most commonly tested ones include environmental damage indicators which are CO, CO_2, SO_x, NO_x, municipal waste and deforestation (all calculated per capita). The X-axis values are representative of the economic advancement of the economy. To express these values, mainly GDP and GNP per capita are used.

The initial phase of the curve is associated with minimal production of harmful substances. This is the pre-industrial phase of the curve, where the majority of economic entities are engaged in activities related to agriculture. These activities bring a minimum production of pollutants, at least those of industrial origin. The shape function is derived from the assumption, that for the residents of an underdeveloped country environmental and natural resources are of high value.

This is mainly caused due to the focus on the primary and secondary sector. So focus on the acquisition of raw materials, fishing, forestry, agriculture and processing received materials. In the early stages of economic development, the increasing degradation, including environmental degradation, are seen as an acceptable side effect of economic growth (Arrow, 1995, p. 520).

The priorities of inhabitants of these economies are more inclined towards income protection rather than to environment protection, and so the governments of these countries are not motivated to start reducing the harm of environmental degradation because at this stage of the EKC it may cause a slowdown in economic growth. It follows that the quality of environment is a luxury good, whose "consumption" is growing with higher income (income elasticity of environment is therefore greater than 1).

A gradual increase in people's income is generally attributed to an increase in the value of the environment. This fact should lead to a situation where a company is able to further increase its economic growth, while lowering its environmental burden. This phase is usually between $ 6000-9000 annual income per capita. The value is calculated in US dollars by the year 2003. The question of the occurrence of the turning point is addressed by many researches. It can be summarized that the various forms of contamination found, reach different points (if any) at various intervals. And also the individual economies can collectively distinguish these intervals. The result was also strongly affected by using different methodologies. This is the period in which a company is beginning to appreciate the environment. That is due to the relative saturation of basic needs transferred to a higher level of attention from their own revenues to the state of the environment. Current economic progress and reducing the environmental impact can be achieved through research, new technologies and new processes to be more efficient. The expected trend of reducing the environmental burden tends to be supported by governments through regulation of markets associated with the formation of pollution. Individual authors attribute different weights to the relationship between the degree of state regulation and environmental quality. The actual separation of the

trend of economic growth from the trend of increasing damage to the environment is known as "decoupling". Graphical representation of decoupling comprises two curves. The Y-axis values are found in economic growth as well as indicators of environmental pollution. The X-axis represents the expression time series. According to the EKC the two curves should initially be growing up until a point where the separation of the curve depicting environmental damage from the constantly rising curve of economic growth happens. This is caused by the above-described phenomenon of the rethinking of economic priorities.

All these economic phases have a prolonged duration and it is estimated that operation of all parts of the curve can take over a century in real time (Yandle et al., 2004, p. 4). This figure varies considerably from individual pollutants, based on the regulation applied, depending on the speed of economic development of the country, according to the degree of liberalization of international trade and so on.

The final phase of the declining EKC graph is therefore associated with increased priority given to the protection of the environment, both by individual businesses and from the state. So it even incentivises the state to regulate the market stronger. In the economic progress of a country it is usual to shift production from primary to secondary sectors and further on to the tertiary sector. Advanced economies are mostly solely focused on the aforementioned tertiary sector, which largely contributes to the reduction of environmental burdens. In developed countries, such as the members of the EU, the share of the tertiary sector in employment is usually about two thirds of all employed (MFA, 2009).

Another possible explanation of the shape of the EKC was mentioned by Harvard's professor Theodore Panayotou, who argues that the evolution of Kuznets curve, the "inverted U" shape, is determined by the different rate of change of the environment and changes in society. Meant is that, societal beliefs regarding the value of the environment are changing with a slower rate than the state of the environment, causing a delay in response to the changes in environmental quality. In different societies this distinction is otherwise significant. Taking that the growth of the economy is faster, it will probably be an even bigger difference between the rate of change of the environment and changes in human values. So the faster the economic growth a country achieves, the steeper the shape of the EKC model for this country would be. The extend of the time-difference between environmental change and society's response to these changes has a big influence on the quality of information provided to the public, both by the state and by private companies. The better this awareness is, the smaller the gap (i.e. delay of response). (Panayotou, 1997, p. 4)

Over time there is a change in the shape of the EKC, namely to its shrinkage and enlargement. In the case of a reduction of the curve, this is a condition where developing economies are starting to reduce the environmental degradation earlier than it was previously usual for the already developed countries. Authors link this phenomenon to technological progress, innovation and research. On one hand these factors helped reduce the cost of preventing and through introduction of new technologies, they also reduce the environmental degradation. On the other hand,

there is the risk of new (as yet unregulated) hazardous waste and as calculated by the model it increases the curve. This increases costs for the prevention and increases the overall environmental burden (Dasgupta, 2002).

The actual tendencies for subjective reassessment of priorities for environmental goods, shifting the main economic focus on the tertiary sector and strengthening government regulation, is on the other hand offset by higher demands on the companies' area of consumption (goods and services) with rising incomes.

4.2.3 Factors affecting the EKC

The shape of the EKC curve for a particular region is affected by a myriad of factors (Alstine, Neumayer 2010). This work does not aim to introduce a complete list of all factors with slightest influence, but has ambitions to create a compact idea to the reader of the complexity of this issue. Influences are sorted in descending order of importance.

One factor is the **role of environmental regulation**. A high degree of influence on the EKC can be assigned to the function of the regulator. Today's advanced economies have not focused major attention on the producer as an entity bringing wealth to society. The main attention is now given to the consumers, who also adapt to market regulation. Regulations should reflect the demands through democratic society as such. It is possible to estimate the societal role of regulatory requirements and concentrate on general trends which can be observed in countries in transition between the industrial and post-industrial part of the Kuznets curve.

In Fig. 3 we can see a graphic representation of the effect of regulation and quality of government institutions to shape a model of the EKC. The highest first concave EKC shows an economy where property rights are not correctly set up, thus giving rise to externalities. These externalities are not included in the cost or income.

Therefore, there are private negotiations. Furthermore, in this economy there are subsidies. The second, middle EKC represents the state when in an economy the inefficient subsidies were removed. A third and final curve is the most effective solution possible. It is a state without subsidies, where all external factors are included in the cost or income, and property rights are perfectly defined. It is important to note that the curve breaks with far less environmental damage than other curves, while at the same stage of economic progress.

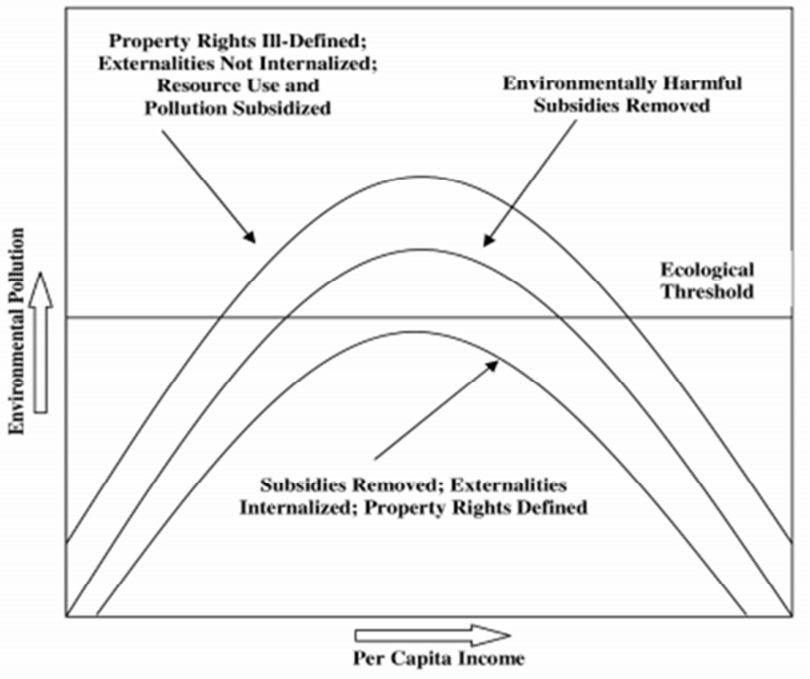

Fig. 3 **Income-environment relationship under different policy and institutional scenarios**
Source: *Panayotou (1997)*

The volume of control varies directly with the amount of income. This statement can substantiate three main arguments. First, the environmental pollution is gaining more attention after the satisfaction of basic needs in health and education. Second, companies with higher incomes have better technical and financial facilities for monitoring and preventing environmental pollution. And third, higher incomes and better education strengthen pro-environmental tendencies among the citizens (Dasgupta et al., 2002, p. 152).

Regulatory environment combined with good functioning of markets, further ensure the exhaustion of natural resources in the presence of the current generation, but also the preservation of these values for future generations, who will procure these goods in even larger scale, if there will be a continuous economic growth.

Other factor is **the degree of liberalization of the economy**. This section is closely related to the previous section regarding the impact of liberalization on the EKC. The liberalization of the economy has an effect on the course of the EKC in terms of the lowest level of regulation in the absence of market failure.

The general trend, which occurs in developed countries, is a deregulation of economies, leading to a free market and a possible specialization. In the area of regulation of environmental impact it is possible to analogically meet with removing commands and control regulations and replacing its market conformable.

In other words, it relaxes control and eliminates obstacles for trade and investment. Efforts to protect the environment at the international level should lead

to a market determined price of environmental damage (mainly due to international emissions trading licences). This deregulation is important to create a market-competitive environment, holding a free international trade. Removing barriers to international trade, leads to an overall improvement in the quality of the environment of the country. T. Panayotou mentions that the level of market liberalization and the effective regulation largely determine the cost of the environment and the possible return of damage caused to the environment.

A liberal economic system which is free from patents, further motivates to focus on innovation. Modern dynamic view of monopoly says it is an effective short-term monopoly market situation, which is the result of good innovation process. The existence of patents causes that streamline monopolies will become inefficient market structures.

Support for innovation and education is on the other side slightly slowing the economy down by the fact that the study of innovation carries a number of positive externalities with itself. These are balanced to some extent by short-term economic profit from the monopoly. Innovations in the prevention of environmental degradation are the most important factor. In this area a good information system is very important, respectively to the knowledge transfer. For these purposes, it should be suggested to have a global limit system using third world countries and other developing countries and it should be recommended to create a certain globally integrated information system. These systems would carry information regarding the use of appropriate technological systems to maximize production itself, so to minimize the generation of waste (pollution). For the good functioning of markets and for high-quality transmission of information it is a necessary to have free international trade. Once developing countries will not be allowed to participate in the international trading system, then these countries are constantly locked in a vicious circle, and there would be no improvement even on the question of the environment.

Another factor affecting the EKC is the rate of economic growth. The conventional approach to the EKC model argues that environmental degradation is affected only by the amount of per capita income, but it can be assumed that if there is too rapid growth over a short period, then ecosystems may not be able to absorb this large volume of pollutants and therefore higher accumulation of impurities (higher degree of concentration of hazardous substances) should be expected. But it may not always be so. It depends on how quickly people will be able to set off economic growth in its reasoning. In reality, there is a reaction gap between economic growth and human answer to this growth. Theodore Panayotou assumed that the higher the growth rate, the greater is the reaction space (Panayotou, 1997). Great influence on the EKC has the composition of economic activity in the country in terms of wide range of economic activities, and in terms of the distribution of these economic activities in various sectors. It is believed that the greater the range of economic activities, the greater will be the rate of environmental degradation. Individual sectors are different units and it differs how intensively each sector uses resources and then discharges waste into nature (Panayotou, 1997).

The shape and particularly the slope of the EKC curve can very significantly affect the formation of new pollutants. This trend can be found particularly in countries where there is chemical industry and heavy manufacturing industries. The great danger of these new pollutants is that their impact on the environment is not that well mapped yet and the resulting ways to handle them are also not yet certain. Another big determinant of the shape of the EKC is the number of active players who will react to economic growth and its side effects. Among the most important players can be mentioned the inhabitants of the country, the business community, policy makers and other regulation makers, NGOs etc. (Dasgupta et al., 2002). Other influences on the shape of the EKC curve include the historical development of land and natural wealth of the country.

4.2.4 Weaknesses of the EKC

The main problems of the EKC model can be regarded as follows:

a) the EKC model includes only one form of human intervention in the environment
b) the EKC model is not comprehensive
c) lack of data
d) the threat of moving production associated with significant environmental damage in countries with less environmental regulation ("race to the bottom")
e) other (Dasgupta et al., 2002)

Ad a) The current theory recognizes three major human interventions in the environment. They are removing substances from nature, clogging substances into nature (waste) and interference in nature of substances (GMO etc.). Environmental Kuznets curve looks only at introducing substances, i.e. waste, into the environment. We can meet such studies analysing for example deforestation, but research of this type creates a relatively minimal percentage of the whole. (Holman, 2004)

Ad b) the EKC examines only one factor of pollution, unless the author is a proxy for environmental damage directly elected by a coefficient calculated from multiple types of pollution. These factors are, however, a problem with longer timelines. Data for calculation may not be available or the collection of such data varies over time, and thus deform actual time series coefficients. However, if the author of a research-paper chooses only one factor of pollution, it can lead to misinterpretation. For example, when the country will drastically reduce emissions and at the expense of a slight increase in the production of harmful substances B, then when examining the EKC for pollutant B it occurs to the author as if the idea of the EKC was not valid for this country. While the EKC for this country can be valid in total scale.

It is very difficult to use only a causal relationship to compare the level of income to the environmental degradation. The overall state of the environment is determined by a myriad of variables that often markedly influence the model. From government interference, over natural disasters, ending with structural

changes in the economy. In this context, it is possible to find authors with criticism of the concept of GDP as a measure of human welfare, respectively the economic development. GDP is not a perfect measure of affluence or wealth. GDP does not measure the wealth of a country, but a measured increase in wealth for one year. Also GDP does not include the benefit of free time or benefit from certain environmental quality. Criticism of the applicability of GDP as a measure of the maturity of the economy does not end with these issues. Another problem with GDP is the actual measurement of the domestic product, which we find to be very inaccurate (Holman, 2004, p. 12-15). On the other hand, we can say that the prosperity or wealth cannot be measured perfectly and GDP can find the most suitable measure for this data. All other attempts are too complex for calculation, or are ignoring other values. Bjorn Lomborg mentions that according to certain surveys in Denmark, attempting a more accurate calculation of human wealth, the difference with GDP values was only minimal (Lomborg, p. 95). Theodore Panayotou argues that the relationship between GDP and environmental damage hides more facts than it reveals. The author sees the solution in adding the role of institutions and government regulations as such to the model (Panayotou, 1997, p. 2).

