Economic Inequality and Environmental Degradation

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Department of Economics at the University of Zurich
Prof. Dr. Josef Zweimüller
Dr. Christian Kiedaisch

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Author:	Roland Toth
Course of Studies:	Economics
Student ID:	09-722-323
Address:	Stadlerstrasse 127
	8404 Winterthur
E-Mail:	roland.toth@uzh.ch
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Abstract

The purpose of this essay is to analyze the impact of income inequality on environmental degradation. The findings of earlier contributions of the scientific literature, revealing the complexity of the relationship, are discussed. In particular, the essay provides a detailed insight into the relationship between per capita consumption and carbon emissions. The emphasis lies on the empirical analyses, conducted in several country case-studies. The profound insight into the consumption patterns as a result of country characteristics are used to derive major trends in terms of carbon emissions: reliance on fossil fuels in the electricity sector, increasing demand for mobility, ageing societies, growing hunger in developing countries and behavioral responses. Eventually, the essay discusses the main challenges climate policy faces today and suggests different policy measures, reflecting the particular situation a country is exposed to.

Contents

1. Introduction

The causes and environmental impacts of climate change are a timeless political issue. Exceptional meteorological events and extreme temperatures are occurring with increasing frequency, not uncommonly with tremendous consequences for human and nature. Since the global average air temperature began to increase noticeably, the debate on climate change and global warming extended from the scientific literature to the popular media. A myriad of studies, based more or less on scientific evidence, were undertaken in order to verify or to refute the occurrence of anthropogenic global warming. The controversy spawned supporters and opponents; the emergence of so-called environmental optimists and pessimists attracted increasing public attention.

Recent natural disasters like once-in-a-hundred-year floods and catastrophic droughts all over the world brought about substantial economic losses, affecting more and more people. Along with this worrying trend, the share of climate change deniers, who are acting to undermine public confidence in the scientific evidence on global warming, appears to shrink. At the same time, the mitigation of pollution becomes an increasing public concern. The aim of the upcoming public action is to avoid environmental degradation in an effective and economically sustainable way; therefore, the main challenge is to detect key influences in the relationship between economic activity and environment.

The purpose of this essay is to analyze the relationship between income inequality and CO2 emissions, and especially to merge the literature of different fields in order to get a comprehensive, if not necessarily exhaustive, insight into the interaction between the distribution of wealth and environmental degradation. An introductory part, examining the interactions between economic growth, inequality and CO2 emissions, is followed by a profound examination of the supply and demand side of the relationship. The former concerns political economic mechanisms and is mainly of a theoretical nature; the latter deals with consumption patterns in cross-national studies. The emphasis of the essay lies on the latter, particularly on the empirical findings of the topic. Furthermore, in order to bridge the gap between theory, empirics and policy, the environmental and distributive impacts of at least four major trends affecting the relationship are discussed. Eventually, the paper addresses possible policy implications and discusses the main findings.

2. The relationship between economic growth and the environment

Economic activities leave traces in the environment. The consumption of tangible and, to a lesser extent, intangible goods has an environmental impact: It causes pollution. Since the beginning of industrialization, unprecedentedly strong economic growth was accompanied by an increase of carbon dioxide emissions in many parts of the world. The price of the rising wealth in industrialized countries became a significant rise of the concentration of a multitude of air-, water- and soil pollutants.

One of the first empirical analyses emphasizing the relationship between economic growth and the expansion of pollutants was made by The World Development Report (1992). The estimates are based on cross-country regression analysis, using data from the 1980s. Some pollutants, like municipal waste and CO2, show a positive relationship throughout. However, they found evidence that income does not necessarily have to be positively correlated with pollution in each case. As for sulfur oxide and particulate matter immission, the obtained results show an inverted U-shaped relationship (World Bank, 1992).

2.1. The Environmental Kuznets Curve

Grossman and Krueger (1995) analyzed the reduced-form relationship between income per capita and a range of environmental variables. Similarly to the above-mentioned study, they found evidence for an inverted U-shaped relationship for 12 of the 14 water- and air quality indicators they examined. Whereas the turning points, i.e., the stage of income where the positive correlation becomes a negative one, differ significantly among pollutants, they conclude that environmental conditions generally do worsen in the early stages of the process of economic growth; nevertheless, they find no evidence that it does unavoidable harm to the natural habitat (Grossman and Krueger, 1995). In the same decade, several researchers conducted similar empirical studies in order to get a better understanding of the environmental impact of economic growth, examining the immission trajectories of different pollutants. They all found evidence for the same, above-mentioned relationship, which was soon entitled as the Environmental Kuznets Curve, in short EKC, named after Simon Kuznets (1955) who observed a similarly shaped relationship between the mean and the distribution of incomes.

The occurrence of the EKC appears to have numerous reasons. Grossman (1995) puts forward three forces where income affects the environment in different, to some extent opposed ways: The ‘scale effect’ captures the intuition that increasing economic activity produces more output and thus inevitably needs more input. This negative impact on the environment is more or less offset by the 'technique effect', i.e., the substitution of obsolete with more efficient production methods, and the 'composition effect', meaning that structural transformation in the economy during the growth process shifts production away from energy-intensive industries towards labor and knowledge-oriented service industries. Considering the three-sector hypothesis put forward by Fourastié (1949), the development path of the average energy-intensity of the production sectors on the one hand and the EKC on the other shows similar trajectories. I would suggest to extend the composition effect with a 'demand side': Not only that the share of services in the production sector rises with income, but also energy-intensive goods are subjected to a saturation effect among consumers, increasing automatically the share of less energy-intensive goods. Therefore, the average energy intensity is decreasing with income.

This finding connects the foregoing effects with another possible explanatory variable for the EKC: The income elasticity of demand. Assuming that environment is a superior good, i.e., the elasticity exceeds 1, demand increases disproportionately with income. Thus, it can be argued that an enhanced environmental awareness of consumers induces the production sectors to fabricate "greener" products in order to adapt themselves to the altered patterns of demand. In addition to the private sector activity, the reaction of the public sector is what Grossman and Krueger (1995) call the 'strongest link' between income and pollution: The citizens' augmented care for environmental issues induces a policy response by the government.

Considering all mentioned effects, it may be assumed that in the earlier stages of income growth, the scale effect is partially offset by the composition-, technique- and elasticity effect. After a peak of highest pollution, called turning point, the scale effect can be more than fully offset by the others, leading to improved environmental conditions with further economic growth. Regarding the shape of the relationship, degradation could be wrongly belittled as a transitional phenomenon, with growth being not only the cause of, but also the remedy to environmental problems (Torras and Boyce, 1998). However, the empirical results of the studies are to a considerable extent sensitive to the sample of countries chosen and the time period analyzed. Furthermore, the explanatory power of the independent variables in the regressions of most studies strongly decreases when moving from low-income to middle- and high-income countries (Magnani, 2001).

Grossman and Krueger (1995) caution that the observed relationship should not make policy advisers believe that the process is an automatic one. In fact, without behavioral adjustments, there is no reason to expect ameliorating conditions in terms of pollution. This circumstance reveals a limitation of the EKC: It describes a reduced-form relationship, mostly with data from different countries, in which the level of pollution is a function of income per capita without further specifications of the links between the two variables (Torras and Boyce, 1998). A single-country study conducted by Vincent (1997) finds no evidence for an inverted U-shaped EKC. Vincent conjectures that the obtained relationship of previous cross-country studies is not due to individual countries being at different points of the same income-pollution trajectory. Instead, the cross-sectional data may project the juxtaposition of the positively correlated relationship found in developing countries and the negative one in developed countries. Generally, it would be too restrictive to assume that the impact of economic growth on the environment follows the same behavioral pattern in countries with considerably different economic, cultural and geographic structures, as Padilla and Serrano (2006) argue. To sum up, economic growth should not be considered as a panacea for environmental quality (Arrow et al., 1995).

Holtz-Eakin and Selden (1995) employ panel data to examine the relationship between GDP per capita and CO2 emissions. They find no evidence for an inverted U-shaped curve; a turning point cannot be observed within the analyzed income range. Although the emphasis of this essay lies on CO2 emissions, it is worth considering the findings of the EKC for at least three reasons. First, it may be argued that the turning point is not yet reached because even the countries with the highest average incomes have not yet reached that reversal point. Shafik and Bandyopadhyay (1992), who use CO2 emissions per capita rather than aggregate emissions, find a strongly hypothetical, yet statistically significant turning point at over $7 million of income. Second, the overall shape of the EKC is not fixed over time. The kurtosis and skewness, the peak (i.e., the turning point) and the dispersion of the curve are subject to mutations over time. The above-mentioned effects may change the relationship between CO2 and income in different ways over time. Third, the marginal propensity to emit (MPE) carbon dioxide appears to be, as can be seen in Holtz-Eakin and Selden (1995), a declining function of income. A similar empirical study conducted by Ravallion (2000) finds the same concave relationship between CO2 and average income across countries. He concludes that marginal impacts of economic growth on CO2 emissions diminish while the mean income increases. This finding supports the idea that, eventually, the CO2-income relationship could become a negative one.

2.2. The globality of carbon emissions

When comparing carbon dioxide, which is a main contributor to climate change, to other substances causing environmental degradation it appears to be one of the pollutants whose adverse impact is most difficult to attenuate. The most obvious reason for this is that the negative effects of CO_2 can be externalized. As pointed out by McConnell (1997), carbon emissions do not inflict local, but rather global damage. Similarly, the local level of CO_2 immission does not only depend on local, but also on global emissions. Furthermore, due to its omnipresence, CO_2 abatement is relatively costly. Lastly, the fact that the private benefits of CO_2 consumption exceed the private costs creates little incentive for individuals to mitigate. Thus, it is obviously an issue of a public good problem. Shafik (1994) argues that the reason for the rising per capita carbon emissions with increasing incomes is a free rider problem. There are no considerable local costs associated with CO_2 emissions; the aggregate costs in terms of climate change are borne globally. Exactly this global nature of carbon emissions is the reason why public action for mitigation proves so difficult. Unlike in other public good problems, where a particular adverse impact is mostly restricted to a bounded area like a municipality or a nation and, thus, can be handled relatively easy, the coordination of this issue is much harder and leaves global CO_2 policy ineffective. In contrast to the relatively ineffective Kyoto Agreement, the promulgation of regulations succeeded to significantly reduce sulfur dioxide (SO_2) levels from the 1970s to the present (Slottje, 2001). This was mainly due to the local impact of local emissions, which CO_2 lacks by nature.

When dealing with environmental degradation, this paper henceforth focuses largely on CO_2. This does not imply that other greenhouse gases are less important or even negligible. The reason for this choice is that most studies that relate consumption patterns to their environmental impact use CO_2 as a proxy variable. Moreover, it is one of the most ubiquitous substances and the most prevailing polluter in the climate change debate.