Ad c) Another problem to the EKC data is insufficient documentation. It is not so much negative criticism of the EKC model itself but rather about its significant limitations. Data is usually very hard to reach, especially for developing countries. So it is very difficult to establish the empirical validity of the EKC. Data is often fragmented internationally because of different rules for data collection and calculation. Another problem in connection with data may be insufficient knowledge in measuring certain pollutants or excessive cost of such measurements.

Ad d) Another drawback of the concept of the EKC, which is emphasized by its opponents, is a phenomenon called "race to the bottom." This critique points out that most studies of the EKC are focused on one state and do not see the impact of economic development in one country leading to a change in other less developed countries. In practice, it happens that in developed countries, due to higher environmental standards costs for producers of pollution are higher. Which makes polluters try to get around this by moving their production to countries with lower purity requirements of production, i.e. in less developed countries (Dasgupta et al., 2002, p. 159).

Ad e) the EKC also does not take into account long-term investments in the future, but only monitors the current rate of environmental degradation and the current domestic product. It does not pursue potential development of the country in the field of environmental degradation. For example, energy generation from renewable sources, which is a good alternative to energy production from fossil fuels, should be considered when looking at a country's actions in the environmental field. (Holman, 2004)

4.3 Alternative views on the use of environmental Kuznets curve for economic analysis and policy

Another part of this thesis focuses on what was already written about the Environmental Kuznets curve hypothesis topic. This study of previously published works covers not only positive responses, but seeks to create a comprehensive picture of the issue. In a review of selected important articles, which were certain milestones for this issue, starting with the already mentioned article written by Kuznets himself called Economic Growth and Income Inequality of 1955. The idea of Kuznets' curve was later brought back to light by G. Grossman and A. Krueger for environmental purposes. Studies concerning the EKC, initially considered whether the data on the production of harmful substances, nor showed a trend of "inverted U" while increasing product per capita. If the studies showed this trend, the study continued calculations of the turning point (at which product per capita and environmental pollution experience the reversal).

After building a relatively broad base of empirical support the idea of the EKC, a subsequent research had begun to verify the accuracy of the original works, not only on the basis of newly acquired data, but also because new statistical methodological procedures were invented. Work has also begun to engage in other forms of anthropogenic impacts on the environment. The research was expanded to include the study of topics such as biodiversity, deforestation, soil pollution and others (Yandle et al., 2004). Works also later began to greatly concentrate on the impact of environmental regulations and not only on the production of harmful substances, but also on trade, cost control etc.

4.3.1 Supporters of the EKC model and their recommendations

No other study would be more appropriate to start the research of EKC studies better than the already mentioned article "Economic Growth and Income Inequality," by the economist Simon Kuznets from 1955. In 1971 Kuznets received the Nobel Prize in economics for the ideas he published in this article. As mentioned above, the author of this article addresses the question of how income inequalities develop between residents of the state during economic growth. Kuznets studied this phenomenon empirically on examples of countries like the United States, Great Britain and Germany. For other countries, Kuznets mostly had major problems with the availability of the necessary data. Using data on the evolution of the income of individuals (before tax) per year, Kuznets examined ratios based on individual statistical quintiles of development of inequality in income distribution. Another statistical method was to measure the amount of income of 5% of the lowest and highest income groups. Kuznets mentions that there are two main reasons why initially the economic development of the country increases income inequalities. The first reason is that according to empirical research only the top 10% from income groups is able to save money. The second reason for the widening of income inequality is the fact that the transition from an agrarian society into an industrial phase of economics noticeably gives advantage to people, who were in-

volved in the production (compared to those in agriculture). There is thus a significant readjustment of income distribution in society. This transition will also build new types of income inequality between rural and urban areas, as well as between factory owners and workers. Kuznets adds that economic growth and technological progress leads to the gradual elimination of temporary fluctuations in income, excluding cyclical fluctuations. The work of this American economist can deduce that the inequality of income distribution in a society initially increases with economic growth and starts declining later on (Kuznets, 1955).

As the first note on the Environmental Kuznets curve in literature is generally considered the article by G. Grossman and A. Krueger. This article was prepared for a conference, concerning the North American Free Trade Area (NAFTA), and talks about the impact of this agreement on changes to the production of pollutants. The contract was originally criticised by some observers (especially among environmental organizations), especially because thanks to this agreement the environment of Mexican production would get worse.

It was assumed that there will be a cross-border transfer of environmentally challenging production from the US and Canada to Mexico (which has softer environmental regulation). Another reason mentioned was a possible adaptation of North American high environmental standards also by Mexico. Grossman and Krueger mention three kinds of impact which would follow the opening of international trade on environmental quality. The first of these is the impact of trade opening on the size of the volume of production in the country ("scale effect"). It depends on whether there is an increase in foreign investments into the country or not. Perhaps the most worrisome for critics of NAFTA was the potential increase in energy demand. This latter effect is the influence on the composition of products ("composition" effect). Or in other words what is the impact of this shift on the spillway of investments across economic sectors. In this case, it depends on what actions the country has as a comparative advantage. We can then expect an increase in this production and with it an increase in the production of pollutants. For comparative advantages can be considered even more benevolent government's approaches to environmental regulation. The third effect is the change in technological processes in manufacturing (the "technique" effect). Particularly in less economically developed countries they are expecting significant progress in technology and manufacturing processes after the opening of cross-border cooperation in this field. The introduction of new technology delivers a cleaner environment for two reasons mentioned. Firstly, newer technologies are generally environmentally cleaner technologies, and are also generally more efficient in the production of the goods. This leads to the increase of people's income and increasing demand of the population (and the controller itself) for environmental regulation.

In the analytical part Grossman and Krueger examined the development of production of sulphur dioxide, smoke and suspended particulates in industrial zones of dozen countries. The surveyed areas were selected evenly, both economically developed and developing regions. The model was adjusted for possible sta-

tistical errors in the form of various abilities of dirt absorption in different locations. According to their investigation the turning point is reach. In terms of recommendations for Mexico the authors mention that at that time (1989), with its GDP per capita being around $ 5,000 the country began to take radical steps to improve environmental quality. The influx of investment and thereby accelerated growth of GDP per capita can only accelerate this phase. Grossman and Krueger also pointed out that the difference between the cost of production for limitation of harmful substances will in most cases not be very striking and will not exceed the level of transaction costs of moving production. According to the article it was assumed that the opening of the Mexican-US trade relations will (according to the theory of comparative advantage) focus on Mexican production associated with large numbers of unskilled labour force and with lower capital requirements. It could, however, be the opposite situation, where the influx of foreign companies from North America to Mexico and could bring still scarce factors of production (skilled workforce, capital). If this move was a significant factor, it could also change the structure of production (in the context of changes in comparative advantage of the country).

Grossman and Krueger in their research apprehend that Mexico should be, after the abolition of international trade barriers, specializing in production with below-average creation of harmful substances. This production is a specific need for large amounts of unskilled labour and physical capital. Finally, the authors concluded that the discrepancy between environmental regulations within NAFTA will cause very minimal transfer of dirty production sector. The impact of this border convention should have, according to the authors, a positive effect on the quality of the environment in Mexico (Grossman-Krueger, 1991).

In the later work of Grossman and Krueger, "Economic Growth and the Environment," the authors attend to similar conclusions. Production pollutants again initially rise and then have a declining trend during economic growth. The minor differences authors reached are on the question of the position of the turning point. In this research production levels of most pollutants begin to diminish before the $ 8,000 GDP per capita level. This research has covered the development of the incidence of sulphur dioxide, suspended particulates, nitrogen oxides, carbon monoxide and lead in the air of cities and river basins (Grossman-Krueger, 1995).

Another article classifiable under the chapter of recommendations for economic policy in order to fulfil the idea of the EKC is "Confronting the Environmental Kuznets Curve" by the authors S. Dasgupta, B. Laplanta, H. Wang and D. Wheeler, from the Research Centre for Development (World Bank). The work mentions that in the 90's the authors have supported the idea of a conventional model of the EKC, but around 2000 some authors began to agree on changing the current waveform of the EKC. The main change in this curve was its overall shrinkage and displacement of the curve toward the beginning of the graph's axes. These changes should lead to a reduction in the turning point and the total environmental degradation associated with economic growth. Theoretical studies published to the year

of 2002 state intervention in order to prevent the existence of externalities (which need to be internalized in the cost/income). Respectively they say that in a society where rights are not perfectly defined then producers usually do not cover all their costs, and are full beneficiaries of the profits, here comes the turning point of the curve over social optimum. This fact justifies state intervention, which will aim to internalize externalities.

The main part of the work of Dasgupta and his team are best practices that achieve significantly lower and flatter EKC. Respectively to accomplish that there is no such significant environmental damage associated with economic growth. In the first place authors see the need of regulation improvement. The authors say that the regulation leads to an overall reduction in pollution and promotes the development of new technologies and propose stricter regulation in the environmental field. On the other hand, the authors attach great importance to the liberalization of economies, both at the state level trade and internationally. This would allow for economies of narrow specialization realizing revenues from the exploitation of comparative advantage. Furthermore, the authors mention that the removal of subsidies has a positive effect on the quality of the environment. It is due to the fact that producers in the most environmentally dirtiest industries are often the recipients of subsidies. Privatisation of these environmentally intensive sectors and stopping the flow of subsidies to these industries will reduce their share in GDP of the region and therefore to reduce the environmental degradation. Another positive effect of liberalization on the environment is the centralization of production and logistics, not only streamlining. This centralization may well lead to local pollution increase, but on a global scale, more efficient distribution leads to a reduction on environmental loads. Liberalization of international trade leads to the rapid spread of technological innovations and new educational approaches. The authors also mention the role of informal institutions, especially in low income regions. It is mentioned in the article that in areas where regulation is weak and ineffective, NGOs and certain social groups (religious, social organizations etc.) replace the role of regulator bodies. These individual organizations negotiate specific terms with business owners, who thereby prevent sanctions coming from the society and governments. Another recommendation may be raising the individual subjects of the environment. Entrepreneurs then do not invest as much in companies which are significantly harming the environment and consumers will more choose products made by environment friendly methods. In general, it can be recommended to raise awareness about the environmental issue.

The study by Dasgupta and his team ends with a conclusion devoted to a warning in conjunction with economic development and the associated environmental damage. According to the conventional model of environmental curve will most African and Asian countries in the near future achieve a highly increased level of environmental pollution. Authors of the article are wondering whether it is not preventable, and if it is even economically advantageous to increase pollution this sharply and if it should be tolerated. Further above mentioned effect of environmental regulation "race to the bottom" is here discussed in depth. The authors

recommend to avoid this situation by setting high international environmental standards. If some countries have not been able or willing to meet these standards, then on their production (associated with environmental pollution) should be, in the opinion of the authors, imposed additional export duties.

These duties should neutralize the cost-benefit states in the production of goods intensive on damaging environment. First, it is necessary to verify the need for such regulation. Another warning is dedicated to the broadness of environmental regulation. The authors point out that the state is focused on limiting production in a relatively narrow range of pollutants and some important pollutants can be overlooked. The authors equally strongly emphasize the need for continuous improvement in the regulatory environment. They point to the need for continuous improvement of information systems at the highest possible economic growth. Finally, the authors state the necessity of international cooperation in the field of environment. The two basic pillars of international cooperation are seen in supporting programs involving the public in environmental issues and work to strengthen the regulating institutions, hence the introduction of cost-effective quality control.

The study team around Dasgupta derive two main recommendations. Researchers should focus on finding out how to achieving a flatter shape of the EKC and its shift toward the left to reduce the environmental degradation to a minimum. The second recommendation relates to environmental regulation. These regulations should not stagnate, but it should lead to their constant updating according to current needs (Dasgupta et al., 2002, p. 147-164).

In the context of the already mentioned effect "race to the bottom" on the restructuring of production between developing and developed countries, it is worth mentioning the work of David Wheeler, based on this topic. The author points out that "race to the bottom" does not work as previous authors have presented it. The main reasons why the effect of regional changes in environmental regulation does not work, Wheeler mentions the fact that the costs of preventing environmental damage are not within the production as crucial as expected. Further, Wheeler points to the underestimation of the role of informal regulation and says that in developing countries, although there is not a well-functioning state regulation, but there is a system of feedback from society. It follows that the costs of prevention are lower than would be the continuation of the non-organic production. In countries where it has a strong regulatory role would be additional costs such as fines for non-prescribed limits. Where more informal regulations work, there should be companies aware of various political, social, and economic sanctions. Rational producer optimizes production volume at equality of marginal cost and marginal avoiding penalties for an additional unit of output. Another argument against transfers of "dirty" industries is that there would be increasing wealth in the target regions, and thus to tightening of environmental regulations. The "race to the bottom" also does not work due to the fact that multinational companies use international environmental standards in all the countries of their competence,

regardless of whether some environmental regulation are weaker in certain countries.

Wheeler decided to empirically test the veracity of the model "race to the bottom" in the examples of China, Mexico and Brazil (specifically the state of Sao Paulo, which is the most industrialized part of Brazil). These states represent the three largest recipients of foreign direct investment over 90 years. On the example of these three regions Wheeler presents a significant growth in investment in regions with a significant reduction in the production of pollutants. For a comparison the research is supplemented by examples of five American cities, where there is also a continuous decline in the production of the pollutants. This suggests that despite an increase in production in developing countries caused by foreign investment, there is generally no increase in the production of pollutants.

In his conclusion Wheeler summarizes that the economic growth of some countries does not maximize the production of harmful substances in other countries (developing). In practice, we meet only with the continuous increase in the bottom of the imaginary potential environmental pollution, both in developing and developed regions. According to Wheeler, even in the poorest countries, thanks to an increase in foreign investment, it leads to increase of employment and incomes and thereby improving the quality of the environment. Lack of phenomenon "race to the bottom" is confirmed by a large amount of empirical studies. Wheeler admits the growth of the production of pollutants within the economic growth only in the short term. This is the case when there is a rapid economic growth, also an increase in industrial investments, there is a sudden increase in the production of pollutants. This short-term effect is not treated by environmental regulations. Another possible cause of an increase in pollution could be the entities' imperfect information. Wheeler considers one of the main areas which should become a focus in an effort to improve the environment, the development of environmental literacy of the population. Other include good information systems (for both public awareness and correct decisions of regulatory institutions) and support of strong regulations while maintaining the highest possible cost effectiveness. To very similar conclusions as Wheeler came already earlier Mani and Wheeler in their article "In Search of Pollution Heavens? Dirty Industry in the World Economy, 1960-1995 "from 1991 (Mani, Wheeler, 1997).

We can find a large amount of research works on the issues of cross-border problems of environmental degradation and production shifts associated with a significantly negative impact on the environment. It is worth mentioning those dealing with the opening of borders to international trade on environmental quality. In addition to the above-mentioned works by Grossman, Krueger, Mani and Wheeler it is also worth mentioning the contribution of Judith M. Dean. The author active in international economic centre of the Australian University of Adelaide differs in her research the effects of the opening of international trade to direct and indirect. This is different from other authors. She is trying on a theoretical model to show the effects of direct and indirect effects of liberalization. Among the direct effects of trade opening Dean ranks change in relative prices and indirect revenue

growth. These two effects are mutually contradictory and the author tries to analyse which one will prevail.

Specifically, the author wonders if there is an increase in environmental degradation from the increase in domestic production, or, conversely, if removing of trade barriers will lead to growth in revenues which would lead to improvement of the environmental situation. In this context, the author mentions different effect. First is Heckscher-Ohlin (H-O) theorem and second Stolper-Samuelson (S-S) theorem. According to the H-O theorem there is a comparative advantage in producing goods that are relatively difficult with factors of production, with which the country is equipped relatively better than other countries. On the other hand, S-S theorem says that after the involvement of the region in international exchange in a given area then there occurs the increase of prices of abundant factors and decrease of the prices of rare factors.

The shift by S-S theorem should therefore reduce international differences in prices. According to the H-O theorem there should be a closer focus on the country's production of goods associated with comparative advantage. On the contrary, according to the S-S theorem there should be the removal of trade barriers, which weakens comparative advantages.

If, therefore, this theory should pass on the example of a country opening its borders to foreign trade, then by H-O theorem there was an increased use of the comparative advantages of permissive environmental regulations. On the other hand, according to the S-S theorem there should occur a reduction of the amount of harmful production in countries with relatively looser environmental regulations, due to the fact that within the S-S theorem there are increased producers' costs of use and degradation of properties of the environment (Dean, 2002).

It should be noted that the idea of H-O theorem can be partially regarded as outdated. H-O theory is not considering the differences between individual production methods (individual factors of production can be substituted in production), the role of technological progress and is generally static (equivalent production factors may change over time).

As a result, the author comes to similar conclusions as her colleagues. Opening a given country to international trade certainly leads to its economic growth. The influence of economic growth on environmental quality generally prevail even in the situation where the country has comparative advantage in the form of looser environmental regulations. For the empirical testing of this theory the author chose the example of the development of water pollution in China after a relatively massive easing of restrictions on international trade in 1991. Despite the big problems with the lack of data the author is sure of the fact that, despite the overall increase in pollution, it can be assumed that at not open trade borders the impacts on the environment of the country (particularly water quality in rivers) are higher. Significantly prevails technological effect. Dean mentions that the restrictive policy of international trade generally leads to lower productivity capabilities of the country. The author of this work also highlights that the level of intensity of harmfulness of per unit production is higher in state-owned enterprises than for private

producers. It is mainly due to lower overall production efficiency of state enterprises (Dean, 2002).

Low productivity rate of state-owned enterprises not only causes higher environmental burden of these enterprises. As described in the article by S. Dasgupta, M., D. Wheeler and Huq from 1997 "Bending the Rules: Discretionary Pollution Control in China", the state as a regulator is often unable (unwilling) to properly control the production of pollutants and enforce payment of fines from their own businesses. The authors decided to test the example of water pollution in China in the 80s and 90s to test the differences between the production of pollutants from private and public enterprises. The test was conducted on a sample of 328 enterprises (overwhelmingly public) occurring in industrial areas. (Dasgupta, Huq, Wheeler, 1997)

The results of Dasgupta, Huq and Wheeler have some interesting conclusions. As the authors expected, state-owned enterprises have significantly greater difficulties in complying with regulatory limits and therefore are forced to pay heavy fines. However, contrary to expectations, it has been revealed that public enterprises are willing to pay such high fines. As the authors expected, the increased rate of production of pollutants above the threshold is being faced especially by older businesses. The research also shows that if the company is larger in terms of number of employees, it is more prudent to perform their limits. These large employers in China are frequently exempted from charges for excess production of pollutants. Research is closed by a remark about the huge impact of the charges for exceeding emission limits for pollutants production (the amount is determined by both centrally and at local government level (Dasgupta, Huq, Wheeler, 1997).

After the works of Grossman-Krueger or Judith M. Dean continues an author called Werner Antweiler. Together with the authors, Brian Copeland and Scott Taylor, he addresses the deeper question of the impact of international trade on environmental quality in the article "Is Free Trade Good for the Environment?". For the purposes of empirical research, the authors have used panel data related to the production of sulphur dioxide by more than 40 developing and economically developed countries. The paper highlights the differences compared to previous studies topics. The authors use panel data, enabling them using regression analysis which can express mathematically influences of individual effects of international trade on the change in emissions of pollutants. The authors chose to use a new method and evaluate structural changes in the production of harmful substances. The work also distinguishes different impact of economic growth (in the production of pollutants) caused by the accumulation of capital and growth due to technological progress.

The conclusion by Antweiler, Copeland and Taylor speaks clearly. Releasing international trade leads to a reduction in environmental pollution. According to the results of this research there should be a one percent increase in GDP per capita while roughly one percent lead to a decrease in the concentrations of pollutants. In particular, when one percent of economic activity (domestic product and in-

come) should increase the concentration under the effect of the level of 0.25-0.5%, and on the other hand to reduce the concentration of 1.25-1.5% under the effect intensity. The influence of structure effect was found to be minimal. The authors criticize supporters of phenomenon of "race to the bottom" who consider that their considerations are static in the sense of the assumption of unchanged regulation time. In this context, the article mentioned the need for a fully flexible regulatory apparatus. Another outcome of the research is the fact that growth of domestic product due to technological progress is positive for the environment, while the increase caused by the accumulation of capital has a negative impact on the quality of the environment (Antweiler et al., 2001).

Another author dedicated to the environmental economics is James Tobey. Tobey dealt with the effects of government regulation on environment. Among his most important works is published the article "Effects of Domestic Environmental Policy on Patterns of International Trade". In this article, he analyses (ex post) the effects of environmental regulation on international trade based on the Heckscher-Ohlin-Vanekova model of international trade. From his results Tobey shows that environmental regulation has relatively small, yet discernible impact on inflation, the volume of domestic product and trade as such (Tobey, 1990).

In the article "Governance, Economic Policy, and the Environmental Kuznets Curve for Natural Tropical Forests" the duo Michael Madhusudan Bhattarai and Hamming explored the relationship between the incomes of the population and the rate of tropical deforestation. The survey was conducted on a sample of 63 countries in Latin America, Africa and Asia endured from 1980 to 1995. The authors mention that the observations of deforestation trends is important for several simple reasons. Forests in general and especially those tropical which are able to absorb carbon emissions and greenhouse gases are an important role for maintaining a wide biodiversity.

These observations of deforestation are particularly interesting because most of the tropical forests are located in developing regions. According to Bhattaraie and Hamming 57% of the total area of forest is located within the territory of developing countries. This makes the issue of deforestation very important. The research results show that a significant positive impact on deforestation (in the sense of reducing the rate of deforestation) makes a change in agricultural technologies, government regulation (or the quality of the relevant regulations), economic growth, real exchange rate (the stronger the position of the domestic currency, the lower the rate of deforestation), education (higher education level of the population of the country leads to a narrower focus on the country's secondary and tertiary sectors of the economy). Negative impact on deforestation was found in the following factors: population growth, economic openness to foreign trade (the more the economy is open to international trade, the greater the pressure on deforestation in this country. The validity of the model of the EKC for deforestation of tropical forests has been verified by the authors, adding that environmental regulation in this area is a strongly determining variable.

It should be noted that the issue of deforestation can not be seen entirely straightforward. The authors warn against excessive optimism and boundless confidence in the market system. They say that because the vast majority of forests in developing countries is in public ownership, the relationship of economic development and deforestation is strongly influenced by the socio-political institutions, the structure of economies and not least the historical development of the country (Bhattarai, Hamming, 2002, p. 6).

The validity of the EKC model for deforestation in Latin America, Asia and Africa was further verified by Maureen Cropper and Charles Griffiths (1994), Theodore Panayotou (1995), Edward J. Barbier and Burgess (2001), Karen Ehrhardt-Martinez, Edward Crenshaw, Craig Jenkinsenem (2002) and others. the EKC validity of the model was also validated for the protection of green areas in urban and wooded vegetation in general, for example, Europe Bimonte Salvatore (1996). On the other hand, Kenneth Arrow and a team of authors (1995), argue in their article that the EKC model may apply in individual economies for emissions of certain pollutants, but not for cases of exploitation of natural resources (Yandle, 2004, p. 20-22; Bhattarai, Hamming, 2002, p. 5,6).

4.3.2 Critics of the EKC model

In 1995 a team of authors led by Kenneth Arrow published an article "Economic Growth, Carrying Capacity, and the Environment," in which we can meet with one of the first critics of the concept of the EKC. The authors of this article criticize the results of supporters of the EKC model (specifically their misinterpretation). Arrow et al. argue that empirical research on the validity of the EKC model confirmed the validity of this model for only a handful of indicators (availability of potable water, sanitary facilities, the emissions of SO_2, NO_x and CO), the curve form of the EKC is usually attributed to all forms of environmental pollution. The authors draw attention to the threat of limitless economic growth regardless of the quality of the environment and irreversible damage to ecosystems. Another of the mentioned threats is wrong interpretation of the results from empirical studies testing the model of the EKC. Because they are typically engaged only in the production of emissions of pollutants to local short-term impacts and do not test production of pollutants with long and diffuse effects on the environment (as well they do not test the accumulation of waste).

Further in this article supporters of the EKC model are blamed that they only deal with the production of harmful substances and not with the use of natural resources, they also do not follow the overall approach to the question of the environment. In the article it is said that in most cases the most radical changes in the production of pollutants were made through reforms of environmental regulations. If there was a misinterpretation of research results and their generalization only to the affect of income growth, then it could lead accordingly to the weakening of the state's role in the fight against environmental degradation. Other problem mentioned is that the concept of the EKC does not include the possibility of irreversible damage to the environment, ecosystem resilience and the ability of local

absorption of pollutants. Finally, the authors note that economic growth is not the main determinant of the quality of the environment in the country, but that they are mainly the composition of inputs and outputs of the economy (including environmental goods) (Arrow et al., 1995).

The above described article by Arrow and his team can say that the authors pointed to several factual mistakes of the EKC model. The model certainly does not include all the variables cited and can therefore lead to its misinterpretation. If, however, this could be avoided, it is possible to work with the EKC as with a fully functional model which is like any other model of its deviation from reality for simplification. For most compelling may be considered warning about the misinterpretation of results.

One of authors with critical approach to the Kuznets curve is Theodor Panayotou. The author says that a simple relationship between GDP and environmental degradation rather creates more questions then answers questions already asked. Panayotou sees the biggest problem in the unexplained role of the state for the validity of the EKC. The studies regarding the EKC simply do not clearly state whether the state should enter the role of regulator for markets in an effort to reduce environmental damage. Furthermore, Panayotou asks whether the level of GDP per head is the only variable that matters or if the different rates of economic growth have an impact on the environment. The author notes that the EKC model ignores the structure nor the extent of the economy, does not explain the effects of environmental investments and costs incurred to prevent. This makes the EKC model a black box. Panayotou argues that the EKC constructs a simple model of the relationship of income and the environment and it is only a useful first step to understanding how economic growth affects the environment. However, it is necessary to go deeper through this simple relationship. Panayotou sees major potential for the creation of the EKC as a manual for state regulatory apparatus for the effective regulation of economic sectors with significant disturbances to the environment. Author also describes the impact of the rate of economic growth, a broad range of economic activities, the distribution of these activities to various sectors of the economy and the impact of inefficient forms of market regulation on the shape of the EKC. Panayotou also says that environmental quality is a luxury good, the Engel curve is growing exponentially, thus shaped as "J". It means that the percentage of demand for environmental quality is growing faster than rising income (GDP). The author points out that the shape of the curve and, in particular, its position is very significantly influenced by the government regulation.

The actual Panayotou's research focused on the role of regulation in a modified model of the EKC for SO_2 for an example of 30 developed and developing countries. Data on SO_2 were always calculated as the median of data on emissions for the whole day for a certain country. This data was obtained from the Global Environmental Monitoring System (GEMS). Empirical testing was done for the years 1982-1994. The data on GDP are at constant prices without using PPPs.

The main finding of the article "Demystifying the Environmental Kuznets Curve" is the fact that the government's regulatory policy (in the case of SO_2) can

significantly reduce the level of pollution at low levels of income (with low GDP per capita) and significantly accelerate the development of the field of technology foregoing pollution at higher income levels. From the results of empirical research, he further suggests that attention should be focused on improving the quality of institutions at the expense of efforts to slow down economic and demographic growth. Theodore Panayotou mentions that it should also look upon the costs associated with the application of individual regulations. The author considers the improvement of institutions for much less costly than the imposition of restrictions in the areas of economic and demographic growth.

In Figure 4, we can observe the actual EKC corresponding to this empirical research. And also in the second picture in this figure we can see a significant and positive downward shift in the curve, due to improving political control (institutions). In figure 5 the effect of changes in the rate of economic growth and changes in population density of inhabitants can be observed as a shift in the EKC. Here we can note that the significant increase in the rate of economic growth will result only in a minimal shift in the curve upwards. In the last picture we can see a little more pronounced curve shift caused by a significant increase in population density per km^2. Nevertheless, this movement is almost negligible in comparison to the shift that is caused by efficient government regulation.