3. Omitted variable: Introducing inequality into the economy-environment relationship

The literature on the EKC often suggests that there may be other important factors explaining the downward sloping part of the curve apart from the average income in a country. Magnani (2001) questions whether there is a development path which mechanically connects improvements in environmental quality with economic growth. The paper emphasizes that the EKC lacks solid theoretical foundations. Furthermore, the instability of empirical results, both across time and across countries, points towards an omitted variable problem (Magnani, 2000). In the formerly mentioned paper, a Ramsey test is conducted: The hypothesis of no omitted variables is consistently rejected for most pollutants examined. Bimonte (2002) reflects the high standard errors in studies dedicated to observe the inverted U-shaped relationship and emphasizes that the wide-ranging effects of time and economic growth on pollution across countries seem to confirm that in the EKC, there is an omitted variable problem. Regarding the low R^2 measures in his regression output, just as in numerous related studies, the conjecture seems legitimate. This finding entails the question whether other explanatory variables besides income per capita should be included into the regression in order to raise the coefficient of determination, i.e., to improve the explanatory power of the regression. One apparent answer is to retain mean income per capita in the regression equation and extend it by its dispersion, i.e., income distribution. If its impact on the relationship is significant, the original Kuznets curve – measuring the effect of income on inequality – will prove to be of a real parentage of the EKC, the two having even more in common than name and shape.

The most popular index measuring the distribution of income is the Gini coefficient which captures the degree of income inequality within an economic area. As of the end of the last century, several studies employed this measure to explore the interactions between income, inequality and environmental degradation. Torras and Boyce (1998) were among the first to introduce the Gini index as an independent variable in an EKC study. Using ordinary least squares (OLS) as an estimation method, they included income per capita in the linear, quadratic and cubic form, the Gini coefficient and other variables, which were aimed to capture the impact of literacy, political rights and civil liberties. The used Gini ratios, which were reported by the World Bank, contain several limitations, however. Besides missing data problems, due to many countries lacking a reliable Gini coefficient, methodological heterogeneities across countries lead to substantial inconsistencies, e.g., some nations referring their Gini ratios to expenditure rather than to income. In general, a caveat applies whenever using Gini measures as regression estimates: There is almost no fully-fledged and standardized panel data across countries. Furthermore, especially in developing countries, the accuracy of the available data is open to doubt. Thus, the authors treat the obtained results with caution, pointing out divergent relationships: For some of the pollution variables, inequality appears to have the tendency to exacerbate environmental degradation; for the others, the opposite holds. In addition, the relationship occasionally becomes reversed when moving from developing to industrialized countries. It should be mentioned that for most of the pollutants the regression estimates are statistically insignificant.

A deeper insight into these ambiguous findings is offered by Ravallion (2000), using only CO2 emissions as pollution variable. The inverted-U shaped relationship, which is found for several pollutants and supports the hypothesis to an EKC, seems not to hold for carbon emissions. As mentioned before, CO2 emissions tend to increase monotonically with income per capita. At the same time, MPE is assumed to be a declining function of income. These findings are consistent with the observation of a non-linear, concave relationship between CO2 emissions and mean income across countries. Thus, considering income distribution, higher inequality would ceteris paribus lead to less pollution, i.e., the relationship would be negative. On the other hand, redistributive policies – aimed to improve social balance – would increase CO2 emissions because incomes of relatively wealthy individuals with lower MPE are transferred to relatively poor individuals with higher MPE. Moreover, due to the various effects introduced in Section 2, economic growth implies higher emissions, at least for the majority of the nowadays common income levels. Thus, the adverse impact of more equality on CO2 emissions and the positive relationship between economic growth and CO2 entail a static trade-off: In the short run, policy measures dedicated to reduce poverty, either through growth or redistribution will run counter and undermine national climate targets.

Considering dynamic effects, Ravallion (2000) points out two striking features concerning the two formerly mentioned relationships. On the one hand, a growing economy improves the trade-off between inequality and CO2 emissions. On the other hand, a more equal society improves the trade-off between economic growth and carbon emission. The reasons for these findings are as follow: First, the study finds evidence for flattening out in the relationship between CO2 emissions and mean incomes when income is sufficiently high. Signs of a turning point at high income levels entail the conjecture that, eventually, the trade-off could vanish completely when all countries achieved a high enough average income level and thus the aggregate worldwide MPE declined sufficiently. According to the paper, this will be the case when all countries reach the level the middle income countries of today. Second, the paper shows that income elasticity of demand for CO2 consumption declines with more equality. According to that, the degree of income inequality has, besides its direct effect via MPE, also an indirect impact on CO2 emissions as it influences the degree to which economic growth exacerbates global warming. In other words, holding the mean income constant, the aggregate income elasticity of demand is lower in more equal societies. For instance, the elasticity for typically carbon intensive energy commodities is higher than 1 in early stages of the growth process. However, it tends to decrease as the growth process proceeds, whereas its development path is to a considerable extent dependent on how income is distributed in the economy. Both findings combined, it can be concluded that the interaction of redistribution endeavors and pro-growth economic policy might mitigate global warming in the long run.

In order to have a deeper comprehension of the relationship between inequality and carbon emissions, it is worth considering how inequality in CO2 emissions across countries relates to income inequality. Padilla and Serrano (2006) made a decomposition analysis, applying non-parametric estimation techniques and distinguishing between CO2 emissions inequality across countries and across groups of countries. Employing cross-country data from 1970-1999, the first finding is that inequality in CO2 emissions decreased over time. The paper compares the Gini index of income with a concentration index of emissions. The latter measures the inequality in CO2 emissions ranked by income inequality across countries, i.e., it reveals the extent to which rich countries pollute more than poor countries. The so-called Kakwani index is a disparity metrics which compares the degree of inequality in the distribution of emissions between rich and poor countries with the Gini coefficient, i.e., it detects the level of progressivity or regressivity in the distribution of CO2 emissions. According to the data, the inequality in emissions declined from 1970 to 1986, whereas the Gini index remained relatively constant. Within this period, the hitherto regressive relationship became progressive. This trend suddenly reversed in 1986, presumably due to a sharp drop in the oil price and reinvigorated growth in developed countries. This evidence gives rise to the assumption that inequality in CO2 emissions reacts more elastically to income shocks than income inequality. In other words, if a positive shock spurs economic growth, subsequent adverse effects concerning income inequality will be surpassed by increasing inequality in the contribution to global warming between rich and poor countries, considerably affecting the further development of global climate policy. The trend of the Kakwani index after the mentioned reversal point in 1986 is less clear-cut. Towards the end of the century, the relationship became slightly regressive again.

In a next step, Padilla and Serrano (2006) compared the aforementioned concentration index to the 'simple' inequality of CO2 emissions, an alternative index which is equivalent to a 'Gini for CO2 emissions'. Contrary to the concentration index, it does not rank the countries according to their income per capita. Therefore, the two measures complement each other, providing information on different features. A comparison illustrates to what extent income per capita can explain inequality in CO2 in a cross-country view; in this case whether the previously mentioned decline over time is due to a decreased income inequality between a rich and a poor country, or rather due to greater equality between countries with comparable income levels. The results show that both indices decreased over time; the concentration index, however, to a lesser extent than the index capturing the 'simple' inequality in emissions. Put another way, although the inequality in CO2 emissions across countries has diminished over time, income inequality between rich and poor countries has not diminished to the same extent. A similar conclusion can be found when applying the Theil index which provides a more sophisticated insight into the 'simple' inequality in emissions: It explains the total amount of inequality, distinguishing between the observed inequality between country groups and within them and finds that the share of the between-group component increased in the considered time period from about 66% to over 77%, whereas the share of the within-group component shrank to the same extent. Both components decreased in absolute terms, yet the reduction in the within-group inequality was much more substantial in relative as well as in absolute terms. This result implies that a reduction of emissions focused on rich countries, which are located at the upper bound of the distribution of CO2 emissions, would be beneficial in reducing global inequality.

Ambiguous findings across the discussed papers raise the question whether inequality is good or bad for the environment in general. As for the already discussed relationship between economic growth and environmental degradation, there are a number of effects that influence the relationship between income inequality and environment. To some extent the effects resemble each other, not least due to the strong interactions between inequality and growth, as was shown by Ravallion (2000).

4. Is inequality good or bad for the environment? – The aggregation effect vs. the political economy effect

Considering the relationship between inequality and environmental degradation from a theoretical perspective, there are two major effects which are running counter to each other and giving rise to a controversy. On the one hand, the main finding in the field of political economy is that a rise in inequality, through various channels, increases pollution in general and CO2 emissions in particular. The principal argument, as was mentioned earlier when analyzing the relationship between income and pollution, is that the change of preferences concerning environmental issues and the subsequently induced policy response are the ‘strongest link’ in the relationship. According to the proponents of the theory, this holds not only for economic growth but also for more equality.

On the other hand, recalling that, empirically, CO_2 emissions tend to increase monotonically with income per capita, and reconsidering MPE which is assumed to be a declining function of income, it can be argued that higher inequality may be associated with less pollution: Aggregating the consumption behavior of all households in an economy without perfect equality, i.e., in an economy with a Gini coefficient higher than zero, and redistributing income, the result would be an increase in CO_2 emissions according to this mechanism. Thus, this aggregation argument is opposed to the political economy argument (Heerink, 2001). The next subchapters discuss the features of the two effects more profoundly in order to obtain a better insight into their mechanisms.

4.1. The political economy effect

The degradation of the environment during economic activities has a varying impact on human beings. On the one hand, some individuals have net benefits because their economic gain exceeds possible inconveniences due to degradation, while on the other hand others bear net costs and are suffering more than profiting. For instance, considering the adverse consequences of global warming, poor countries suffer disproportionately more than their contribution to it. In contrast, rich countries, at least until today, have profited more from fossil fuel combustion than they have suffered from global warming. Boyce (1994) was among the first to address inequality as a cause of environmental degradation in a political framework, providing three different theories explaining the relationship. First, he argues that if the winners who derive net benefits from the activity are more powerful than the net losers, pollution levels will be higher than in the reverse case. Assuming that greater differences in political and purchasing power are strongly correlated with income inequality in an economy, this finding supports the assumption that inequality and degradation are positively correlated. Second, the net costs that the relatively powerless and poor individuals have to bear can have an adverse effect to income not only in a static but also in a dynamic view. For example, the environmental consequences due to deforestation in developing countries may cause serious damage to the population, cutting their revenues for years. Thus, their ability and, hence, willingness to pay for prevention measures decrease. As the valuation of environmental quality, in monetary terms, decreases, so does the “cost” of deforestation. Third, the author hypothesizes that more inequality raises the mean environmental time preference in the population, whereas a high time preference implies that an individual values the present situation relatively more than the future, i.e., inequality makes people more careless about their future. Both the poor and the rich extract resources from the environment and consider less the intertemporal impacts, though for different reasons: The poor due to the imperatives of day-to-day survival and the rich because of depleting and capitalizing natural resources, as long as they have the power. This theory applies mainly to developing countries, being unequal in terms of both incomes and political power. These theories, put forward by Boyce (1994), were quoted and scrutinized by various subsequent publications. Nonetheless, it provides a good surface impression of the relationship between inequality and environment from a political economic point of view.

The paper employs the Coase theorem to show how transfer payments from the net losers to the net winners of degrading activities could lead to a Pareto improvement. This theorem is based on the assumption that property rights are defined without ambiguities. However, this is not always the case. Furthermore, the transfer payments mentioned in the theorem, e.g., the farmer compensating the rancher for preventing his cattle from eating the entire harvest, are rarely observed in reality. Instead, a society attempts to enforce environmental-friendly behavior by issuing laws and regulations. Therefore, it appears to be the public sector, rather than individuals, that is in charge of managing environmental concerns.

The environment in general is considered to be a public good. In order to restrain degradation, the state takes measures aimed to mitigate pollution while the costs are bared by the citizens. In political systems where participation is possible, i.e., a democratic voting system is in place, the voters can choose between consuming private goods and contributing to public goods via tax payments. The proportion of the contribution to environmental amenities is therefore determined by preferences of the population. Assuming that these are dependent on individual revenues, the distribution of incomes plays an important role concerning pollution abatement. If the preferences change monotonically with income, the median-voter theorem applies. In other words, if society has to decide whether or not to contribute to a mitigating measure, the choice of the majority will equal the choice of the individual with the median income, i.e., the preferences of the median voter will be pivotal. Due to the fact that changes in income distribution shift the relative position of the median-voter in it, political decisions involving environmental measures may hinge heavily on the extent of income inequality in a society.

In order to assess how inequality affects political decisions, two features of the relationship have to be considered: First, whether preferences for environmental quality are an increasing or a declining function of income and second, how income elasticity of demand behaves. It can be reasoned that when average income grows, the median voter has a higher ability to pay. At the same time, a prospering economy may come along with better education and thus better informed population, increasing the awareness of the median voter about environmental concerns and thus the willingness to pay. Therefore, it can be assumed that preferences rise with income. Regarding income elasticity of demand, Komen (1997) finds that environmental quality has the property of a superior good. Employing data on public R&D for environmental improvements funding in OECD countries as a proxy for environmental preferences, the empirical results show that income elasticity significantly exceeds 1. Based on these findings, the relationship between preferences and income appears to be positive and convex. According to the obtained shape of the curve, it can be inferred that the largest possible contribution to the public good environment can be achieved when the income of the median-voter is maximized. More specifically, income redistribution, narrowing the mean-median difference and thereby decreasing inequality, increases the preference of the median-voter for environmental quality. Furthermore, due to convexity, the probability of the median-voter approving an environmental measure in the political decision process rises over proportionally, making redistribution an even more effective instrument to reduce degradation.

Income inequality does not only impact the probability to approve a measure in the political process, it also influences the share of income the citizens assign to public goods, compared to private goods, given average income. For instance, the distribution of income may not only determine whether a carbon tax is implemented, but also how high the tax rate will be. Magnani (2000) argues that the marginal rate of substitution between consumption goods and environmental quality depends on the position of the individual in the income distribution. This finding is based on the fact that a consumer does not only consider his absolute, but also his relative income. When inequality increases, i.e., the gap between the mean and median income widens, the median voter becomes relatively poorer. Being concerned about his social status, he will presumably be more reluctant to finance a purely public good – aimed for the entire population – compared to the purchase of private goods which help him maintain his own prosperity. For instance, people in particularly unequal societies like Russia or the United States appear to care more for prestigious goods highlighting their status than in a very equal society like in the Scandinavian countries. Comprising various factors of influence, the field of political economy supports the idea that income inequality and environmental degradation are positively correlated.

4.2. The aggregation effect

These findings run counter to the empirical observations of the relationship between inequality and CO2 emissions. As discussed earlier in the essay, the marginal propensity to emit (MPE) carbon dioxide is a declining function of income. Besides the already discussed results of Holtz-Eakin and Selden (1995) and Ravallion (2000), a study conducted by Heil and Wodon (2000) observed a declining MPE for six alternative time periods between 1950 to 1992 across 135 countries with throughout significant estimates and consistent algebraic signs. Like in the formerly mentioned papers, the linear per capita income estimate was significantly positive; the quadratic one significantly negative. These findings give rise to the assumption that households on a micro level emit more CO2 as income grows; however, the emissions rise less than linearly with income. With the households' revenues being unevenly distributed, considering their aggregate CO2 emitting behavior, redistribution of income would yield an increasing CO2 emission rate. This is due to the fact that resources are taken away from above-average income citizens with a relatively low MPE, transferring them to below-average income citizens with a higher MPE. The consequence of this mechanism is called the aggregation effect (Heerink, 2001). With regard to this effect, CO2 mitigation efforts may be more effective if social balance policies would be restricted, at least in the short run. The same applies to all other pollutants where the MPE is a decreasing function of income. In the case of pollutants whose adverse impact is a decreasing function of income, the aggregation effect operates in the same direction as the political economy effect (Heerink, 2001).

4.3. Combining the two effects

At first appearance, the two discussed effects could not be more different: According to political economy, in order to minimize CO2 emissions given the average per capita income level, the revenue of the median-voter must be maximized. This implies a perfectly equal income distribution, i.e., the complete absence of income inequality or a Gini coefficient approaching 0. On the other hand, taking the aggregation effect into account and considering declining MPE, the lowest possible CO2 emissions could ceteris paribus be achieved when all resources are owned by a single individual, i.e., income inequality is absolute and the Gini coefficient approaches 1. Although both scenarios are highly hypothetic, their discrepancy becomes evident for the simple reason that their optima lie in opposite extremes.

In fact, the two effects are strongly connected. Both theories argue with income elasticity of demand. On one side, demand for environmental quality (political economy); on the other side, demand for CO_2 emissions (aggregation). When the incomes of the citizens grow, MPE declines not because of citizens being richer per se, but due to higher demand for regulations (Dasgupta et al., 1995). This is exactly the argument used by the supporters of the political economy effect. In other words, rising incomes do not only increase CO_2 emissions but also the ability and willingness to avoid them. Because of the fact that environmental quality is a superior good with income elasticity above one, i.e., the relationship between income and demand for environmental amenities is convex (Komen, 1997), the trajectory of the relationship between income and propensity to emit becomes concave, making MPE a declining function of income. In other words, the political economy effect, influencing CO_2 emissions indirectly via behavioral policy responses, affects the aggregation effect which influences carbon emissions directly.

Considering the relationship between inequality and CO_2 emissions, the above-mentioned findings provide ambiguous results, raising the question which of the two effects is the stronger one. An empirical study employing cross-national regression analysis, conducted by Heerink (2001), finds that the aggregation effect runs counter to and tends to outweigh the political economy effect for some environmental indicators, like for CO_2 emissions per capita, where the Gini coefficient is significantly negative on the 1%-level. In the case of particulate matters and SO_2 immission, the net effect is insignificant; for deforestation, the political economy affect appears to dominate. Finally, the paper concludes that "at least in the short and medium term, redistribution may contribute to a deterioration of environmental quality whenever the relationship between income and environmental pressure is concave and the aggregation effect is sufficiently large" (Heerink, 2001, page 8).

A principal finding is that MPE declines in income because of various behavioral changes of the individuals during the growth process. In this section, it was emphasized that the reason for that is not the population becoming richer per se, but rather the induced policy responses. However, the interactions between income inequality and CO_2 emissions have another aspect. Whereas a democratically elected government cares for the supply of environmental amenities according to the preferences of the voters, e.g., by investing in projects aimed for CO_2 mitigation, the citizens are able to influence the trajectory of the MPE in a direct way, namely, via their consumer behavior. Therefore, differences in consumption patterns are presumably an important indicator of CO_2 emissions, too. The next section explores the consumption patterns in different country case-studies employing multivariate input-output analyses in order to capture the effect of inequality on the environment from a demand perspective.

5. Case-studies of consumption patterns across countries

A principal cause for environmental degradation, as was shown in the earlier sections, is the increasing wealth in growing economies. Under the assumption that the saving rate is less than one for all relevant income stages, larger wealth is associated with more consumption. On the other hand, consumption is connected with carbon emissions since almost every kind of materialist consumption good leads to CO_2 during its production and/or consumption process. This supports the idea that consumption is a key indicator for degradation, i.e., pollution. However, consumption in the world is not evenly distributed. Furthermore, behavioral patterns tend to differ across countries, even if the income variable is held constant. Reasons for this finding could be cultural differences, varying degrees of awareness according to environmental impacts, information diffusion in general, preferences for environmental integrity, and exposure to risks or dependencies. Australia, for instance, which is considered to be one of the wealthiest countries in the world, features consumption patterns that lead to a much higher CO_2 emission rate than those of countries with similar per capita GDP. The disproportionately high emissions are to a substantial extent due to the fact that the country heavily relies on coal, as consumption good and a key export factor. On the other hand, Bhutan is an example of a country where the opposite holds: It consumes less CO_2 emissions per capita than other countries with comparable income levels. It can be argued that the country has fewer endowments due to resource scarcities and for geographical reasons. Nonetheless, differences to other countries in terms of culture and mentality might be a factor, too.

Consumers' behaviors vary significantly across countries. Thus, it is worth exploring consumption patterns in countries with different endowments and characteristics in order to gain an insight into the origins of carbon emissions, i.e., to find out where pollution comes from. Understanding the causes and detecting the contributors of environmental degradation are crucial when intending to design effective countermeasures. For this reason, this section analyses a series of case-studies conducted across six countries, aiming to make out what citizens consume and how their consumption differs from other patterns in the rest of the world.

The first subsections discuss methods and data employed in the considered analyses and deals with the shortcomings of the studies. Second, referring to the empirical evidence in the respective countries, I analyze the consumption behaviors in depth. Third, using the aforementioned differences in characteristics and endowments, I discuss how these may affect outcomes and create environmental challenges.

5.1. Methods

In the empirical studies of the earlier sections, the main explaining variable on the right hand side of the equation is income, i.e., the mean and the dispersion of the income variable. The papers that follow do not analyze from the revenue-, but from an expenditure perspective. Since for the determination of emission rates it is not the amount of earnings which is necessarily important, but rather what share of these earnings is spent on what, the studies take the consumption expenditure of households as key explanatory variable.

Extracting the results from not only within-country, but also between-countries case-studies, the methods employed cannot always be assigned to a single nation. Therefore, the findings are sorted in a country perspective, and the methods are discussed in this separate subsection. Most of the considered papers distinguish between direct and indirect emissions. The former occurs during the consumption of the good by the end-user, mainly in combustion processes like heating. The latter is caused not by the consumer himself, but at the stage of production. In this case, the environmental impact of household consumption occurs indirectly. Commodities and services are typical representatives of the indirect group. The measurements of direct emission rates depend on the energy-intensity of the regarded technology. For instance, to capture the environmental impact of car use, the CO2 emissions of an average-sized combustion engine per kilometer is multiplied with the mean amount of kilometers driven by a representative household. Computing the same type of values in the case of the indirect group requires more sophisticated methods. The considered studies employ input-output analysis in order to capture the partial environmental impact of different stages in the entire production process.