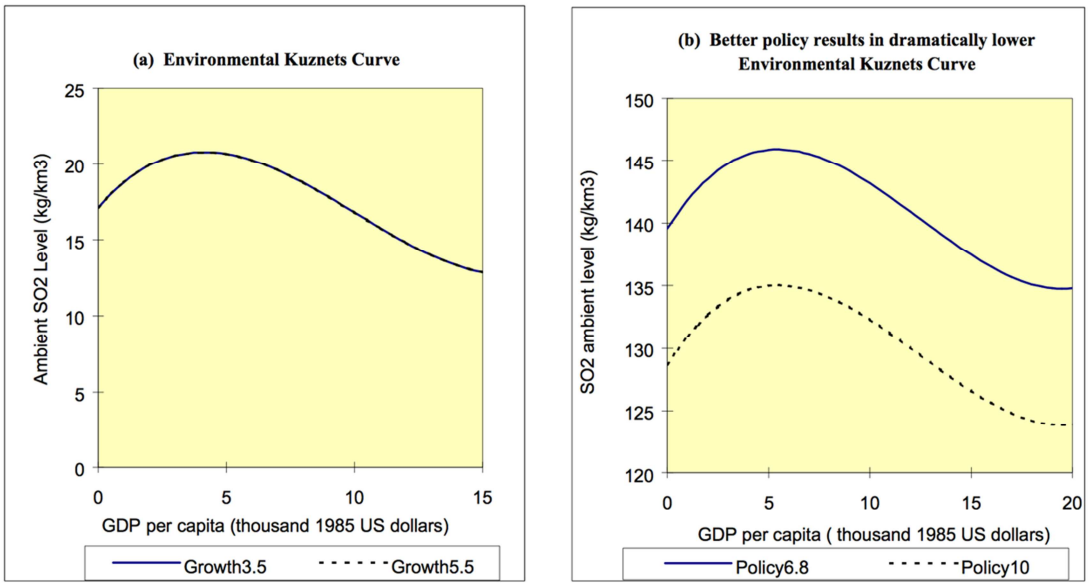

Fig. 4 **Normal EKC and EKC at more effective regulation**
Source: *Panayotou, Demystifying the Environmental Kuznets Curve, p. 23*

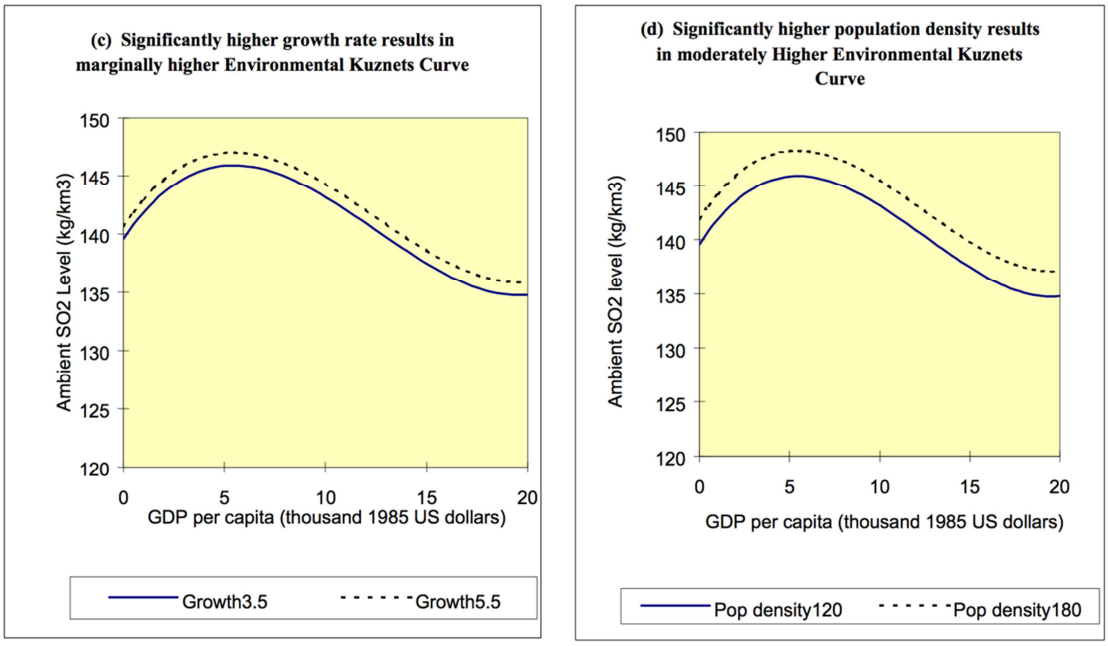

Fig. 5 **EKC with higher economic growth and at higher population density**
Source: *Panayotou, Demystifying the Environmental Kuznets Curve, p. 23*

These charts clearly confirm the above stated words, that the government, as a holder of the monopoly on political regulation, should strictly focus on improving the quality of institutions (Panayotou, 1997). This improvement should provide

perfect transparency and enforceability of rights, minimizing bureaucracy, ensuring the highest degree of respect for contracts and minimize expropriations.

Probably the most famous opponent of the concept of the EKC and a man with very positive relationship to the environment in general is Nicholas Stern. This is a British economist who was the head of the Grantham Research Institute at the London School of Economics, dealing with climate change and the environment. His most important achievement is the creation of a very comprehensive report, "Stern Review Report on the Economics of Climate Change" on the global state of the environment for the British government (October 2006). The report covers all aspects of the relationship between climate changes and the current and future global production. In his report, Stern highlights the urgent need for stringent control of production of pollutants. Stern is focused on the exploration of major economic and environmental indicators globally and tried to do projection of future development in these areas.

For him the only way is a departure from the current trend of production of pollutants in radical changes on a global scale. But back to the results of Stern's report. Stern presents his results on several models of possible development. From the most optimistic to the most pessimistic, which counts with warming of the earth's atmosphere up to 5 °C in the following decades. Stern considers the most pressing problem of global warming to be melting glaciers, declining crop yields, better conditions for the spread of disease and the weakening of biodiversity. The author argues that the trend of global warming will hit the poorest countries in particular. Stern estimates the rise in temperature of 2 °C in the middle of this century, while preserving the current (2006) emissions. Stern also states that economic growth has always supported the growth of emissions. But actually economic growth is accompanied on one side by an increased emission levels due to the effect, but on the other hand, reduces emissions due to the effects of intensity and structure. Claiming that economic growth evokes the growth in emissions is therefore extremely misleading.

Stern notes that addressing climate change is a huge challenge for economists because it is historically the biggest market failure. With this statement we can only agree due to the fact that environmental degradation occurs primarily due to poorly defined property rights, hence the existence of externalities. These externalities are considered by economists as the major obstacle to free trade without state regulation and thus for market failure.

To set up relevant measures it is needed to correctly estimate the costs of environmental degradation and then select such option where the marginal revenue from an additional unit of output is equal to marginal cost including environmental damage (including future impacts). A major role here is played by the method of valuation of costs associated with environmental degradation and general appreciation of the environment as such. Setting appropriate pricing for the production of pollutants is essential to internalize negative externalities. Bjorn Lomborg criticized the behaviour of the supporters of the maximum possible production regulation of pollution in this area in the long term.

The costs of such measures should never exceed their marginal income. Lomborg says that global efforts to reduce the production of harmful substances would lead to an inefficient allocation of resources, and that it is much more efficient for mankind to tolerate a certain level of pollution to maintain economic growth. According to Stern, it is important to define the political environment with a minimum market failures and the relevant market for carbon emissions. The author proposes a system based on long-term control rates of carbon emissions through taxation, trading or regulation. Stern also requires regulatory measures dynamism in adjusting to the immediate needs of the markets. These regulatory measures should be aimed at accelerating the development of low carbon technologies and remove barriers in applying the new measures.

Finally, it should be said that Stern has done huge amount of work and contributed to interesting topics of discussion, but in many ways it is not possible to agree with him from the point of liberal economic perspective.

4.4 Possible relationships between economic growth and environment

As mentioned above, many empirical studies have tested the EKC hypothesis through various environmental indicators, countries, regions and econometric techniques (Ekins, 1997) and found contradictory results in recent years. Several studies focusing on the same environmental pollutant have shown contradictory results of the EKC presence in the comparison of the pollution and income (Aslandis and Iranzo, 2009, Poudel, 2009). A specific study by Aslandis and Iranzo (2009) examined the CO_2 emissions of several countries from 1971 to 1997. No statistical evidence was found that supported the presence of an EKC due to CO_2 emissions. On the contrary, Poudel (2009) found an N-shaped curve using 15 Latin American countries using CO_2 emissions. An N-shaped curve is the same as the standard EKC shape, except when environmental degradation decreases, pollution begins to increase again and the curve begins an upward trend. These two studies show that contradictory results can be found in the EKC literature. Contradictory results also suggest that a meta-analysis should be performed to statistically summarize the literature to find out which factors can lead to the presence or absence of the curve.

There have been many different studies in the past years on the topic of the EKC. Lopez (1994) and Seldon and Song (1995) consider exogenous technological change and pollution is done by production. The ratio of pollution and income levels depends on the elasticity of the substitution of goods and the threat to the vulnerability of households (Lopez, 1994). Stokey (1998) allows for endogenous technological change, and Lieb (2002) generalizes the Stokey model and argues that saturated consumption is required for the generation of the EKC. Andreoni and Levinson (2001) show that economies of scale in reduction are sufficient to produce the EKC. They derive them directly from the technological link between the consumption of a desired good and the reduction of its undesirable by-product.

The role of mitigation costs is crucial to reduce pollution in production (Selden and Song, 1994). However, the reduction activity begins with a substantial capital stock (Seldon and Song, 1995). In addition, Lopez (1994), Bulte and van Soest (2001) develop models for the depletion of natural resources such as forest or soil fertility. Thus, these models create EKC's under good assumptions. More recently, Stern (2004) discussed the latest theories, and Brock and Taylor (2004) discuss that pollution is decreasing in high-income countries due to technological change.

Cavlovic et al. (2000) carried out the first meta-analysis of the the EKC hypothesis by compiling the EKC studies from the early 1990s. They analysed 25 studies with 155 observations and considered 11 different environmental disturbances. Their study showed that methodological decisions can influence the results (i.e. The magnitude of an income turning point). A second meta-analysis has been carried out since then by Li et al. (2007), with 52 studies on the original Cavlovic et al. (2000) with a total of 588 observations. This study investigated two major categories of greenhouse gases: anthropogenic activity-related gases (i.e. CO_2, CH_4, N_2O, PFC, HFC and SF_6) and chemically active gases (i.e. SO_2 or gases that can interfere with the formation of other greenhouse gases. Li et al. (2007) found no statistically significant evidence supporting the EKC for anthropogenic activity-related gases, but they found that longer periods, panel data, and global data all significantly increase the likelihood of finding a significant EKC pattern.

The relationship between environmental degradation and economic growth may be linear, monotonic decreasing, an inverted U-shaped relationship, i.e. EKC, a U-shaped relationship, a cubic polynomial or N-shaped curve, an Inverted-U shaped relationship or different or no relationship.

Omay (2013) describes the possible relationship by a model form, Eq.1, which allows to test the various possible relationships between pollution level or environmental degradation and income:

$$y_{it} = \alpha_i + \beta_1 x_{it} + \beta_2 x_{it}^2 + \beta_3 x_{it}^3 + \beta_4 z_{it} + \varepsilon_{it} \quad (1)$$

where y is the environmental degradation indicator, x is income and z are the other variables relation to environmental degradation. The subscripts i and t are the country and time, respectively. Testing different relationship forms between environment and income are done through the following forms:

Linear (monotonic increasing) relationship

This relationship can be depicted as: $\beta_1 > 0$ ve $\beta_2 = \beta_3 = 0$, which is the linear relationship. In **linear relationships**, any given change in an independent variable will always produce a corresponding change in the dependent variable.

This means that if income grows the environmental degradation grows as well.

Monotonic decreasing relationship

Monotonic decreasing is a very rare type of relationship with connection to environmental degradation and economic growth. The script looks like this: $\beta_1 < 0$ ve $\beta_2 = \beta_3 = 0$

Inverted U- shaped relationship

This type of relationship is the one which represents the environmental Kuznets curve. It is written as: $\beta_1 > 0$, $\beta_2 < 0$ ve $\beta_3 = 0$. Kuznets curve shows the hypothesis that market forces will first increase in economic growth and then reduce economic inequality. Kuznets believed that inequality would follow an inverted "U" form when it rises and then falls again with the increase in income per capita. (Yandle, 2002)

U-shaped relationship

Opposite to the inverted U-shaped relationship states U shaped which suggests that first with growing economy the environmental degradation sinks and then from certain point the economic degradation grows together with the rising economy. $\beta_1 < 0$, $\beta_2 > 0$ ve $\beta_3 = 0$

N-shaped relationship

N-shaped relationship is indicating that pollution increases as a country develops, decreases once the threshold GDP is reached, and then begins increasing as national income continues to increase. $\beta_1 > 0$, $\beta_2 < 0$ ve $\beta_3 > 0$

No relationship

In this case there is no relationship between environmental degradation and income.

$\beta_1 = \beta_2 = \beta_3 = 0$

4.4.1 Empirical studies

This subsection describes the studies for the empirical part of the work. The last number of studies used is 69.

The overview of the analysed studies can be found in Appendix A. It contains names of authors, year of publication, first author's country, duration of studies, type of relationship found or geographical area in the concrete study and the type of pollutant which was measured. The papers are limited to the year of publication, so the contributions in the table have been dated since the year 2000. The latest study in the sample comes from 2012. In the sample which is selected are studied data that are analysed from articles of each country and also panel data.

There exist different authors from various countries analysing different geographic areas. As it was said before, the results of articels vary as well and it is hard

to reach the consensus among these. But to have a better understanding of these empirical studies it is the best to read through the results part of this thesis.

4.5 The influence of trade on EKC

Many authors have covered variables to study the impact of openness to international trade on the growth to environment relationship. It is also crucial to examine the influence of the across country movement of goods that demonstrate pollution. In this situation, it is very important to acknowledge trade in both energy-intensive and non-energy-intensive goods. This happens because of the production chain for both non-energy-intensive goods which may involve big amounts of energy-intensive inputs. An example which can be given is trade in the area of motor vehicles. Because the manufacturing and also the assembling processes do not need big amounts of energy, they use many inputs, for example steel or rubber, that are very high on energy and are also pollution intensive. Thanks to this trade in motor vehicles business would create a small amount of pollution directly but a there would be also significant amount which would be created indirectly. For example it is estimated that all the cars which are produced in the USA require only 0.23 quads of energy directly but there is the direct plus which is created indirectly where energy content was almost six times as large. There is a similar example for electrical and non-electrical machinery and also in light manufacturing we can find an evidence. Wyckoff and Roop (1994) estimate the carbon emission which grew in the manufacturing imports of five big OECD countries. It is cruscial to mention that they found that a bit over half of this carbon was demonstrated in the non-energy intensive goods. This highlights the point which was said above that in order to determine the impact of trade on pollution, there needs to be a much broader class of manufactured goods considered.

5 Results

This chapter deals with executing the meta-analysis of the studies which were being evaluated.
In the beginning a statistical summary of the studies is made. The focus is on the most compelling characteristics. This part of the thesis should create a general picture of the dataset, which was used in the analysis which follows. Following is a binary logit model, that is created and there is always given a description of the model. At last there is created a multinomial logit model and a needed commentaries are stated to support the conclusion.

In total there are 69 examined studies and every each of them is individually coded. For every study there is an individual estimation for each sample so in total there are 128 observations.

Many of the studies are based on data, which are annual. Many of them also use quite long time periods, the median of the length is 22 years. Interesting is, that only 49,22% consider that there might be a possibility of presence of some structural breaks, it makes 63 studies in total.

In table 1 it is possible to see the frequencies of the 8 possible relationships considering the individual observations. Then figure 6 follows depicting these percentages in a chart.