In general, to capture the environmental impact of consumption patterns the case-studies employ multivariate input-output analysis. First, they determined CO2 emission intensities measured in emissions per financial unit of the domestic currency for a multitude of consumption goods, mostly on a highly disaggregated level. In other words, the "energy use of all processes is summed up and then divided by the retail price of the product" (Kerkhof et al., 2009, page 2). The calculated intensities may deviate in the case-studies, thus reflecting the fact that technology differs across countries. Second, the obtained intensities are combined with household expenditure data, which provide the amount of consumption of the corresponding products (Lenzen et al., 2006). A principal advantage of disaggregating is that it enables to distinguish the properties of hundreds of product groups. This provides a profound insight into consumption patterns and the origins of CO2 emissions, i.e., the emergence of environmental degradation. Furthermore, most of the examined case-studies linked the obtained results with inequality in order to detect how consumption behaves as a function of income distribution, dividing CO2 intensity-weighted household expenditures to income quantiles. Some studies further assess data capturing various socioeconomic characteristics, like household size and demographics, aiming to capture their partial impact on consumption and emissions. The versatility of the empirical analyses is certainly subject to the availability of data in the respective country.

5.2. Data

The empirical studies rely mainly on data gathered in the corresponding country. The types of data employed resemble each other across the case-studies. One of the most comprehensive analyses was conducted by Kerkhof et al. (2009) who constructed a 112×112 matrix of input-output coefficients to define intermediate input requirements per unit output of each of the totally 112 production sectors considered, including both domestic production and imports: The matrix of input-output coefficients is derived by dividing all intermediate inputs of a sector by the total production of that sector. Furthermore, they employed 'supply tables', i.e., a 112×365 matrix of supply coefficients based on the National Account that "define the supply of the 112 domestic and foreign industry sectors to 365 product groups purchased by Dutch consumers. The matrix of supply coefficients is derived by dividing the supply of a sector by the total supply of all sectors to a particular product group." The considered emission data of the production sectors and the product groups come from the Dutch National Emission Inventory. Data on household expenditures rely on the results of the Dutch Expenditure Survey of 2000 (Kerkhof et al., 2009). In this essay, I waive to discuss the case of the Netherlands, since it includes a number of characteristics, whose impact can be better explained in a decomposed view, which is offered by the evidence in other countries.

In general, all case-studies employ data on household expenditure and consider product groups on a disaggregated level. The differences lie in the extent of inclusion of energy goods and commodities, on the time basis the data are gathered and on the number of households polled. Thus, a number of caveats apply regarding the data.

First, the standard errors in the obtained estimates heavily rely on the number of households, i.e., the sample size. For instance, Lenzen (1998) conducted a study with data from the Australian Household Expenditure Survey of 1993 and 1994, which collected comprehensive information from 8389 out of totally 6.6 million households in the examined region. Due to this relatively small sample size, the standard error of mean expenditure is higher than 25% for some of the commodities considered, narrowing the validity of the study.

Second, the clusters of consumption goods are not always clearly distinguishable: The defined groups may comprise heterogeneous commodities across countries. A typical example is the group "recreation". The studies have to some extent different opinions of which activities can in fact be assigned to recreation, and which are accompanying factors. For instance, whereas some case-studies elaborate a decomposition analysis for the "mobility" group, i.e., assign each mobility need like "commuting" or "recreation" to the specific purpose, others simply gather all kinds of mobility needs in a single cluster. These discrepancies are detrimental to comparison purposes.

Third, data inconsistencies can occur even within countries. National statistical offices may alter their methodologies of collecting panel data within the time period considered in a study. Small changes in the measuring type, even for the sake of better comparability of the data across countries, could lead to substantial bias in a country intern study. As already mentioned in Section 3 qualifying the Gini coefficient, the lack of standardized data evokes inconsistencies in the estimation results. Thus, they have to be treated with care, and the observer should be cautious when inferring causality.

Finally, there appears to be a urbanity bias due to better data availability in metropolitan areas compared to far-flung regions. This is particularly the case in the examined developing and emerging economies. For this reason, Cohen et al. (2005) waived the involvement of rural areas of Brazil; instead, his paper concentrates on 11 capital cities which comprise around 30% of the country population. Although being less comprehensive, focusing only on a part of the population can be beneficial in terms of inequality: For the majority of countries worldwide, it appears that in the upper tail of income distribution, urban households prevail, whereas in the lower tail, the majority of the underlying households is located in rural areas. In the case of Brazil, however, inequality remains high even when taking only the urban population into account. In an Australian study, Lenzen (2004) confined the observed territory to the largest metropolitan area. Doing this, he could avoid fixed country intern effects due to national discrepancies in climate, geography or density. In fact, it is worth considering these findings when conducting any country intern analysis, particularly in big and heterogeneous countries. In general, comparison across countries might be difficult because data are gathered in different ways, and the methods across the case-studies are not always identical in design.

5.3. Shortcomings

Besides data inconsistencies, the models contain a number of further shortcomings which are addressed in the following. A principal method-immanent drawback is that the input-output matrices do not take into account that production technologies differ across countries. In fact, in the country intern case-studies, the environmental impact of all product groups is computed with energy intensities according to the domestic technology, based on the assumption that imported goods have the same energy intensity as domestic substitutes. In across-country studies, the technology of the country with the most comprehensive data available operates as default for the others. There are several reasons to doubt this hypothesis. The development of technologies is, despite international transfer becoming ever faster, not synchronized across countries, i.e., substantial differentials remain. For instance, patents and property rights can lead to a worldwide concentration of market power, where large firms maintain production facilities in a few countries and dominate the technological frontier. At the same time, smaller domestic firms may supply similar products in considerably lower quality and quantity. Pharmaceuticals and generics are an example for this phenomenon. Furthermore, since the estimates in the studies are based on aggregated data, differences in product brands and types of production cannot be captured. Gysi and Reist (1990) conducted a study to examine the production of tomatoes with regard to energy consumption and greenhouse gas emissions. "These authors calculated the energy required to produce and deliver one kilogram of tomatoes to be 2MJ for natural cultivation, 55 MJ for greenhouse cultivation, and 168 MJ for imports in the case of the Canary Islands" (Lenzen, 1998, page 4). Our country case-studies generally use an average value for tomatoes, which may distort the results considerably if the goods consumed are produced with different technologies.

Endowments differ to a large extent across regions. More specifically, they are key indicators for the historical development of country-specific technology levels and lead to comparative advantages, as the corresponding theory of Ricardo suggests. Comparative technological advantages are the principal reason for trade, besides factor resource scarcities. In many cases, domestic production sectors with inferior technologies can only exist because of the lack of technological transfer, trade barriers like tariffs and quotas, subsidies for domestic producers, transport costs due to geographical factors, preference bias towards domestic products, politically motivated issues like preventing new unemployment and thus keeping alive unproductive sectors (e.g. Swiss agriculture) or slow structural transformation processes. Therefore, it can be conjectured that taking the domestic energy intensity values for both domestic and imported products overestimates the environmental impact of consumption, since the foreign technology, which can be considered as good or even better when imports exist, is on average more efficient and thus less energy intensive. This theory is opposed to the finding that especially in the case of labor-intensive, mass-produced goods like textiles the facilities are located in countries where the factor 'labor' is cheaper, i.e., in poorer countries. Poorer countries, in turn, tend to use energy less efficiently and have more polluting energy supplies, which lead to higher energy intensities. The overall effect appears ambiguous. However, it is likely that the input-output matrices under- or overestimate the energy intensities of the examined product groups.

This is especially the case in smaller and more open countries with a smaller degree of autarky. When the share of imports of the goods consumed is higher, there is also a rising uncertainty according to the results computed with domestic energy intensities. In fact, they might significantly deviate from the weighted energy intensities, which depict the actual impact on the environment. For instance, around 20% of the total emissions assigned to consumption of Danish households take place abroad (Lenzen et al., 2006).

As already mentioned, the case-studies are based on the assumption that the energy intensity of a commodity does not vary across brands, production process and location. On the other hand, the studies also assume that the energy embodied in a product is proportional to its price, i.e., the specific energy intensity value operates as proportionality constant which is multiplied with the purchase price of the product (Lenzen, 1998). In the case of agricultural goods, this assumption appears plausible on the whole: 2kg of tomatoes generally cost twice as much than 1kg of the same origin, unless there are discounts or price differentials across supermarkets for competitive reasons. However, for several non-foods, the assumption does not hold. Consider an example of two citizens, whereas one is richer than the other. Both own five sweaters; however, the rich person paid $100 and the poorer person $10 for each piece. The results computed with the methods of the studies would suggest that the environmental impact of the consumption of sweaters is ten times higher in case of the rich citizen, although both possess the same amount of sweaters. This obviously incorrect outcome is based on the assumption that the factor shares stay the same within a product, i.e., the share of the factor 'energy' remains constant regardless the purchase price. In fact, a hypothesis of declining marginal energy intensity is far more plausible, since more expensive commodities entail a higher amount of labor and technology.

5.4. Consumption patterns: Evidence within countries

The examined case-studies include six countries in four continents. The group of developed countries is overrepresented mainly because of the availability of reliable data sources. Nonetheless, it is possible to extend the findings to countries that are not included in any of the studies. The aim of this section is to investigate the consumption patterns of regions around the world and, more importantly, to infer general findings in a global context from the observed results in the case-studies. On that score, the countries examined feature specific characteristics. In order to capture the characteristics of a large country with heterogeneous characteristics concerning geography and urbanity, the studies conducted by Manfred Lenzen for the case of Australia offer a deeper insight into the relationship between consumption and environment. Therefore, it is considered as the focus country in the essay. Similarly, Japan provides a reference of a developed country outside Europe with some remarkable cultural specifics. The representative of a highly developed state in terms of both economy and energy use is Denmark. The paragon of a large emerging economy with a notably "green" electricity sector is Brazil. In addition, being a very unequal country in many respects, the examination of the country offers insightful findings regarding the relationship between income distribution and the marginal propensity to consume. Finally, the representative of developing countries with both low income and energy efficiency is India.

5.4.1. Australia

Lenzen (1998) defines eight clusters of consumption to explore the relationship between CO2 emissions and 'human needs': 'Shelter', 'Food', 'Clothing', 'Care', 'Mobility', 'Recreation', 'Community' and the composite group 'Other'. The paper offers a detailed breakdown of CO2 emission requirements for the four clusters which contribute most to pollution by computing the relative share of the product groups that underlie the clusters. Furthermore, it provides comprehensive breakdowns of monetary, energy and CO2 emission quantities into

‘Industries’, ‘Commodities’ and ‘Human Needs’ in order to capture the relative impacts of product groups on an aggregated and disaggregated level. The employed data come mainly from the Australian Household Expenditure Survey conducted in 1993 and 1994, which surveyed 8389 households throughout Australia. According to Lenzen (1998), “the published data contain average weekly household expenditures on 376 commodities, with available breakdowns by 13 household characteristics”.

The breakdowns of the consumption clusters provide a first insight of which product groups are the main contributors to CO2 emissions. In the ‘Food’ group, meat and dairy products are the prevailing causers of carbon emissions. Furthermore, although the physical amount of fruit and vegetables consumed is equally high, their contribution share in the group is only 10%, i.e., less than a third of meat and dairy products. In ‘Shelter’, the product groups ‘fuel’ and ‘power’ contribute most, whereas electricity alone accounts for more than 40%. The high impact is due to the energy-intensive electricity generating sector, which relies mainly on coal as domestic resource. Breaking down the CO2 emission requirements of the ‘Mobility’ group, it is remarkable that the vast majority is assigned to private vehicle use, mainly due to gasoline. In the ‘Recreation’ group, about half of the emissions emerge from holidays both domestic and oversees. On closer examination, the study reveals that 75% of the CO2 emitted in holidays occur during transportation. 28% of the emissions in the ‘Recreation’ group are caused by air transport. This finding reflects the geographical characteristics of Australia. As a country both very large and remote, the lack of substitutes for air transport leads to a considerably high contribution of the aviation sector to CO2 emissions. According to the Australian Bureau of Infrastructure, Transport and Regional Economics, more than 7 million air passengers traveled merely between Sydney and Melbourne in 2011. The flight schedule comprises around 90 connections daily for this route alone, making it one of the busiest worldwide.

The papers introduced earlier studied the trajectories of CO2 emissions during the income growth process. In most cases the relationship was reported to be positive, yet with a declining MPE. These cross-country studies provide an aggregated view, whereas the studies of this section offer a deeper insight into the MPE-characteristics by breaking down carbon emissions into product groups on a highly disaggregated level. In all countries examined, consumption goods can be classified into necessities and luxuries, according to the corresponding income elasticity of demand. The former is subject to saturation, which leads to a declining share in the consumption basket, whereas the share of the latter increases with rising incomes. In the case of developed countries like Australia, the major part of the necessities causing a high amount of CO_2 emissions belongs to the group of products where emission occurs directly, i.e., during consumption. In the indirect group, the majority of the CO_2 intensive goods class among the luxuries, which are relatively income elastic. Since the direct group contains principally energy goods and the indirect group mainly services and commodities, it is evident that the average energy intensity of the products belonging to the direct group exceeds the intensities of most products clustered in the indirect group.

Combining the above-mentioned findings, the assumption of a declining MPE appears plausible, at least for developed countries. This relationship is to be examined by exploring the consumption patterns of six different countries. In the case of Australia, Lenzen (1998) finds that the overall growth of energy expenditure while consumption expenditure increases is assigned mainly to products of the indirect group. Comparing the relative energy expenditures to other countries, Australia shows a higher share in the 'Mobility' group than countries like Germany or The Netherlands. This reflects the fact that due to geographical factors, citizens of basically all income groups rely on car use more than in many European countries. Comparing the average CO_2 emission intensity of the 'Mobility' group among the income distribution, the paper reveals a slightly negative relationship. Furthermore, the household's average consumption expenditures of CO_2 emissions increase considerably with income, however not mainly due to the contribution of the 'Mobility' group. These findings are remarkable and unique within the countries examined. They basically state that relatively wealthier households do not have a significantly higher demand for gasoline, which is clearly not the case in most other countries. In fact, the emergence of the 'scale effect' in most countries, leading to rising CO_2 emissions with increasing income levels, is to a major extent due to increasing mobility, specifically more private cars. In Australia, this does not seem to have a substantial impact. Furthermore, the slightly falling average energy intensity in the 'Mobility' group with income runs counter the circumstance observed, e.g., in Europe that richer households on average tend to buy larger cars with higher gasoline consumption and thus CO_2 emissions. For Australia, it can be conjectured that poorer households own less expensive and therefore older cars with less energy-efficient combustion engines.

In Lenzen et al. (2006), the average expenditure elasticity of energy requirements is found to be 0.78, thus supporting the assumption of a declining MPE for the case of Australia. In fact, overall energy intensities decrease towards higher consumption expenditure levels, because the share of typically less energy-intensive services increases when a household becomes wealthier. According to Lenzen (2004), outstanding single components with regard to CO_2 emissions are gasoline for cars, household electricity, and holidays involving air transport as well as meat and dairy products. Compared to others, these consumption goods have both a relatively high energy and CO_2 intensity and claim a relatively high share of household expenditures. With respect to income distribution, it appears that the overall expenditures of rich households concerning these products increase with higher revenues, though not overwhelmingly. Furthermore, two effects partly offset this scale effect: First, the weighted average energy and CO_2 intensity of the mentioned products decline with income, mainly due to the 'Housing' group, which reveals that electricity consumption, being a necessity, is strongly subject to saturation. Second, as it was stated in the 'Shortcomings' subsection, the study assumes that energy requirements of product groups increase proportionally with their purchase price. Since it can be assumed that wealthier households on average purchase more expensive versions of the same product groups, especially in the 'Food' group, the obtained results for the overall energy requirements of rich households might be overestimated. On the whole, however, households with higher incomes consume more carbon emissions, not least due to the 'Recreation' group: The results show a rising energy and CO_2 intensity after a turning point around AU$10,000, which can be ascribed to the income elastic demand for air transport of the Australians.

In the same study, Lenzen (2004) examined the fixed effect of urbanity, dividing the observed regions into 'Metropolitan', 'Urban' and 'Rural'. He finds that energy expenditure increases with urbanity, however, to a lesser extent than the average revenues do. Correspondingly, the average energy intensity decreases with urbanity, reflecting that the share of energy-intensive goods is higher in rural areas. The driving groups of this finding are 'Shelter' and 'Mobility' whereas other groups like 'Food' or 'Recreation' do not seem to vary significantly with respect to population density. It can be argued that the 'Shelter' group is more CO_2 intensive in rural areas because of the higher share of detached houses compared to the more energy-efficient apartment buildings. In the case of 'Mobility', the results show a non-monotonous relationship with respect to density: Urban areas show a lower energy intensity than metropolitan areas, and an even lower than rural areas. For the 'Mobility' group it may be reasoned that towns may have intra-urban public transportation systems and rather short commuting distances, whereas workers in metropolitan areas, whose dwellings are often located in far-flung suburbs, commute much longer. Finally, the lack of substitutes in non-urban areas due to the absence of public transport services, plus the relatively long distances between neighbor villages in rural Australia give rise to higher energy intensities in consumption goods belonging to the 'Mobility' group. Although in both 'Metropolitan' and 'Rural' traveled commuting distances may be high, it should be recalled that due to the metropolitan households being on average richer than the rural ones, the mean energy-efficiency of private vehicles fleet in metropolitan areas is presumably better than the fleet of rural areas. In other words, driving the "average car" of Sydney or Melbourne requires less energy per kilometer than the corresponding one in the Outback. This hypothesis is not based on empirical evidence; however, it is supported by the obtained results. Finally, household size does not vary considerably between urban and rural areas. It appears that energy requirements of the households do not increase proportionately with the number of household members. In fact, including additional members into a household does not even show a significant rise in energy and CO2 intensity. Thus, it must be concluded that the range of commodities purchased does not increase in the same proportion. It can be reasoned that larger families mostly share commodities, e.g., lightings and vehicles, and hence inflict less environmental impact (Lenzen, 1998).

5.4.2. Brazil

In the case of Brazil, a study conducted by Cohen et al. (2005) addresses the household energy requirements in the largest economy of South America. This country is taken as proxy for a strongly emerging economy with increasing income inequality. For reasons of data availability, the study restricted the ambit to 11 capital cities, i.e., the largest metropolitan areas of Brazil. For that reason, implications concerning urban-rural discrepancies cannot be drawn. However, as the cities feature both emerging household incomes and income distribution, the study provides information about how environmental degradation and inequality interact in a large, growing economy. The survey lists expenditure on 112 consumer items of 16,014 households. The items are decomposed into 12 clusters; in order to address inequality, the households are broken down into income deciles.

The most striking difference to Australia and the majority of developed countries is that the expenditure elasticity of overall energy requirements tends to slightly exceed one (Lenzen et al., 2006). Since it can be assumed that energy intensity (MJ/$) is strongly correlated to CO2 emission intensity (CO2/$) and other degrading activities, it is conceivable that the elasticity of emitting CO2 is above one, i.e., the MPE in the case of Brazil appears not to be a declining, but a slightly increasing function of income. Cohen et al. (2005) provide a more profound insight into the expenditure elasticities by a breakdown into consumption groups that contribute to a large extent to CO2 emissions, and compares the results across the 11 capital cities examined. The elasticity estimates are above 1 in all cities for the groups 'Shelter' and

'Mobility'. Considering the overall expenditure elasticity, the results across the cities show an ambiguous picture, i.e., for all consumption categories the obtained expenditure elasticities of energy requirements are not significantly different from 1. This finding supports the assumption that MPE in Brazil is on average constant, thus not changing in income. Second, the high elasticity estimates in the housing and the mobility sector encourage examining those groups in depth. Lenzen et al. (2006) find that the share of expenditures for products assigned to the 'Housing' sector remain relatively constant across income groups. Since the climatic conditions in most metropolitan areas of Brazil do not entail considerable heating costs, the most important contributor to CO2 emissions, i.e., combining carbon intensity with quantity purchased, is not considered to be electricity. Being rather unusual for an emerging economy, the Brazilian electricity generation consists to a prodigiously large extent of renewable energy sources, particularly hydroelectric power. This technology, dominating the Brazilian electricity sector, narrows the adverse impact of economic growth on the environment. Comparing to other emerging countries like China, where the role of coal power becomes larger on a weekly basis, the Brazilian hydroelectric plants are strongly beneficial for the global environment. It can be concluded that the 'Housing' sector is not a principal cause of CO2 emissions, despite the considerable share in household energy requirement.

The principal contributors to CO2 emissions in Brazil are presumably found in the 'Mobility' sector. Cohen et al. (2005) find that this sector accounts for around 18.5% of total consumption expenditure. The authors explain this high share with large commuting distances in the examined Brazilian cities and with the lack of a good public transportation policy. The results show that the demand for fuel in private vehicles increases disproportionately with income. Furthermore, the reason that income elasticity of demand does not decrease even for the highest income levels may be found in air traveling, a consumption good reserved only for the highest incomes in Brazil. In sum, the 'Mobility' sector appears to be a principal contributor to CO2 emissions, mainly because of a relatively clean electricity generation and climatic conditions that do not require households to devote large expenses for heating. It can be concluded that if the MPE is a rising function of income in Brazil, it is due to the relative dominance of the 'Mobility' sector in energy requirements, although energy intensity for this sector does not necessarily deviate from the situation in other countries in absolute terms. In terms of inequality, the progressivity of fuel consumption supports the idea that redistributive policies might be beneficial in terms of carbon emissions. Considering the consumption distribution of all goods examined, the picture is ambiguous. However, since the relationship between per capita income and propensity to emit CO2 is not concave, it appears that measures aimed to mitigate the ever-growing inequality in the country would not exacerbate global warming.

5.4.3. Denmark

As an open, industrialized country with a high human development index, Denmark operates as proxy for a typical Western European country. Munksgaard et al. (2000) analyzed the change in consumption behavior of Danish households over time. Using decomposition analysis, the authors examined the factors affecting the trajectory of CO2 emissions from 1966-1992, including 66 commodities, covering 117 production sectors and with a special emphasis on the partial impact of groups causing emissions directly and indirectly.