Tab. 1 Frequencies of relationship types

Relationship type	Frequency
Positive	11,72%
Negative	1,56%
Inverted U-shape (EKC type)	54,69%
U-shape	0,78%
N-shaped	4,69%
Insignificance	2,34%
Different	18,75%
None	5,47%

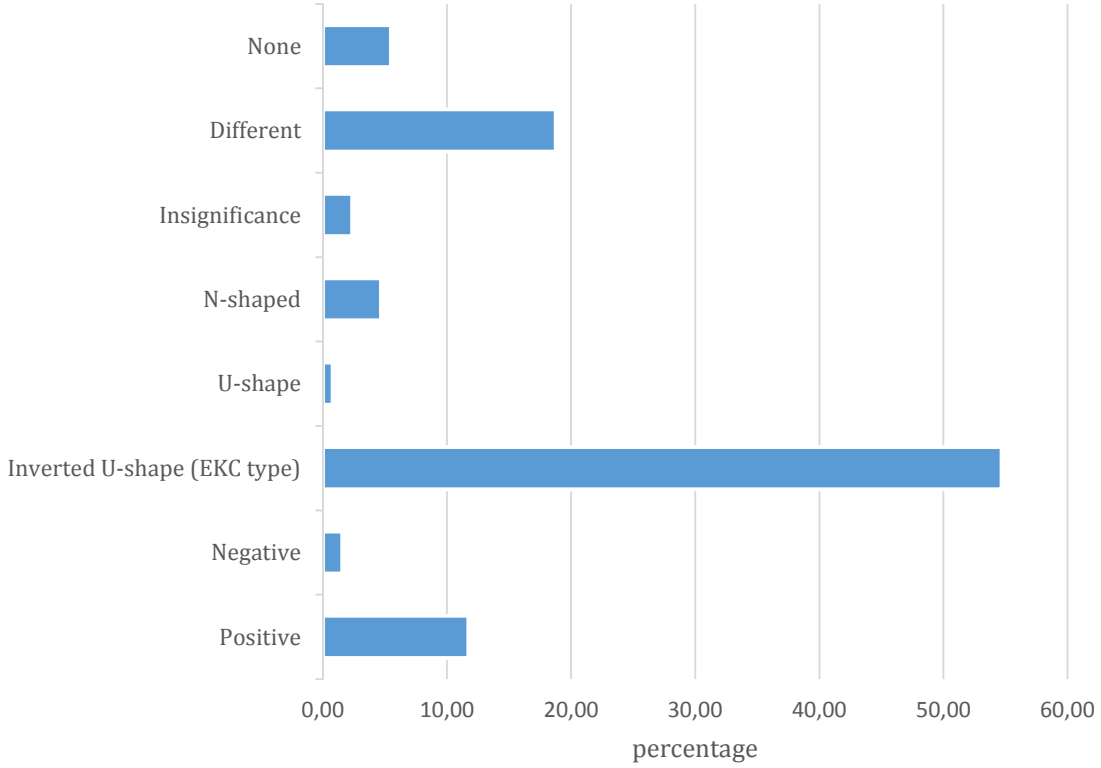

Fig. 6 Occurrences of relationship types

For better imagination, in Figure 7 is depicted the comparison of count of studies who confirm the environmental Kuznets curve and then all the other types of relationships are merged into one. So basically this is as in the binary coding. The sum of all the other non-EKC types makes 58 studies and EKC type sums up to 70.

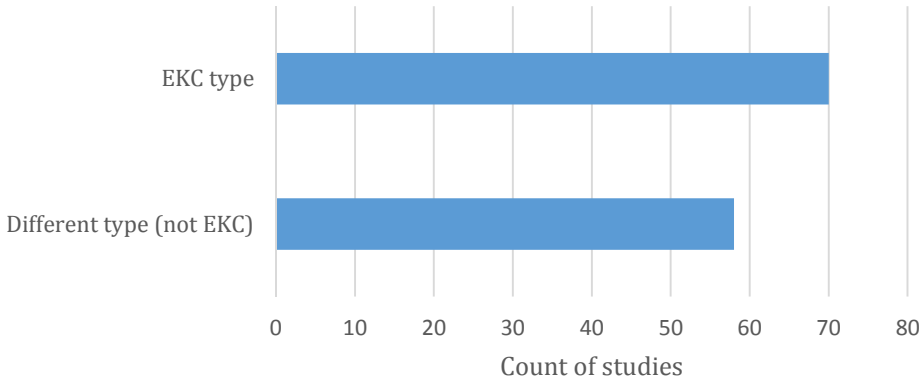

Fig. 7 Count of studies who support EKC relationship and different types

It can be seen from the dataset that about 54% of studies use panel data and the number of cross sections was very diverse. The focus is on high income economies. That makes together around 41% of all the investigations including countries which are classified as high-income economies. In Table 2 is shown the decomposition of economic development of studies used.

Tab. 2 Decomposition of economic development

Economic level	Frequency
Low-income economies	5,47%
Lower-middle-income economies	4,69%
Upper-middle-income economies	19,53%
High-income economies	41,41%
High-income OECD members	10,16%
Mixed	20,31%

Most of the articles and studies handle samples with only less than hundred observations. Table 3 shows that vast majority of the analysed observations come from mixed areas, exactly 63 observations. North America and Europe can be said to have the most developed countries. Both together have a count of 44 observations. That makes it about one third of all observations. Because there are in total 128 observations and all of them were acquired from quite a mixture of areas. From this we can make a conclusion that from a geographical point of view there was no focus of this dataset in a way of concentrating on developing or developed countries.

Tab. 3 Decomposition of geographical areas

Geographical area	Frequency
Mixed	49,22%
Asia and Pacific	13,28%
Europe	25,78%
Caribbean and Latin America	1,56%
Africa and Middle East	1,56%
North America	8,59%

The length of years of study is another characteristic which is very common. Most of the papers focus on quite long study periods. The mean length was 22.42 years for the study period of studies observations. One year was the minimum amount and maximum was 57 years of study years. Even though the articles studies quite long time periods, few of the authors considered the possibility of structural breaks in analyses. We can see the distribution of frequencies in study periods in Figure 8.

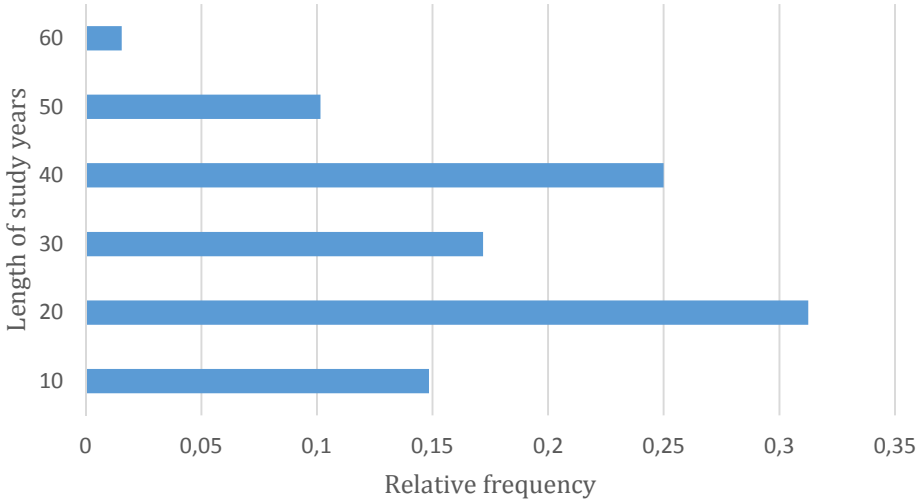

Fig. 8 Frequency distribution of study periods

Another very important aspect of studies on environmental Kuznets curve is the pollutant examined. In Table 4 is shown the percentage composition of studies pollutants. The main pollutant is carbon, which was examined in 49 studies, the second major one was sulphur, which was tested in 12 studies. Other 60 studies used different pollutants and 7 used a mix of pollutants. In Figure 9 is shown the percentage decomposition on a bar chart.

Tab. 4 Composition of pollutants

Pollutant	Frequency
Carbon	38,28%
Sulphur	9,38%
Other	46,88%
Mixed	5,47%

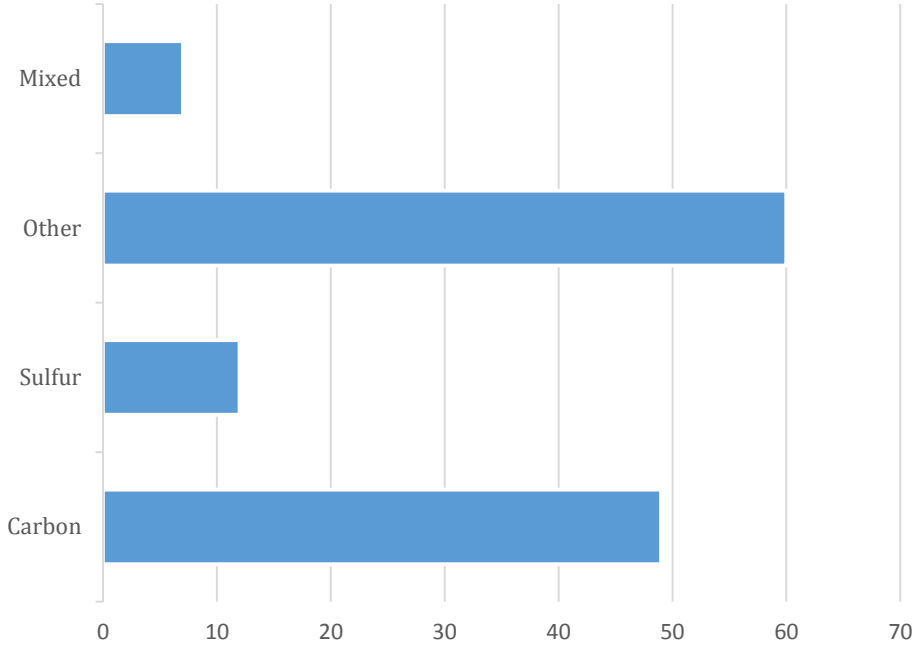

Fig. 9 Percentage depiction of pollutants

5.1 Binary Logit Model

At the beginning the binary logit model has to be estimated to test the casual relationship for this thesis. Variable called Annual was removed from the model because of the perfect prediction which was caused by not sufficient variability in the dataset.

One after the other, three of binary logit models were made, Model 1, Model 2 and Model 3. The models can be seen in Table 5 for Model 1, followed by Table 6 for Model 2 and then Table 7 for Model 3. In brackets are written numbers which state the number of correctly predicted studies. It is always stated for relative and absolute values. For each variable in every model there are three values, which are marginal effect, coefficient and p-value.

Tab. 5 Binary Logit Model 1

Variable	Model 1 (70; 54.7%)		
	Coefficient	**P-value**	**Marginal effect**
const	0.188	0.290	
Geo_area			
No_cross_sections			
No_observations			
Length_of_study			
Sample_size			
Year_of_publication			
Overall_econ_level			
Panel_data			
Single_region			
Multivariate			
Structural_breaks_considered			
Significance_level_used			
Variables_per_capita			
Emission			

Tab. 6 Binary Logit Model 2

Variable	Model 2 (93; 72.7%) Likelihood ratio test = 40.2963		
	Coefficient	**P-value**	**Marginal effect**
const	144.706	0.392	
Geo_area	−0.088	0.588	−0.022
No_cross_sections	0.009	0.507	0.002
No_observations	−0.065	0.162	−0.016
Length_of_study	0.046	0.269	0.012
Sample_size	**−0.001**	**0.051**	**−0.000**
Year_of_publication	−0.071	0.402	−0.018
Overall_econ_level	**0.332**	**0.083**	**0.083**
Panel_data	**−4.279**	**0.018**	**−0.783**
Single_region	−2.027	0.174	−0.467
Multivariate	**−1.210**	**0.033**	**−0.292**
Structural_breaks_considered	**0.791**	**0.090**	**0.194**
Significance_level_used	**0.471**	**0.019**	**0.117**
Variables_per_capita	**−1.328**	**0.060**	**−0.330**
Emission	0.175	0.539	0.044

Tab. 7 Binary Logit Model 3

Variable	Model 3 (85; 66.4%) Likelihood ratio test = 21.3395		
	Coefficient	**P-value**	**Marginal effect**
const	0.723	0.319	
Geo_area			
No_cross_sections			
No_observations			
Length_of_study			
Sample_size	−0.001	0.006	−0.000
Year_of_publication			
Overall_econ_level			
Panel_data			
Single_region			
Multivariate			
Structural_breaks_considered			
Significance_level_used	0.328	0.043	0.082
Variables_per_capita			
Emission			

The first model is a simple naïve model. It can be noted that it correctly predicted 70 studies out of the total count of observations which is 128 which represents 54.7%. The next model (Model 2) correctly predicted the highest number of cases, which is 93 observations, which makes 72.7%. If 10% significance level is considered then there are seven significant predictors, which are: Sample size, USA only, Panel data, Multivariate, Structural breaks considered, Significance level used and Variables per capita. Negative signs of some predictors have some quite interesting features. These are namely Sample size, Panel data, Multivariate and Variables per capita. The probability to find the EKC relationship decreases with the negative signs of the variables which are significant. Panel data according to the results reduce the chance to find the EKC type as well as using of multivariate studies or the studies which used variables per capita.

It also shows that there is a better probability to confirm the EKC theory when overall economic level or considering structural breaks are used. The influence of variables is explained by the values, which are being referred to in the column Marginal effect. But it is clear that there are still few insignificant variables.

The final model form is provided by Model 3 after sequential elimination tests were ran using two sided p-value (0.05). 85 cases were correctly predicted. That stands for 66.4% of the observations. If it is compared to the Model 2 it makes 8 observations less.

It is possible to find 2 variables which are significant out of which one has a negative sign (Sample size) in its coefficients. One variable which remains has a positive sign which indicates that its presence increases in the study the probability to confirm the EKC relationship. Even though there are found only two variables in the last final model, their influence on prediction capacity and the dependent variable is quite low. The major problem with these study characteristics is that there is just low frequency in the dataset.

5.2 Multinomial Logit Model

Structural breaks were considered only by 63 studies and only 62 of studies used panel data. In the following step the multinomial logit model is going to be elaborated. It identifies the important factors which influence the prevailing type of this hypothesis. As it was mentioned in the theoretical part, there is around 8 different types of hypotheses, each of them identifies one direction of relationship between economic growth and environmental degradation.
In these cases one of the categories of outcome is hold as a reference and all other seven categories are being compared to it. The Gretl is using the first type of causality, or if there is none, as the reference one.

Model 4 is there to represent naïve model which does include only the constant. There are correctly predicted around 70 observations. That meaning the success ratio is 54.7%.
Model 5 correctly predicted 79 cases. That represents 61.7% of observations. All variables except the variable called Relation_EKC were used. If the variable Relation_EKC is used, then there is 99.2% correctly predicted, because this variable clearly says which study has confirmed the EKC theory and which did not.