With respect to direct and indirect energy consumption, the across-country study of Lenzen et al. (2006) shows that both increase with expenditure. However, a marginal consideration detects substantial differences between the two groups: Direct consumption increases with expenditure strongly under-proportionately and indirect consumption closely, yet also less than proportionately. The former finding can be explained by the saturation effect in typically energy intensive goods like fuel, whereas the growing variety of commodities like household appliances led to an increase in luxury goods, which mainly belong to the indirect group where the saturation effect is still to arise. Therefore, high income households have on average a lower share of energy intensive goods, which explains the overall under proportionate growth. Thus, it can be assumed in the case of Danish households that MPE is declining with consumption expenditure. The most striking result in the study by Lenzen et al. (2006) is that differences in education and employment status seem not to influence consumption expenditures. Unlike in the majority of developing and emerging countries, education in Denmark accomplishes the characteristics of a public good almost entirely. This finding highlights that education, which is strongly correlated to revenues, does not have to imply higher per capita CO2 emissions as the positive relationship between income and emission rates would suggest.

Munksgaard et al. (2000) explored data between 1966 to 1992 to examine long term trends concerning consumption patterns, CO2 emissions and their interaction. They found that in the considered time period, consumption increased by 58%, whereas emissions rose only by 7%. This astonishing finding is caused by a variety of major trends that can be observed in numerous developed countries. First, growth in consumption has been partly offset by conservation measures in the energy intensive sectors. Second, energy-intensive industries have been outsourced to other countries, leading to a higher share of the relatively less energy intensive services sector. Third, substantial improvements in energy intensity were achieved due to public funding. Forth, after the oil price shock, emerging political concerns about the reliance on fossil fuels gave rise to subsidies in order to transform the energy supply – an ongoing process down to the present day. In fact, Denmark invested in the wind power development as of the 1970s. Finally, due to the emerging saturation effect, mostly in the case of energy-intensive goods, the vast majority of growth in consumption was assigned to indirect energy consumption, lowering the average CO_2 intensity of goods purchased in Denmark.

The fact that emission growth due to increasing consumption has been remarkably cushioned by conservation efforts appears even more astounding when considering the change in consumption patterns over the observed time period. Despite of the fact that consumption goods on average decreased in CO_2 intensity, the country witnessed a rise in mobility consumption of almost 40%. In fact, the increasing demand for transportation may cause emissions that foil the mitigation efforts. According to Munksgaard et al. (2000), controlling private transport is one possibility to respond to climate goals. However, measures in other sectors, like food production or electricity generation, may contribute, too.

5.4.4. India

Being one of the fastest growing regions worldwide, the Indian subcontinent is supposed to be one of the most crucial regions worldwide in terms of environmental development. India represents a developing, yet strongly growing economy not only in relative, but also in absolute terms. For instance, from 1983-1993, the population of the country increased by the tremendously large amount of 150-170 million. In other words, the number of Indians increased per year twice the current Swiss population. In fact, according to growth rate forecasts, India will soon be the most populous country in the world, and having an annual economic growth rate between 7% and 9%. In view of these facts, the further development path of countries like India is crucial for environmental prospects. Changes in behavioral patterns of consumption and in energy intensities may certainly give rise to considerable impacts on environmental degradation. Against this background, mitigation efforts of both the public and private sector might lead to staggering adjustments in the worldwide CO2 emissions trajectory.

Pachauri and Spreng (2002) were the first to examine energy requirements of different household consumption categories in India. Using input-output analysis, they disaggregated the available data to 100 sectors, including non-commercial energy. The authors found that the Indian household's energy requirements on a per capita level are 7-10 times lower than in most industrialized countries. Furthermore, in the examined time period from 1983 to1993, an overall 43% increase in real household expenditures per capita came along with an 8% increase in per capita energy requirements. This implies an expenditure elasticity of around 0.19. Lenzen et al. (2006) find an elasticity of 0.86. The large difference might be explained by the fact that Pachauri and Spreng (2002) considered a longer time period and included other sectors using three input-output tables instead of one like Lenzen et al. (2006). Regarding the development over time, the Indian MPE appears to be declining with expenditures. Unfortunately, none of the two studies examines the time-fixed MPE across income groups. Thus, it cannot be assessed whether the propensity to emit CO2 really increases under proportionately with income or whether the data merely illustrates a trend.

Pachauri and Spreng (2002) analyzed the energy intensity of key Indian sectors which are considered to be the main contributors to CO2 emissions. They found that over the 10-year period, the energy intensity decreased on average. However, a considerable increase is observed mainly in the food and agricultural sector. This can be explained to a large extent by the growth of energy use in agriculture. In fact, electricity use for agricultural purposes was subsidized, which seems a plausible consequence of the rapid population growth. The increasing usage of fertilizers in the time period might be due to the same development.

In contrast to intensity, the average energy requirements increased by 8% from 1983 to1993. The authors distinguish between energy requirements causing emissions directly and indirectly, whereby they further differentiate between commercial and non-commercial direct energy requirements. The results indicate that the commercial direct and the indirect requirements grew and partly substituted the non-commercial energy group, which declined over time, but is still the dominant energy source especially in rural areas. The slight increase in energy requirements compared to the household expenditures can, to a large extent, be explained by the drop in energy intensity. The reasons are given by a breakdown of the aforementioned groups to the underlying energy carriers. On the one hand, relatively energy-intensive coal and lignite were substituted by petroleum products and electricity. In fact, the share of areas connected to the electricity grid has been rising remarkably during that time period and is still an ongoing process. On the other hand, the use of energy-intensive non-commercial energy sources, especially in rural areas, decreased. In terms of CO2 emissions, this tendency is not necessarily an advantage. Traditionally, rural areas in India used mainly fuelwood and other biomass as principal energy sources (Pachauri, 2004). The progressive substitution of these renewable energy sources by fossil fuels, either directly due to petroleum products or indirectly due to electricity, which is generated in thermal power plants, may exacerbate global warming.

The authors find that not only the energy intensity increased in the 'Food' sector, but it also witnessed the largest absolute increase in energy requirements. The share of the 'Food, beverages and tobacco' category of total consumption expenditures in India increased over 40% during that time period. Furthermore, the authors suggest that the category will further grow and eventually exceed 50% of total energy requirements in Indian households. The anomalous trend that the average energy intensity appears to increase in the food sector over time, combined with the growing importance of that sector in terms of consumption gives 'Food' an especially important position in the Indian economy. Although the share of 'Transport' and 'Communication' experienced an increase in total energy requirements as well, it appears to have had a minor significance in environmental terms compared to the 'Food, beverages and tobacco' category. The process of mass mobilization, like observed in Brazil, is yet to come in India. It can be therefore concluded that the emphasis concerning CO2 emission mitigation measures should lie mainly on the 'Food' sector, with a second focus on the electricity and the transportation sector.

5.4.5. Japan

Representing a large, industrialized country in Asia, the results of Lenzen et al. (2006) for Japan show similar consumption and behavioral patterns like for other developed countries. However, some specific characteristics and emerging trends have implications for the environmental impact of the country: The Japanese are an example of an ageing society which is met throughout the world, mainly in industrialized countries. According to the Japanese Statistics Bureau, the total fertility rate did not exceed 1.4 in the last ten years, leading to a net rate of reproduction of less than 0.7. Weil (2009) defines the net rate of reproduction as the number of daughters that each girl can be expected to give birth to, assuming that she goes through her life with the mortality and fertility of the current population. Since this measure has been significantly less than 1 for a longer time, it can be expected that the Japanese population will considerably decrease in the future, unless substantial net immigration occurs.

Furthermore, the changing demographic structure will lead to a substantial rise in the share of elder citizens.

This fact has important implications for both inequality and environmental degradation via changing consumption patterns. Although the empirical results of the study conducted by Lenzen et al. (2006) do not consider 'age' as a statistically significant variable with respect to energy requirements, there appears to be a rather positive than negative correlation. It can be argued that 'age' and 'expenditure' are positively correlated, and the latter, in turn, is significantly correlated to energy requirements and thus CO2 emissions. This can be expected since more expenditure enables more energy requiring consumption on the one hand, and higher ages on average come along with higher revenues. According to the authors, 'age' has a positive impact on direct energy consumption and a negative impact on transportation. More concretely, the elder Japanese tend to consume more energy for heating and air-conditioning, but less for mobility.

In the context of an ageing society, the structure and size of households become crucial in terms of environmental degradation. As was shown at the example of Australia, energy requirements do not increase proportionally with household members, because commodities like heating and lightning can be shared. Assuming that in an ageing society the average household size becomes smaller due to a smaller share of family households, rising per capita energy intensity in the housing sector might be a consequence of losses in economies of scale (O'Neill and Chen, 2002). However, in the unique case of Japan household size does not tend to have a negative relationship with total energy requirement. Lenzen et al. (2006) reason that in most Japanese households heating and air conditioners are not centralized, but installed for each individual room. As a relatively wealthy population, most households afford separate equipment for each member, including bathrooms, televisions and other consumer electronics. Eventually, the ageing Japanese society may have less adverse effects on the environment due to household structure as it would be expected considering the evidence in most countries. Nonetheless, some other consequences of different lifestyle might influence energy requirements. According to the authors, whereas energy requirements in urban houses are relatively small due to typically small floor areas in Japanese apartments, traditional houses in rural areas are very open to the outdoor environment. The conjecture that the share of employed citizens is larger in urban areas and the share of the elderly in rural areas, the current demographic trend may imply increasing per capita energy intensity for housing, assuming that the retired prefer to settle down in the countryside. Furthermore, assuming that jobholders, being most of the time outside of their home, consume less heating, air conditioning and cooking than the retired could be a further reason that the ageing Japanese society might increase the adverse effect of the housing sector on the environment. On the other hand, since the demand for transportation and, thus, private cars is higher for working commuters, the adverse effect caused by this sector may decrease in Japan.

Combining the demographic trends, the country-specific characteristics of Japan will presumably have considerable distributive implications. The expenditure elasticity of energy requirements was estimated 0.64, using data of around the year 2000. This amount is lower than in the other countries the authors have examined. This implies that MPE is declining even stronger in expenditures. Furthermore, the estimated expenditure elasticity of the direct energy requirements, containing the key factors fuel and electricity only, is on average 0.434. These values are in line with the findings of comparable countries: The propensity to emit CO2 increases under proportionately with consumption expenditures, and the elasticity of direct energy requirements is generally lower. This is because the underlying product groups are subject to saturation more than luxury goods which are mainly assigned to the indirect group, at least in developed countries. However, considering the prospects of demand patterns in the Japanese economy, these could entail a particularly unpleasant trade-off between inequality and environmental quality. In order to smooth income distribution, there will be no way around the financial reinforcement of the national pension system. If the elder citizens have on average larger energy requirements due to higher demand for energy-intensive goods like heating fuel or electricity, redistributive efforts might exacerbate global warming in the future. Therefore, environmental policy in Japan should consider the prospective needs of the ageing population and focus on mitigation strategies which address the demand patterns of the prospective largest share of the population.

5.4.6. Spain

A decomposition of the propensity to emit CO2 was conducted by Duarte et al. (2012). Using household expenditure and demographic data from 1999, the authors examined the underlying factors of a declining MPE, which is observed in Spain as in many other countries. Combining energy intensity of commodity groups, income distribution of households and consumption patterns, the following findings emerge: Urbanity, population density, education, social class and monthly household income are positively correlated with CO2 emissions. However, since the variables are mutually correlated, their partial contribution remains ambiguous. In addition, the direct emissions account for less than 20% of total emissions per capita. According to Duarte et al. (2010), this can be explained, to a large extent, by the increasing spending on fuel for private vehicles. The reason for this outcome is not clear-cut, because even though Spain has a rather low population density overall, the majority of the population is clustered either in metropolitan or coastal areas. The inner land is relatively sparsely populated, apart from major cities like Madrid and Zaragoza. Therefore, it cannot be necessarily concluded that high car use has mainly geographical or infrastructural reasons, as it can be seen in Australia. Rather, it may be conjectured that cultural aspects play a considerable role, too. According to Eurostat, the relative number of private vehicles is disproportionately high in Spain. Considering that, on the one hand, commuting distances are not significantly longer than in other European countries and that, on the other hand, public transportation is well developed in most urban areas, it can be assumed that car ownership is an important part of the Spanish lifestyle. This 'can support the idea that, generally, cultural characteristics and consumer habits may influence the emissions level and the propensity to emit; that is, the behavioral patterns of a region in terms of environmental degradation are not solely defined by endowments.

6. Cross-country analysis: implications and policy recommendation

Regarding the specific characteristics of countries, a number of similarities and deviations emerge. Considering the relationship between inequality and CO2 emissions, the key indicator is the MPE. Before exploring the consumption patterns within countries, the only insight was provided by studies that mainly conducted correlation analysis in an aggregated view, showing a non-linear, yet ambiguous relationship. However, the across-countries studies, introduced in earlier sections, did not take into consideration that the origins of pollution may lie with different country specifics. This section has shown that consumers' demand patterns caused by country-specific characteristics may, to a considerable extent, explain what underlies the emissions development path. The first main implication of this section is that the data does not support the hypothesis of a single, uniform relationship between household expenditure and energy requirements across countries; regional elasticities of demand vary due to different endowments (Lenzen et al., 2006). This finding can be related to the earlier mentioned study conducted by Vincent (1997). The author argues for the case of the EKC such that a possibly found shape of the relationship with cross-sectional data is not due to individual countries being at different points of the same trajectory, but that the outcome reflects the juxtaposition of different trends. Furthermore, it may be not excluded that time effects, reflecting global trends, explain the obtained relationship better than time-fixed studies across countries.

Whether the MPE is a rising or declining function of income cannot be answered in general. Instead, it was shown that it strongly depends on the consumption patterns of the considered region. The main driver of the MPE trajectory is the income elasticity of demand. In fact, demand elasticities and the emergence of saturation effects influence the propensity to emit CO2 to no lesser extent than the induced policy responses, whose mechanisms are referred to as the "political economy effect". It is not possible to determine whether changes in consumption are due to demand patterns, or whether the induced policy responses are the stronger driver of the MPE in general. Eventually, it may depend on the clout of the public sector.

Comparing the 'aggregation effect' with the 'political economy effect', Heerink (2001) finds that the former runs counter and tends to outweigh the latter in the case of CO2 emissions. The main reason is that the propensity to emit increases less than linearly with income. This is in accordance with the results found in consumption pattern studies. With a few exceptions like Brazil, the MPE was generally declining in income. This also implies that redistribution will exacerbate global warming. When revenues are transferred from above-average income households with a relatively low MPE to households with a higher MPE at the lower tail of income distribution, CO2 emissions will presumably increase. As the country case-studies reveal, this is mainly due to the fact that poorer households tend to purchase more energy intensive goods which are subject to saturation only at an income level well above their current situation. Depending on the country considered, the product groups may differ: Citizens buy food in India, private vehicles and gasoline in Brazil. Furthermore, in the case of developed countries, revenue improvements through transfers may be partially invested even for purely luxury purposes, e.g., holidays including air travel in Australia.

According to these findings, one has to conclude that redistributive efforts can exacerbate global warming. Considering the discussed paper of Ravallion (2000), the static trade-off between inequality and carbon emissions might be curbed in the long run due to the mentioned beneficial interactions between economic growth and income inequality. However, reconsidering the properties of time preference, which was put forward by Boyce (1994), the optimistic hypothesis of Ravallion (2000) might be correct in theory but may fall short in real politics. The majority of prevailing political systems incentivize politicians to put the emphasis on rather short- and medium term objectives for the sake of re-election. Therefore, the politicians may be reluctant to implement measures against environmental degradation with large adverse effects on short term economic well-being, unless the citizens themselves vote in favor of the bill. In fact, more promising results could be achieved with a bottom-up mitigation strategy, considering how CO2 emissions could be mitigated both most effectively and most cost-efficiently. The optimal strategy depends on consumption patterns and behaviors, the availability of substitutes and income elasticity of demand, and not least the country-specific endowments. Put another way, the effectiveness of pollution mitigation is deviant across countries, thus it is crucial to take the insights of decomposition analyses in country case-studies into consideration when providing policy recommendation.

The key indicator to consider is the average energy intensity of a product group, combined with the aggregate quantity consumed annually by the citizens. Examining the evidence across countries, two principal sectors emerge as key CO2 emitters. On the one hand, the carbon intensity of the electricity generating sector explains to a large extent the per capita consumption of CO2 emissions. This is due to the fact that electric current is used for a myriad of purposes: Households consume electricity directly through the socket and indirectly by demanding commodities, for which electricity is required in the production sector. Thus, depending on the degree of reliance on fossil fuels of the electricity generating plants, per capita CO2 emissions can vary substantially. On the other hand, the demand for mobility gives rise to high fuel consumption which is considered a major cause of global warming. The more dominant contributor of the two is determined by country-specific endowments and demand elasticity structures, giving rise to different implications. Applying the findings of the country case-studies, the following section discusses possible policy measures aiming to mitigate CO2 emissions. The outcomes are not to be considered as a panacea for the country addressed, rather they should reflect how different characteristics may give rise to varying optimal policy responses for any region in a comparable initial position.

6.1. Reliance on fossil fuels: The electricity sector in Australia

In the case of a wealthy country like Australia, it is important to distinguish between necessities and luxury goods, since products belonging to both categories are consumed abundantly. When taking measures to reduce CO2 emissions, it is crucial to take distributional effects into consideration. The most striking characteristic of the country is its tremendous reliance on coal. According to the Australian Department of Resources, Energy and Tourism, more than 75% of the generated electricity originate from coal-fired power plants, making electricity one of the most CO_2-intensive products in the commonwealth. Obviously, a large amount of emissions might be avoided when the share of brown and black coal in the electricity mix would decrease, e.g., through substitution with power plants deploying renewable energy sources. Although the share of wind and solar power are low at the present, these technologies promise large potential in the country. Against the background of dropping prices for wind turbines and photo-voltaic systems, the Australian public sector already encourages the diffusion of renewables with feed-in tariffs, yet there is scope for widening incentivization (Zahedi, 2010). Electricity being predominantly a necessity good, instead of penalizing consumption by taxation, it is generally more favorable to reward endeavors for a more sustainable production. A power bill add-on in the form of a proportionate carbon tax would have a regressive effect, i.e., poorer households would carry a relatively higher burden because the share of electricity to total consumption is larger than for richer households due to the fact that electricity as a necessity is strongly subject to saturation. Decreasing reliance on coal in Australia is bound up with at least two obstacles: First, the central power grids have to be transformed into a decentralized smart grid, allowing local plants to feed in electricity, the generation of which is fluctuating. Second, the emerging opposition of pressure groups like the Australian Coal Association may impede the development. Thus, the support of a majority at a political level is inevitable. These fundamental features apply to all countries that aim to convert their domestic electricity sector towards a more sustainable energy supply.

6.2. Emerging mobility demand: transportation in Brazil

In the case of Brazil, the main contributor to environmental degradation is found to be the transportation sector. The reason for the uniquely dominant position of mobility in pollution terms is the relatively 'green' electricity sector, relying mainly on hydro power. Since the marginal propensity to emit CO_2 in transportation remains high even for the highest income deciles (Cohen, 2005), it can be assumed that an implemented carbon tax on the sector, including fuels for private transport and air travel, would be of a progressive nature. Emphasis in the Brazilian environmental policy should therefore lie on decreasing the adverse impact of growing demand for mobility on the environment. A possible policy measure in a country with 'Brazilian' characteristics could be a redistribution system, as already introduced in a number of European countries. The main purpose is to shift the modal share towards more environment-friendly means of transportation. This implies taxing energy intensive mobility and employing the revenues to subsidize less carbon intensive forms of transportation. Taxing the use of private vehicles with combustion engines can be conducted in several ways. For instance, fuel consumption can be taxed directly. This measure, which is already in force in most countries, is efficient since it taxes consumption linearly. Furthermore, it creates incentives to save costs by reducing consumption. A second possible mitigation strategy is the implementation of a bonus-malus system for the purchase of private vehicles. The emphasis lies on giving incentives to prefer energy efficient vehicles, with a net tax for cars with above-average carbon emissions and a net subsidy for cars with below-average carbon emissions. Brazil has already implemented a property tax on motor vehicles which has to be paid on an annual basis. According to the Brazilian Ministry of finance, the amount is a percentage share of the value which can vary across the municipalities.

The main objective of taxation should be to decrease traffic congestions and to increase the capacity of the public transportation systems. Considering the increasing income inequality in the Brazilian society, it is crucial that measures to mitigate pollution avoid regressivity. In other words, an environmental tax should not burden poorer households relatively more than wealthier households. In the case of the transportation sector, this does not currently seem to be the case. Whether the progressivity could be retained after further economic growth and behavioral responses by consumer demand is to be forecasted before implementation. Eventually, a mix of the above-mentioned measures might mitigate the adverse impact of the growing economy on the environment in Brazil to a considerable extent.

6.3. Demographic challenges: the ageing society of Japan

Most of the developed countries are going to face tremendous demographic changes in upcoming years. The total fertility rate dropped significantly after the period of the 'baby boomers' following the Second World War. According to Eurostat, in almost all European countries the total fertility rate has been significantly below the replacement fertility rate for more than a decade, implying that the population will decrease and the share of retired citizens will increase. The unstoppable development of a greying society entails serious challenges particularly for the Japanese society. Having one of the highest life expectancies at birth in the world, the fertility rate is as low as only in a few other countries. At the same time, the aforementioned study of Lenzen et al. (2006) revealed that the MPE is substantially declining in consumption expenditures. The fact that the energy requirements of the elder population in Japan are mainly based on demand for relatively carbon intensive heating and air conditioning, the aging of society will presumably give rise not only to distributional issues, but also to environmental challenges. Therefore, climate change mitigation policies of countries like Japan should put their focus on the consumption patterns of the retired. In particular, the electricity supply – mainly relying on fossil fuels – needs to be transformed in order to decrease its carbon intensity. In the context of the recent nuclear reactor accidents, this endeavor is a strongly controversial issue. A second emphasis should be laid on measures regarding energy efficiency. Specifically, there is large scope for enhancements in the Japanese building sector. According to Lenzen et al. (2006), the Japanese dwellings are usually not well isolated. Eventually, mitigation efforts in this sector might contribute considerably to the attenuation of the adverse environmental impact of the changing demographical structure in Japan. Again, this phenomenon is present in almost all developed countries. Therefore, the demand patterns of pivotal demographic groups have to be taken into consideration in general.