The prediction rate continues to be quite low. The significant variables in the case of relationship 2, which is the negative relationship, in this model considering the 1% significance level are namely Geo_area, No_observations, No_cross_sections, Length_of_study, Sample_size, Year_of_publication, Overall_econ_level, Single_region, Multivariate, Structural_breaks_considered, Significance_level_used and Emission.
The variables Geo_area, No_cross_sections, Length_of_study, Single_region, Multivariate and Structural_breaks_considered are decreasing the probability to find the negative relationship between economic growth and environment compared to the case of finding the EKC curve. On the contrary the probability to find negative relationship between economic growth and increases when analysing No_observations, Sample_size, Year_of_publication, Overall_econ_level, Significance_level_used and Emission. No other significant variables are added if the significance level is increased to 5% or even 10% significance level.

In case of the positive relationship we have only one variable for the 1% level of significance which is Multivariate which increases the probability to find the positive relationship. With 5% significance level the variable Overall_economic_level is added. This variable is decreasing the probability to find the

positive relationship. And again if the 10% significance level is set, then one more significant variable appears which is the Sample_size, which increases the probability of finding the positive relationship in comparison to the EKC relationship.

For relationship 4, being the U-shaped relationship, there are no significant variables in any significance level.

Relationship 5 represents the N-shaped relationship. In this case there are 6 influencing variables at the 5% significance level. Only Panel_data increases the probability of finding the N-shaped relationship. The other variables, which are decreasing the probability are No_Cross_Sections, Length_of_Study, Structural_breaks_considered, Significance_level_used and Emission. With the 10% significance level there is one more variable, which increases the probability and that is Sample_Size.

In the case of relationship 6 there are many significant variables already at the 1% significance level. Namely are Geo_area, No_observations, Length_of_study, Year_of_publication, Overall_econ_level, Panel_data, Single_region, Multivariate, Structural_breaks_considered, Significance_level_used, Variables_per_Capita, Emission and the constant. Out of these 13 variables 6 have a decreasing affect on the finding of N-shaped relationship with comparison to finding the EKC type relationship. These are No_observations, Year_of_publication, Panel data, Single_region, Significance_level_used and Emission. There are no other added variables nor at 5% neither at 10% significance level.

Looking at relationship 7 describing all the different relationships here it gives only 1 significant variable at the 1% level which is Significance_level_used. This variable decreases the probability. At 10% significance level there is a different variable Sample_size which on the other hand increases the possibility of finding a different relationship compared to the base model.

Relationship 8 is to depict the non existing relationship. There are no significant variables at 1% or 5% significance level. Only at 10% significance level we find one variable, which negatively helps to not find any relationship between economic growth and environmental degradation.

In three previous models few of the variables have quite high standard errors if they are compared to the other ones. Namely Panel_data. Because of it the collinearity test was done. The outcomes of collinearity test are pictured in Table 8. It was confirmed that Panel_data has the VIF value higher than 10, to be exact 13.772. The decision about if to remove this variable from the model was based on the model´s prediction success rate increase when we eliminated the variable. The increase was by 3.1%. The value of No_observations was very close to 10 so it was examined to also remove this variable from the model, but the prediction rate stayed exactly the same (83 studies, 64.8%) and the likelihood ratio test even lowered a bit so it was decided to keep the variable No_observations in the model. After one variable was removed, the values for VIF were lower than 10 in collinearity test for all the variables which are included. That says there should not be a problem with collinearity.

Tab. 8 Test of collinearity of multinomial logit model

Variable	VIF
Geo_area	2.003
No_cross_sections	6.231
No_observations	9.339
Length_of_study	6.862
Sample_size	5.816
Year_of_publication	1.388
Overall_econ_level	1.371
Panel_data	**13.772**
Single_region	7.809
Multivariate	1.468
Structural_breaks_considered	1.279
Significance_level_used	1.339
Variables_per_capita	1.408
Emission	1.924

There is a conclusion from the previous analysis that the variable Frequency is low in giving any informative value. That is because of the data collection was done annually in most of the studies. To find more detaild if the variable is any significant for that reason the analysis of data using a contingency table was done. The cross-tabulation of variable Frequency and dependent variable pictured that there is only one observation which has its frequency other than annual which leads to the relation to the small informative value. The result is seen in Table 9. Quasi-complete separation was found and it states that for some subsets of the data, there is the outcome which can be classified as perfect. When examining the first type of relationship, where is EKC hypothesis, the table states that if dependent variable Y=1 then variable Frequency equals 1 or X=1. This is the reason why the variable annual had to be removed from the model.

Tab. 9 Contingency table Frequency (columns), Relation (rows),

	[0]	[1]	Total
[1]	0	15	15
[2]	0	2	2
[3]	0	70	70
[4]	0	1	1
[5]	0	6	6
[6]	0	3	3
[7]	1	23	24
[8]	0	7	7
Total	1	127	128

The variable *Single region* had extremely high values of standard errors in the first regression which looked a bit suspicious. That analyses the non positive relationship type if it is compared to the reference category which is the EKC type.

But in the contingency table shown in Table 10 we see that in all the other relationship types the variable does not have a low variety and therefore also good informative value so this variable will stay in the model.

Tab. 10 Contingency table Relation (rows), Single region (columns)

	[0]	[1]	Total
[1]	30	40	70
[2]	2	0	2
[3]	8	7	15
[4]	0	1	1
[5]	2	4	6
[6]	2	1	3
[7]	21	3	24
[8]	3	4	7
Total	68	60	128

The same problem was seen with the variable *Variables per capita*, see Table 11. There are three zero cell out of which one (relationship 6) is causing the issue with high standard errors. Because the variables in most of the cases used per capita data it was removed from the model to see if the prediction ratio increased but it lowered so the variable was kept in the model.

Tab. 11 Contingency table Relation (rows), Variables per capita (columns)

	[0]	[1]	Total

[1]	11	59	70
[2]	0	2	2
[3]	1	14	15
[4]	0	1	1
[5]	2	4	6
[6]	0	3	3
[7]	5	19	24
[8]	1	6	7
Total	20	108	128

After the problematic variables were eliminated, the model correctly predicted 83 cases which can be seen as 64.8 and the likelihood ratio test was equal to 150.68. Then a search for the highest prediction success began. It was achieved by the moderate elimination of variables and by comparing of qualities of models with different results. In the end the highest prediction success was this model which forecasted 83 cases.

After the conclusion the final model consists of 14 variables including constant. Three other variables were also removed from the model for being redundant. Anyway, the prediction success stays rather low.

Feature of the first regression is that there is one of the highest numbers of significant variables, there are thirteen in total, all with the 1% significance level. Specifically, Geo_area, No_observations, No_cross_sections, Length_of_study, Sample_size, Year_of_publication, Overall_econ_level, Single_region, Multivariate, Structural_breaks_considered, Significance_level_used and Emission. Six of the variables increase the probability and seven decrease the probability to find negative relationship between economic growth and environmental degradation compared to the EKC theory which stands there for the reference category.

The outcomes suggest that the higher the number of observations then the higher is the chance to asset the negative relationship. This exact effect is colluded if the study examines sample size, year of publication, overall economic level, significance level used or emissions. Emission plays the highest role actually in determining this relationship. On the contrary, if a study includes geo area, Number of cross-sections, length of study years, single region, multivariate or considers structural breaks then the probability of finding relationship type two declines.

The second regression does not contain so many significant variables, actually zero at the 1% significance level, at 5 % level there are two. Length of study years and Multivariate. Both of these variables increase the probability of finding the positive relationship compared to the EKC type.

In the third regression there is the lowest number of significant variables, zero in total. Relation 4 stands for the U-shaped relationship which was found only once in all the studies, which explains this result.

Relation 5 has in total 4 significant variables. Two of them at 1% significance level, one more at 5% and another one shows up with 10% significance level. All of

them decrease the probability to find N-shaped relationship compared to finding the EKC type. The highest impact on this has the emission and significance level used in the studies. Smaller influence then has significance level used and the consideration of structural breaks.

Regression of relation 6 has the highest of all number of significant variables. All fourteen variables are significant at the 1% level of significance. Number of cross sections and also observations decreases the probability. Also the year of publication and the analyse of only single region. The same effect has the significance level used and also emission has a negative effect on finding insignificant relationship between economic growth and environmental degradation compared to the EKC relationship. All the other variables increase the probability of finding this relationship.

Different relationship is explained in the sixth regression. Here are only 3 significant variables. At 1% significance level there is the negative effect of the variable standing for the use of which significance level. Then sample size at 10% significance increases the probability and number of observations decreases it at the same significance level.

The last regression has a similar result as the third regression. This means that non of the variables has any real effect in determining the possibility of occurrence of no relationship between economic growth and environmental degradation compared to the inverted U-shaped relationship of the EKC hypothesis type.

Table 12 depictures this model. To make is easy to understand, there are provided just values for the constants and significant variables.

Tab. 12 Model with the highest prediction level

Variable	Coefficient	Z	p-value	
Relation = 2				
const	−10121.300	−18.010	0.000	***
Geo_area	−16.741	−14.370	0.000	***
No_cross_sections	−2.506	−34.750	0.000	***
No_observations	8.619	27.440	0.000	***
Length_of_study	−5.057	−22.060	0.000	***
Sample_size	0.039	23.280	0.000	***
Year_of_publication	4.812	17.610	0.000	***
Overall_econ_level	57.559	31.170	0.000	***
Single_region	−220.461	−30.500	0.000	***
Multivariate	−46.708	−18.820	0.000	***
Structural_breaks_considered	−89.930	−33.450	0.000	***
Significance_level_used	39.086	31.400	0.000	***
Emission	82.797	34.970	0.000	***
Relation = 3				
Length_of_study	0.098	2.099	0.036	**
Single_region	2.788	1.856	0.063	*
Multivariate	2.191	2.414	0.016	**
Relation = 5				
Multivariate	−2.568	−1.693	0.090	*
Structural_breaks_considered	−2.787	−2.095	0.036	**
Significance_level_used	−2.174	−2.657	0.008	***
Emission	−3.405	−2.598	0.009	***
Relation = 6				
const	11449.100	8.014	0.000	***
Geo_area	8.235	8.982	0.000	***
No_cross_sections	−1.246	−9.704	0.000	***
No_observations	−0.918	−7.429	0.000	***
Length_of_study	2.301	11.200	0.000	***
Sample_size	0.032	9.201	0.000	***
Year_of_publication	−5.868	−8.236	0.000	***
Overall_econ_level	5.015	7.737	0.000	***
Single_region	−29.844	−5.084	0.000	***
Multivariate	57.709	30.730	0.000	***
Structural_breaks_considered	27.131	12.840	0.000	***
Significance_level_used	−36.634	−30.910	0.000	***

Variables_per_capita	179.261	31.640	0.000	***
Emission	−53.946	−33.050	0.000	***
Relation = 7				
No_observations	−0.093	−1.706	0.088	*
Sample_size	0.001	1.686	0.092	*
Significance_level_used	−0.692	−2.616	0.009	***

There are no variables which would be significant in all of the regressions, But there are two variables, which occur in four out of five regressions, where significant variables occur. These variables are Significance_level_used and Multivariate.

After keeping only the mentioned two variables in the model and removing the rest, both of them dropped significance in one regression leaving them to be significant in three of the regressions. Interesting is that in regression with Relation equal to four, there were no significant variables, now in this model there are significant both of the above mentioned. In contrast, in regression dealing with Relation 6 there were all variables significant and now none of them is. The values are shown in Table 13.

Tab. 13 Model with two most significant variables

Variable	Coefficient	Z	p-value	
Relation = 2				
const	−88.942	−0.801	0.423	
Multivariate	−18.200	−22.660	0.000	***
Significance_level_used	17.194	0.786	0.432	
Relation = 3				
const	−2.667	−2.363	0.018	**
Multivariate	1.252	1.953	0.051	*
Significance_level_used	0.162	0.765	0.445	
Relation = 4				
const	−0.011	−0.009	0.993	
Multivariate	−19.532	−16.930	0.000	***
Significance_level_used	−1.038	−5.921	0.000	***
Relation = 5				
const	1.003	0.930	0.352	
Multivariate	−0.253	−0.319	0.750	
Significance_level_used	−0.918	−2.976	0.003	***
Relation = 7				
const	1.344	1.535	0.125	
Multivariate	−0.093	−0.164	0.870	
Significance_level_used	−0.602	−2.946	0.003	***

To study the data more in detail, we can look closer at the link between the type of relationship that resulted in the studies and individual geographic areas. The goal is to find out if there are any similarities in results for countries in the same region. Cross tabulation of the variable Geographic area (columns) against dependent variable Relation (rows) is displayed in Table 14.

It is clear that the outcomes for each and individual geographic areas differ but two of the results are interesting. We can conclude that the EKC curve can be found either in studies who focused on mixed regions but also 27 studies which concentrated on Europe described the curve as inverted U-shape.

Tab. 14 Contingency table for Geographic area (columns), Relation (rows)

	[1]	[2]	[3]	[4]	[5]	[6]	Total
[1]	**26**	11	**27**	2	0	4	70
[2]	2	0	0	0	0	0	2
[3]	9	1	3	0	1	1	15
[4]	0	1	0	0	0	0	1
[5]	2	2	1	0	0	1	6
[6]	2	0	0	0	0	1	3
[7]	20	1	1	0	1	1	24
[8]	2	1	1	0	0	3	7
Total	63	17	33	2	2	11	128

Another contingency table is created to see how are the different relationships spread across the economic levels. Within economies with lower-middle income the relationship is divided among the EKC type, positive increasing relationship and different relationship. Unfortunately, the sample is too little to make any real assumptions. Thirty-six of studies on high-income economies have concluded that the relationship between economic growth and environmental degradation has an inverted U-shape. With studies where economies were mixed we find 10 studies with the EKC relationship and 9 with different than any other mentioned relationship.

Very interesting is that with economies with low-income we find only studies (except one) where the type is stated as EKC.

Tab. 15 Contingency table Overall economic level (columns), Relation (rows)

	[1]	[2]	[3]	[4]	[5]	[6]	Total
[1]	5	1	11	36	7	10	70
[2]	0	0	0	1	1	0	2
[3]	0	2	4	4	1	4	15
[4]	0	0	1	0	0	0	1
[5]	0	0	2	2	1	1	6
[6]	0	0	0	1	1	1	3
[7]	0	2	6	5	2	9	24
[8]	1	0	1	4	0	1	7
Total	6	5	25	53	13	26	128

For more detail, the focus can be dragged to individual countries. There were only considered countries with more than one observation. By analysing the dataset, the outcomes confirming the possibility of a EKC are found in these countries:

In China seven (Bringezu, Schütz, Steger, Baudisch, 2004; Song, 2008; Shen 2006; Jalil 2010; Diao, Zeng, Tam, 2008) out of twelve studies found the relationship to be confirming the EKC theory. It could be stated that there is a chance of this relationship even though the number of studies and observations could be considered low to make any conclusion. But if this is correct, China reaches a turning point where economic growth still raises while the environmental degradation starts to lower.

Studies on Japan (Coondoo, Dinda, 2002; Bringezu, Schütz, Steger, Baudisch, 2004) show that two out of two cases fit the EKC hypothesis. This is a very small sample of data but it gives an idea about how Japan is doing.

Similar results can be seen in Norway (Bruvoll, Medin, 2003; Bringezu, Schütz, 2004) and Sweden (Lindmark, 2002; Bringezu, Schütz, Steger, Baudisch, 2004) where also all four studies proved the EKC hypothesis.

The situation in Spain is shown on eight cases out of which five (Bringezu, Schütz, Steger, Baudisch, 2004; Roca, Padilla, Farré, Galletto, 2000; Roca, Serrano, 2000) confirm the EKC theory.

On the other hand, USA's results vary more than the others. Only three (Aldy, 2004; Bringezu, Schütz, Steger, Baudisch, 2004; Khanna, Plassmann, 2004) out of eight studies confirm the EKC hypothesis.

If we look at for example studies made on OECD countries, there we find the evidence of a EKC in six (Galeotti, Lanza, Pauli, 2008; Stern, Common, 2001; Richmond, Kaufmann, 2006; Dijkgraaf, Vollebergh, 2005; Zaim, Taskin, 2000; Brock, Taylor, 2004) out of ten studies. In Table 16 you can see the counts of above mentioned countries and the frequency of the relationships found.

Tab. 16 Table Country (rows), Relation (columns)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	Total
China	7	0	0	1	2	0	1	1	12
Japan	2	0	0	0	0	0	0	0	2
Norway	2	0	0	0	0	0	0	0	2
OECD	6	0	1	0	1	1	1	0	10
Spain	5	0	2	0	0	0	1	0	8
Sweden	2	0	0	0	0	0	0	0	2
USA	3	0	0	0	1	1	1	2	8

The last contingency table is constructed to see which emission is most likely to be present in studies confirming the EKC theory. We can see that the most frequent is mixture of pollutants, to be precise 40 studies confirm the EKC theory by examining a group of different pollutants. Second frequent are studies testing carbon emissions. These studies sum up to 22. If we compare the percentage of presence of a EKC between carbon and sulphur, we can see that a EKC occurs in 55% of studies studying just carbon but only 33% studies focused only on sulphur. Which tells us that carbon is more likely to confirm the EKC hypothesis. If we compare it to the mixed group of pollutants, there the percentage is 67%. See the results in Table 17.

Tab. 17 Contingency table Relation (rows), Emission (columns)

	[1]	[2]	[3]	[4]	Total
[1]	**22**	4	**40**	4	70
[2]	0	0	2	0	2
[3]	8	2	5	0	15
[4]	0	0	1	0	1
[5]	4	0	2	0	6
[6]	3	0	0	0	3
[7]	10	6	6	2	24
[8]	2	0	4	1	7
Total	49	12	60	7	128

To make a conclusion, it is clear that it is difficult to reach a consensus in most of counties or regions. But unfortunately, many of them have quite low amount of observations which leads to doubts of veritability of their results. The best results acquired from this thesis which look very promising are for China, Spain and OECD countries out of which more than half of the studies state to find the EKC relationship, which is an inverted U depicting the relationship between economic growth and the environment.

A deeper analysis can be done on the year of publishing. The most frequent year is 2004, in which 35 studies were published out of which 27 confirmed the

EKC theory which makes 77%. The percentage of studies published in total in a year and the number of studies confirming the hypothesis in the same year were very high in three years. The already mentioned year 2004, also year 2001 with 86% and the highest percentage was in year 2002 where 92% of studies published in that year confirmed the EKC theory.

Tab. 18 Contingency table Year of publication (rows), Relation (columns)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	Total
2000	5	1	2	0	1	0	5	0	14
2001	6	0	0	0	0	0	1	0	7
2002	12	0	1	0	0	0	0	0	13
2003	3	0	0	0	1	0	1	0	5
2004	**27**	0	0	0	1	1	6	0	**35**
2005	1	0	4	0	0	1	4	0	10
2006	5	0	2	1	1	0	2	2	13
2007	2	1	3	0	0	1	1	5	13
2008	5	0	1	0	2	0	2	0	10
2009	0	0	0	0	0	0	0	0	0
2010	2	0	2	0	0	0	1	0	5
2011	0	0	0	0	0	0	0	0	0
2012	2	0	0	0	0	0	1	0	3
Total	70	2	15	1	6	3	24	7	128

6 Discussion and Recommendations

The recognition of a consensus in the literature of environmental Kuznets curve and finding the important factors which are influencing the prevailing type of some hypothesis was achieved thanks to conducting of a meta-analysis. To be concrete, binary logit model and also multinomial logit model were created. The existence or non-existence of the EKC relationship was examined in the case of binary model. In the multinomial regression were eight basic hypotheses targeted, which are inverted U-shape, positive, negative, U-shape, N-shape, insignificant, different and no relationship hypothesis.

6.1 Statistical overview

The most interesting findings for the dataset were presented in the statistical overview at the beginning of the analysis. The absolute number of studies which are included in the dataset is 69 which accounts for 128 individual observations. The articles were coded on aggregated and disaggregated levels of detail. Disaggregated dataset aimed on each individual observation and served as a basis for creating a meta-analysis. On the other hand, aggregated dataset focused on individual studies and helped with the statistical overview and the more general analysis of dataset.

The common features of the datasets are as follows. Around 55% (58 studies) of papers report a EKC relationship between economic growth and environment. Therefore, it can be concluded that there is about the same amount of impulse to use and mention papers which caught some indication of EKC and also ones in which this inverted U-shaped curve is missing. Each study except one analysed annual data. It was discovered that 54% of studies use panel data and the number of cross sections was very diverse. The focus was on high income economies, which summed up to around 41% of all observations. This also included countries which are classified as high-income economies.

Majority of all of studies handled samples which had less than hundered observations. The most of the observations analysed the relationship in mixed areas, to be exact 63 observations. North America together with Europe can be considered to got the majority of developed countries, it accounts together for 44 observations, which rounds up to around one third of all observations. The other mutual characteristic of this dataset can be considered the length of study years.
All studies were focusing on quite long study periods. 22.42 years was the mean length of an observation. The shortest amount of study years was one year and the maximum was 57 years. Another very important aspect of studies on environmental Kuznets curve was the pollutant examined. The main pollutant was carbon, which was examined in 49 studies, the second major one was sulphur, which was tested in 12 studies. Other 60 studies used different pollutants and 7 used a mix of pollutants.

6.2 Binary logit model

In binary logit model is being examined whether there is or if there is no relationship between the economic development and environmental degradation. Three models were created using binary logit regression. Model which had the highest prediction success came out to be the simple naïve model which includes only constant. In the final model only significant variables are included. Final model had to go through elimination test where two sided p-value (0.05) was used. It should be noted that the naïve model predicted 70 cases out of 128 observations correctly, that represents 54.7%.

Model which correctly predicted 93 observations cases (72.7) was Model 2. Using 10% significance level, there are these 7 significant predictors: Sample size, USA only, Panel data, Significance level used, Multivariate, Structural breaks considered and Variables per capita. The negative signs of several predictors are quite interesting features, namely it is seen in Sample size, Panel data, Multivariate and Variables per capita. The negative sign of the significant variables suggested that the existence of this variable in a study lowers the probability that we find the EKC relationship.

After conducting a sequential elimination tests with two sided p-value (0.05) then Model 3 creates its final model form. In this model were 85 cases correctly predicted which stands for 66.4% of the observations. Opposed to the Model 2 it was 8 observations less. There were two significant variables. Variable Sample size had negative signs of coefficients. The same effect as described in the paragraph above is concluded. One remaining variable (Significance level used) had a positive sign indicating that because of its existence in the study there is a increase in the probability to find the EKC relationship between economic growth and environment. It says that it is important which statistical levels were used in the studies. Only 2 variables are found in the final model, however their impact on the prediction capacity and dependent variable is rather low. The major problem with a number of the study characteristics was seen in their little frequency in the dataset, which can be represented as for example insufficient variability of the studies. Note that only 62 observations used panel data and only 63 studies considered structural breaks.

6.3 Multinomial logit model

In this analysis 8 types of hypotheses create the multinomial logit model: one of them is being hold as the reference category so it can be said there are seven regressions in total. For the objection of multinomial logit regression seven models were created as well. The logic behind creating the models is the same as in the binary logit regression. The prediction success in all of the models was not so high. At the beginning of modelling of the final model, there had to be done exclusion of some of the variables from the model. The reason was that there existed problems with collinearity and also large values of their variance inflation factors were

found. There were several significant variables occurring in the model with the highest prediction score. These variables possibly influence the EKC theory. The significant variables differed in each of the regressions.

There are no variables which would be significant in all of the regressions, but there were two variables, which occur in four out of five regressions, where significant variables occur. These variables are Significance_level_used and Multivariate. After other variables were removed and only the mentioned two were kept in the model, both of them dropped significance in one regression leaving them to be significant in three of the regressions. The effects on the dependent variable varied and Multivariate's prediction capacity is quite low because only 27% (35 out of 128) studies were using multivariate models. The result is fairly questionable considering this problem.

The farther analysis of the dataset targeted similar results for geographic areas. We concluded that the EKC can be found in studies which focused on mixed regions but also 27 studies which concentrated on Europe described the curve as inverted U-shape. Another contingency table was created to see how the different relationships were spread across the economic levels. Within economies with lower-middle income the relationship was divided among the EKC type, positive increasing relationship and different relationship. Unfortunately, the sample is too little to make any real assumptions. Thirty-six of studies on high-income economies have concluded that the relationship between economic growth and environmental degradation has an inverted U-shape. With studies where economies were mixed we find 10 studies with the EKC relationship and 9 with different than any other mentioned relationship. Considering the individual countries, in only 6 (China, Japan, Norway, Spain, Sweden and USA) the similar results were reached so the EKC theory could be confirmed. Very low amount of observations leads to doubts of the results verity.

Another contingency table was constructed to see which emission was most likely to be present in studies confirming the EKC theory. We could see that the most frequent is mixture of pollutants, to be precise 40 studies confirm the EKC theory by examining a group of different pollutants. Second frequent are studies testing carbon emissions. These studies sum up to 22. If we compare the percentage of presence of the EKC between carbon and sulphur, we can see that the EKC occurs in 55% of studies studying just carbon but only 33% studies focused only on sulphur. Which tells us that carbon is more likely to confirm the EKC hypothesis. If we compare it to the mixed group of pollutants, there the percentage is 67%, which is relatively high.

Even though, a few variables concluded to be significant. The importance decreases with a problem in low informative value together with marginal effect. This results in none of the variables being concluded to substantially impact the EKC theory. The relationship type between economic growth and environment cannot be achieved. A strong suspicion grows together with the question whether there actually could be found any evidence to validate the topic.

6.4 Influence of trade

Thanks to the finding that China has the most confirmed hypotheses confirming the inverted-U theory, closer look at the connection to trade was concluded. Having the data of trade, economic development and environmental conditions and foreign direct investment in China's 30 provinces from Haisheng (2005), it is possible to deal with the impact on environmental Kuznets curve of trade and foreign investment in China. The conclusions show no impact which would be direct on EKC of trade. In any case trade contributes in a large scale to economic growth, and plays a positive role in applying advanced pollution prevention technologies and environmental management methods to China. So it is possible to say that a proactive trade policy could help to solve the environmental pollution problem which is brought by economic growth. There is on the other hand a positive correlation between foreign investment and pollutant emission. This says that foreign direct investment does have some negative impact on environment in China.

6.5 Recommendations

The outcomes of this thesis display the demand for an increase in the heterogeneity of the samples found in different studies. Many same characteristics were found in many of the 69 top-cited studies. Practically, the observational studies should better concentrate on filling the insufficiencies, rather than extend the same research. Among the recommendations are:

- to develop the number of observations,
- to use different pollutants,
- to use different but mainly larger frequencies than annual,
- to cover the structural breaks for observations of which duration lasts several decades,
- to focus more on individual countries.

All the recommendations depend on the past analysis and their explanations which were provided. Because of the large similarity of study characteristics number of variables, even though they were significant, got rather low overall impact and that resulted in the informative value being lost.

7 Conclusion

The goal of the thesis was to analyse whether there is a unity in the field of environment Kuznets curve literature. Methods which ere used served to creating of a systematic overview of empirical literature. The aim was to examine the presence of significant evidence for the prevailing type of the relationship between economic growth and environment. This study was elaborated by studying the influence of a number of different study characteristics, such as sample size, geographic area, number of observations, length of study years, frequency, overall economic level, panel data, variables per capita, relation or emission.

Emerging evidence on the EKC relationship will likely continue to be the focus of considerable attention, and thus underscores the task of summarizing current evidence. This study brings a big contribution thanks to meta-analysis, which is used to statistically summarize the existing empirical values from the EKC literature.

To confirm the given hypotheses binary logit model and a multinomial logit model were created. Summed up, the outcomes showed that every variable which possibly could have an influence on the presence of the EKC relationship, or any other particular type of the relationship between economic growth and environment, are uncertain or do not show sufficient influence.

It was not proven that the choice of a certain type of emission would remarkably contribute to the existence of one type of relationship.

There is also no confirmation that any specific type of relationship would triumph in any specific geographical areas or individual countries.

Due to the low presence in studies, and therefore limited informative value, of variables, no definite conclusion could be made. As it was mentioned above, that 58 papers (55%) report the EKC relationship between economic growth and environment. Most of the articles used annual data and relied on long time periods around 22 years. Large number of articles studied the relationships at the aggregate level, resulting in the number of studies examining the sectorial level being low. These results support the debate of not being able to find any consensus in this field. The main issue of the 69 top-cited papers was the homogeneity of their characteristics.

However, it has to be said that in the field of the EKC, there is more work to be done. Mainly more intensive research without limiting the subject area.