6.4. Growing hunger in the developing world: The agricultural sector of India

In contrast to the ageing societies observed in industrialized countries, most developing countries experience a strongly increasing population size. Even though the fertility rates tend to decrease over time in the majority of poor countries, it is estimated that population growth will continue throughout current century at the least. The predominant part of this growth will take place in regions where the largest energy requirements are assigned to the agricultural sector. The case of India is a perfect example of this development. According to recent data from the World Bank, the Indian total fertility rate has been declining fairly constantly for the past 30 years: From 4.7 in 1980 to 2.6 in 2010. Even if the country is assumed to arrive at the replacement fertility rate of 2.1 in the foreseeable future, population growth will continue for several decades until an equilibrium population level is reached (Weil, 2009). This finding applies to the majority of the developing countries, whereas the total fertility rate of most of them is significantly higher than in India, as the latest data from the World Bank show.
In this context, the environmental impact of food production will play a key role in climate change policy. The study conducted by Pachauri and Spreng (2002) shows that for households in India the 'Food' category makes up almost half of the indirect energy requirements. Furthermore, due to a substantial rise in energy intensity during the considered period mainly in the agricultural sector, food production today leads to higher carbon emissions not only in absolute, but also in relative terms. The authors found that the combination of the indirect energy needs and direct energy requirements for cooking comprised about 60 to 65% of total

energy used by an average household in India. Therefore, the most effective mitigation strategy would lie in increasing the energy efficiency in both food production and preparation. In the case of the former, the current subsidy policies in the agricultural sector could be shifted from electricity use towards more sustainable cultivation techniques, e.g., encourage the use of appropriate fertilizers and pesticides in adequate quantities, together with conservation measures. In the case of the latter, the authors suggest promoting the use of more sophisticated fuels and cooking appliances. In addition, considering the diminishing role of the mostly renewable non-commercial direct energy sources, it might be beneficial to preserve some traditional forms of energy use. Households employing biomass and wood fuels rely on re-growing resources, contributing to a sustainable energy mix. The substitution by mainly fossil commercial fuels would imply a step backwards. Therefore, encouraging the households to retain traditional consumer behaviors may be beneficial in terms of avoiding environmental degradation. These findings apply not only to India, but to a majority of developing countries that experience a comparable transition process.

6.5. Current trends in highly developed countries: Evidence from Switzerland

The adverse impact of environmental degradation has become a political concern, particularly in the wealthiest countries with a high human development index. Not least, the availability of an excellent public education system fosters the upcoming demand for environmental integrity. The resulting rising awareness gives rise to policy measures in different areas, yet with the same objective: Decreasing the carbon intensity of economic activity.

The availability of a well-developed public transportation system is a key factor in confining CO2 emissions in the mobility sector. In order to shift the modal share away from car use and towards less energy-intensive means of transportation, the public sector may implement a redistribution system: On the one hand, imposing a tax on fuel consumption and, on the other hand, subsidizing the public transport infrastructure with tax revenues. In the case of Switzerland, a 'mineral oil tax' is the duty paid for fuel consumption, while at the same time the state-owned public transportation infrastructure is heavily subsidized. In the discussed case-studies, neither of the authors found evidence that a tax on the mobility sector might be considerably regressive. In fact, employing Danish data, Wier et al. (2005) find that taxes on gasoline tend to be progressive rather than regressive. Since the Swiss demand patterns are assumed to be roughly comparable to the Danish, the 'mineral oil tax' does not appear to imply adverse effects on income inequality due to regressivity.

In the analyzed case-studies, it seems that the main contributor to CO_2 emissions, besides fuel combustion, is found in the electricity sector. As was shown in the case of Australia, even the wealthiest nations often rely on heavily polluting power plants. In order to decrease the dependency on fossil fuels in electricity generation, some countries implemented a feed-in law aimed to encourage private households and firms to install equipment that generates electricity with renewables. This rethinking in energy policy led to a very strong increase in household demand for subsidized solar cells in Switzerland. Due to an annual cost ceiling, a waiting list with over 10,000 applicants emerged soon after the implementation. The lack of a cost ceiling in Germany led to a massive over subsidization of the solar industry, which eventually triggered large price drops due to fast technological progress. In fact, bringing down the market prices of solar panels through innovation, the German mittelstand largely contributed to the worldwide emergence of a solar industry. However, the diffusion of renewable energies has a distributional drawback: The tax burden on electricity is not equally shared by economic agents. First, the energy-intensive industrial sector has to be exempt from taxation, unless the policy makers risk plant closures and mass unemployment. Second, in order to profit from the subsidy program, households need to own land or a private roof on which they can install wind turbines or solar panels. Since the households with relatively lower incomes tend to live rather in apartment buildings in Switzerland, it is conceivable that they will not be able to derive benefit from this program. Similarly, most of the municipalities sponsor house owners when they invest in energy efficiency measures like building isolation. Thus, the public support of renewables and building efficiency reaches the relatively wealthier households in the first place, yet the financial burden of the subsidy programs are carried by the whole society. Eventually, the redistributive impact of such public policies should be taken into consideration.

The endeavors to mitigate CO_2 emissions in developed countries entail a rather inconvenient facet: Peters et al. (2011) conducted a study, constructing an annual time-series from 1990 to 2008 of CO_2 emission inventories. In order to differentiate between territorial emissions and emissions based on aggregate national consumption, the authors adjusted the territorial account by computing estimates of the net emission transfers embodied in international trade. These represent the balance of the carbon dioxide emitted to produce goods and services for export minus the emissions of foreign countries in the production process of imported products. The authors found evidence for the assumption that the recent stabilization of CO_2 emissions in developed countries is due to the emergence of rising net emission imports from developing countries. In other words, rich countries tend to outsource carbon intensive production sectors to poor countries, obscuring their still increasing demand for CO2 consumption. The study revealed that, in fact, 24% to 33% of emission growth in developing countries can be assigned to consumption taking place in developed countries. The net emission transfers between the two regions increased from 0.4 Gt. CO2 in 1990 to 1.6 Gt. in 2008. This implies an average growth rate of 17% per year, a value far beyond the general increase in global trade volume during the same period. Furthermore, comparing the consumption-based view of the study with the territorial-based balance, which is generally considered in climate policies like the Kyoto Agreement, the results show a substantial divergence: Whereas the territorial accounts indicate an overall decrease in CO2 emissions of 3% in developed countries between 1990 and 2008, the consumption-based inventories point out that 11% of the growth in global CO2 emissions can be ascribed to the increasing demand in developed countries. In spite of the rising mitigation efforts within the national borders, it is highly likely that Switzerland contributes substantially to this tendency, not least due to the ongoing structural transformation towards sectors that require rather knowledge than energy-intensive factors of production. Concerning the rising emergence of emissions embodied in trade, increasing cross-country income inequality may have strong adverse effects on global pollution. A widening income gap across countries might exacerbate the tendency to consume CO2 embodied in trade: Rich countries wanting to get rid of smokestack industries on the one hand, and poor countries, longing for prosperity and thus accepting even strongly polluting sectors on the other hand. Eventually, the externalization of environmental degradation is not viable on a global level, because the poorest countries today will not be able to replicate the same behavior in the future.

7. Conclusion

This essay has analyzed the interactions between income inequality and environmental degradation, particularly carbon emissions. Considering earlier contributions in the scientific literature, I examined the empirical relationship by means of different subject areas. The first finding was that the obtained results of the studies depend strongly on the area of concentration. Comparing different papers, it appears that some findings derived from the empirical results provide ambiguous, partially even contradictory conclusions.

Around the end of the last century, a multitude of studies were conducted in order to examine the relationship between economic growth and environmental quality. Whereas for some indicators, the authors found the pollution levels decreasing after a certain income level, it seems that the propensity to emit carbon dioxide keeps increasing with growing average income levels, i.e., a turning point has not yet been observed. As a number of studies have revealed, the hypothesis of an Environmental Kuznets Curve does not hold in this case. However, the marginal propensity to emit CO_2 appears to decline with average income in the majority of cases.

The non-linear relationship between income levels and carbon emissions implies that redistributive policies – aimed to mitigate economic inequality – may have adverse impacts on the environment. On the other hand, less inequality was found to be beneficial to environmental quality in terms of political economy: Since a relatively wealthier median voter can be assumed to care more for environmental amenities, policy measures intended for pollution control are more promising in the political process than in highly unequal societies. The two findings, providing contradictory results at first appearance, both explain the observation of a declining MPE: On the one hand, the aggregation effect reveals that income elasticity of demand for CO_2 increases under proportionately with income. On the other hand, the political economy effect proves this evidence by arguing that demand for environmental amenities increases disproportionately with income.

In order to analyze the drivers of the MPE trajectory, I examined the consumption patterns across six countries on four continents in depth. The main finding of this section was that the environmental impact of income and inequality depends to a large extent on country-specific endowments and demand patterns. Besides the usual prosperity indicators, climate, geography, population density and demography are considerable factors in explaining the environmental impact of a region. In terms of product groups, it can be concluded that the main contributors to carbon emissions are found in the electricity, mobility and food sector. Their partial contribution depends strongly on the above-mentioned factors. For instance, a country with relatively 'green' electric power plants will presumably have more pollution caused by mobility. On the other hand, a densely populated region with a well-developed public transportation infrastructure and an energy supply relying on coal might face more environmental challenges in the electricity supply than in the mobility sector.

Considering the findings of the examined country case-studies, at least four major emerging trends affect the impact of income inequality on environmental degradation to a considerable extent. First, the reliance on fossil fuels in electricity generation is an increasing concern, even in most developed countries. Second, the emerging demand for mobility, mainly in threshold countries, is becoming a threatening participant of global warming. Third, the ageing societies in industrialized countries and, at the same time, the strongly growing population in developing countries entail challenges in both environmental and distributional terms. Finally, an annually increasing share of carbon emissions is embodied in trade, leading rich countries to get rid of polluting industries and exposing poor countries to increasing contamination.

The emerging climate policies face various distributional challenges. Depending on income elasticity of demand and the availability of substitutes, policy measures like carbon taxes may have adverse impacts on income inequality. The consequence of the observed MPE declining in income is the regressive effect of taxes on product groups with an income elasticity of demand lower than 1. Therefore, achieving the optimal mix between progressive taxes and regressive transfers remains the main challenge, when managing the trade-off between inequality and environment. In fact, designing both effective and socially acceptable taxes will be the main remedy to counteract environmental degradation in the future.

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