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Appendices

A Overview of analysed studies

ID	Authors	Country of the first author	Year	Study period (years)	Geographical area	Type of relation	Emission	Panel data
1	Soytas, U., Sari, R.	Turkey	2007	44	USA	Insignificant	Carbon	No
2	Kojo Menyah, Yemane Wol-de-Rufael	United Kingdom	2010	41	South Africa	Positive	Carbon	No
3	Huang, B.-N., Hwang, M.J., Yang, C.W.	Taiwan	2007	30	Mixed low income group	EKC type	Carbon	No
4	Galeotti, M., Lanza, A., Pau-li, F.	Italy	2004	26	Mixed	Other	Carbon	No
5	Lise, W., Van Montfort, K.	Netherlands	2006	33	Turkey	Positive	Other	No
6	Lee, C.-C., Chang, C.-P., Chen, P.-F.	Taiwan	2007	41	OECD	Positive	Carbon	Yes
7	Apergis, N., Payne, J.E., Menyah, K., Wolde-Rufael, Y.	Greece	2010	23	Mixed	Other	Carbon	Yes
8	Apergis, N., Payne, J.E.	Greece	2012	17	Mixed	Other	Other	Yes
9	York, R., Rosa, E.A., Dietz, T.	USA	2002	1	97%of world	EKC type	Carbon	Yes
10	Soytas, U., Sari, R., Ewing, B.T.	Turkey	2007	44	USA	None	Carbon	No
11	Andreoni, J., Levinson, A.	USA	2001	17	USA	Other	Other	No
12	Stern, D.I., Common, M.S.	Australia	2001	30	81% of the world popula-tion in 1990	EKC type	Sulphur	No
13	Friedl, B., Getzner, M.	Austria	2003	39	Austria	N-shaped	Carbon	No
14	Perman, R., Stern, D.I.	Australia	2003	31	81 per cent of the world population	Other	Sulphur	Yes
15	Managi, S.	Japan	2006	27	USA	N-shaped	Other	Yes

16	Ehrhardt-Martinez, K., Crenshaw	USA	2002	15	Least Developed Countries	EKC type	Other	No
17	Auffhammer, M., Carson, R.T.	USA	2006	10	China	Other	Carbon	No
18	Bhattarai, M., Hammig, M.	USA	2001	19	Mixed	EKC type	Other	No
19	Coondoo, D., Dinda, S.	India	2002	30	Mixed	EKC type	Carbon	No
20	Cole, M.A., Neumayer, E.	UK	2004	24	Mixed	Other	Mixed	No
21	Fischer-Kowalski, M., Amann, C.	Austria	2001	21	Mixed	EKC type	Carbon	Yes
22	Azomahou, T., Laisney, F., Nguyen Van, P.	Germany	2005	36	Mixed	Insignificant	Carbon	Yes
23	Richmond, A.K., Kaufmann, R.K.	USA	2006	24	Mixed	Other	Carbon	No
24	Bringezu, S., Schütz, H., Steger, S., Baudisch, J.	Germany	2004	8	Mixed	EKC type	Other	No
25	Hettige, H., Mani, M., Wheeler, D.	USA	2000	7	Mixed	Other	Other	Yes
26	Magnani, E.	Australia	2000	12	Mixed	Negative	Other	Yes
27	Martínez-Zarzoso, I., Bengochea-Morancho, A.	Spain	2004	24	OECD	N-shaped	Carbon	Yes
28	Roca, J., Padilla, E., Farré, M., Galletto, V.	Spain	2000	6	Spain	EKC type	Mixed	No
29	Wagner, M.	Germany	2005	13	Mixed	Other	Carbon	Yes
30	York, R.	USA	2007	41	Europe	None	Other	Yes
31	Aldy, J.E.	USA	2005	41	Mixed	Other	Carbon	Yes
32	Lindmark, M.	Sweden	2002	37	Sweden	EKC type	Carbon	No
33	Stern, D.I.	Australia	2002	16	Mixed	Positive	Sulphur	Yes
34	Taskin, F., Zaim, O.	Turkey	2000	16	Mixed	N-shaped	Carbon	Yes
35	Roca, J., Serrano, M.	Spain	2000	6	Spain	Other	Mixed	No
36	Dijkgraaf, E., Vollebergh, H.R.J.	Netherlands	2005	38	Mixed	Other	Carbon	No

37	Zaim, O., Taskin, F.	Turkey	2000	11	OECD	EKC type	Carbon	Yes
38	Culas, R.J.	Australia	2007	23	Tropical developing countries	Other	Other	No
39	Coondoo, D., Dinda, S.	India	2008	31	Mixed	EKC type	Carbon	Yes
40	Song, T., Zheng, T., Tong, L.	China	2008	21	China	Other	Mixed	No
41	Aldy, J.E.	USA	2004	40	USA	EKC type	Carbon	No
42	Brock, W.A., Taylor, M.S.	USA	2004	39	OECD	EKC type	Carbon	Yes
43	Managi, S., Jena, P.R.	Japan	2008	13	India	EKC type	Mixed	No
44	Shen, J.	Japan	2006	10	China	Other	Mixed	No
45	Bruvoll, A., Medin, H.	Norway	2003	17	Norway	EKC type	Other	No
46	Lantz, V., Feng, Q.	Canada	2006	31	Canada	None	Carbon	No
47	van Ruijven, B., Urban, F., Benders, R.M.J., Moll, H.C., van der Sluijs, J.P., de Vries, B., van Vuuren, D.P.	Netherlands	2008	26	Latin America, Africa, the Middle East, Asia, and Oceania	Positive	Carbon	Yes
48	Dasgupta, S., Hamilton, K., Pandey, K.D., Wheeler, D.	USA	2005	14	Developing and newly industrialized countries	Positive	Other	Yes
49	Canas, Â., Ferrão, P., Conceição, P.	Portugal	2003	39	Developed countries	EKC type	Other	Yes
50	Jalil, A., Feridun, M.	Pakistan	2010	54	China	EKC type	Carbon	No
51	Caviglia-Harris, J.L., Chambers, D., Kahn, J.R.	USA	2007	40	Most of the world	None	Other	Yes
52	Müller-Fürstenberger, G., Wagner, M.	Switzerland	2006	13	Mixed	Other	Carbon	Yes
53	Hamit-Haggar, M.	Canada	2012	18	Canada	EKC type	Other	No
54	McPherson, M.A., Nieswiadomy,	USA	2003	1	Mixed	EKC type	Other	Yes

	M.L.							
55	He, J., Richard, P.	Canada	2010	57	Canada	Positive	Carbon	No
56	Ozturk, I., Acaravci, A.	Turkey	2012	48	Turkey	EKC type	Carbon	No
57	Kwon, T.-H.	Korea	2005	31	UK	Positive	Carbon	No
58	Deacon, R.T., Norman, C.S.	USA	2006	21	Canada, Japan	EKC type	Sulphur	Yes
59	Bertinelli, L., Strobl, E.	Luxembourg	2005	41	Mixed	Positive	Mixed	No
60	Liddle, B.	USA	2004	41	OECD	Insignificant	Carbon	Yes
61	Maddison, D.	UK	2004	6	Mixed	Other	Mixed	Yes
62	Khanna, N., Plassmann, F.	USA	2004	1	USA	EKC type	Mixed	No
63	Dinda, S., Coondoo, D., Pal, M.	India	2000	12	Mixed	Other	Sulphur	No
64	Mills, J.H., Waite, T.A.	USA	2008	21	Tropical countries	Other	Other	Yes
65	Diao, X.D., Zeng, S.X., Tam, C.M., Tam, V.W.Y.	China	2008	11	China	EKC type	Mixed	No
66	Hu, C., Huang, X.	China	2008	16	China	N-shaped	Carbon	No
67	Bagliani, M., Bravo, G., Dalmazzone, S.	Italy	2008	1	Mixed	Other	Other	Yes
68	Ghertner, D.A., Fripp, M.	USA	2007	7	USA	None	Mixed	No
69	Tamazian, A., Bhaskara Rao, B.	Spain	2010	12	Mixed transition countries	EKC type	Carbon	Yes

B Coding of attributes and logit models

Coding of attributes

The last step is created by encoding data in a numeric form. In order to introduce the dataset in more detail, the encoding of individual variables is described in the following section.

Geographic area is divided into 6 subcategories which are: 1=Mixed, 2=Asia and Pacific (including Australia), 3=Europe (including Turkey and Russia), 4=Latin America & the Caribbean, 5=Middle East and Africa, 6=North America.

Number of cross sections is an integer number indicating the number of countries/regions/sectors in the study.

Number of observations indicates the number of period observations.

Length of study years naturally displays the length of the study period in years.

Sample size is calculated as number of cross sections multiplied by the number of period observations.

Year of publication was coded according to the date of publication, from 2000 to 2015.

Frequency specifies the rate at which data were collected (annually, quarterly, monthly, other). Because almost all data were annual (except for one observation), additional dummy variable annual data is used instead.

Overall economic level classifies countries in 6 categories: 1= Low-income economies, 2=Lower-middle-income, 3=Upper-middle-income economies, 4=High-income economies, 5=High-income OECD members, 6=Mixed.

Dummy variables are used to indicate whether the study uses *panel data* and whether a study focuses on a *single region*.

Significance level used is coded as: 1=1%, 2=5%, 3=10%, 4=not specified, 5=multiple levels used.

Other variables like *structural breaks considered* take value 1 if the attribute is present in a study, otherwise are 0.

Dependent variable called *relationship* defines the type of relationship which resulted in individual studies and it is coded as follows: 1= inverted U-shape (EKC type), 2=negative relationship, 3=positive relationship, 4=U-shaped, 5=N-shaped, 6=insignificant, 7=different relationship, 8=none.

For binary model there is also a variable *relation_EKC* which is coded 0=different than EKC type (inverted U-shaped curve) and 1=EKC type.

It was planned to also create and use variable *ITP*, which stands for the Income Turning Point, but unfortunately the values of ITP were present in only very small amount of studies that it was necessary to leave this variable out.

After coding the data and completing the data set, binomial and multinomial logit models can be used to perform a meta-analysis. All tables and figures that show and comment on the results in the current work are based on the own calculations that the Gretl program uses, unless otherwise specified.

Binary logit model

In all cases where the variable can take only two possible values, such variable is called binary. The two results are labelled as 1 ('success') and 2 ('failure'). In this thesis, the model is made to find out what determines Y_i^* or whether there is a relationship found in

the i^{th} study (Y_i*=1), or the relationship is missing (Y_i*=0). This dependent variable can be influenced by several independent variables X that have been already specified above (Heijl et al., 2004). The dependence then corresponds to the following model:

$$Y_i * = \beta X_i + \varepsilon, \quad (1)$$

$$Y_i * = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_k X_{ki} + \varepsilon_i \quad (2)$$

where index i serves for the description of individual studies. Yi* is unobserved variable and ε_i has normal distribution $\varepsilon \sim [0, 1]$. Yi can be seen as an indicator and if the latent indicator is positive then: $Y_i = \{0, 1\}$ when $Y_i * > 0$, $-\varepsilon < \beta X_i$, otherwise 0 (Verbeek, 2004).

Following paragraphs are derived from the book written by an author Němec, (2012), if not stated otherwise. The probability of the choice 1 can be expressed as:

$$P(Y_i = 1) = P(Y_i * \geq 0) = P(\beta X_i + \varepsilon_i \geq 0) = P(\varepsilon_i \geq -\beta X_i) \quad (3)$$

when the model is defined and in the case of interpretation of estimates results the proceeding is as follows. Since the variables take values 0 (absence of the EKC relationship) and 1(existence of the EKC relationship), we consider the probability of a given option. Because ε_i has logistic distribution, the probabilities are given as:

$$P(Y_i = 1) = exp(\beta X_i) / (1 + exp(\beta X_i)) \quad (4)$$

$$(PY_i = 0) = 1 / (1 + exp(\beta X_i)) \quad (5)$$

These relationships can be used to interpret the results of a logit model. In regression models, coefficients are interpreted as measuring the marginal impacts of explanatory variables on the explaining variable. In the case of logit models, the interpretation is not completely direct. We report coefficient, p-values and the marginal impact of the variable X on the probability of the option 1. Marginal impact of X on the probability 1in logit model is:

$$(exp(\beta X_i) / 1 + exp(\beta X_i)) (1 / 1 + exp(\beta X_i)) \beta \quad (6)$$

Another usual way of interpreting the marginal effects is the use of odds ratio. Odds ratio is the ratio of probabilities of the choice of each alternative.

$$P(Y_i = 1) / P(Y_i = 0) \quad (7)$$

Odds ratio can be, on the basis of previous explanations (see formula 4 and 5), rewritten into the form:

$$exp(\beta X_i) \quad (8)$$

The logarithm of the odds ratio is then, in this case, βX_i. The interpretation of the parameter β is following: if X is increased by one unit the logarithm of odds ratio changes by β units. In Gretl programme, marginal effects are labelled as 'slope'.

In the results part was as the dependent variable used *relationship_EKC*, which states in binary coding if the EKC relationship was found or not.

Multinomial logit model

The data are called multinomial if the explanatory variable has a finite number of possible results. This happens when we can select from more than two options. These options can be ordered (for example, how much you agree or disagree with) or unordered (e.g. the choice of travel agents by commuters). In this model we are looking for the kind of relationship between environmental degradation and economic growth, so the options are unordered. Y_{ji} can use the values 0, 1, 2, ...,J. Y_{ji} then represent the type of relationship in the i-th study (Heij et al., 2004).

The types of relationships are characterized as:

- j=1: inverted U-shaped
- j=2: negative relationship
- j=3: positive relationship
- j=4: U-shaped
- j=5: N-shaped
- j=6: insignificant relationship
- j=7: different relationship
- j=8: no relationship

In multinomial logit regression, one of the outcome categories is always hold as a reference category and each of other three categories are compared to it. In practice, the choice of a reference category among outcome categories is indifferent. The results are always the same. In Gretl programme the first alternative (presence of the EKC type) is used as a reference one. Hence, this analysis fits simultaneously seven models:

- negative relationship compared to inverted U-shaped
- positive relationship compared to inverted U-shaped
- U-shaped compared to inverted U-shaped
- N-shaped compared to inverted U-shaped
- insignificant relationship compared to inverted U-shaped
- different relationship compared to inverted U-shaped
- no relationship compared to inverted U-shaped

Types of relationships are dependent on the explanatory variables defined above. The following regression model is defined:

$$Y *_{ji} = \beta_j + \beta_{j1} X_{1i} + \beta_{j2} X_{2i} + \ldots + \beta_{jk} X_{ki} + \varepsilon_{ji} \qquad (9)$$

The attention should be paid to the down indexes. Unlike binary model, there is not only one regression but J different regressions (each for the comparison of all alternatives to the reference alternative). There are different coefficients in each of the regressions. β_j is a constant containing difference in utilities between an alternative j and the reference alternative. β_{j1} is the coefficient of the first explanatory variable in the regression (Němec, 2012).

The probability that the type of causality j is present in the i^{th} study, in the case of multinomial logit model, is given as:

$$P(Y_i = j) \frac{\exp(\beta_j X_i)}{1 + \Sigma_{s=1}^{J} \exp(\beta_s X_i)} \qquad (10)$$

where for the simplification of the formula, the regression dependence with one explanatory variable is considered (Němec, 2012).