Export diversification and CO2 emissions: an augmented environmental Kuznets curve

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Abstract:

The mitigation of global warming by reducing greenhouse gas emissions has been the objective of successive negotiations and agreements between nations. At the same time, there is a consensus on the virtues of export diversification for the development of less advanced countries. This article investigates the effect of export diversification on CO2 emissions in the context of an environmental Kuznets curve hypothesis in 98 developed and developing countries during the period 1995-2013. Using short-run (system GMM) and long-run (PMG) estimation methods, we find that the environmental Kuznets curve is valid, and that export diversification has a positive effect on CO2 emissions.

Keywords: Export diversification, pollution, CO2 emissions, Environmental Kuznets Curve hypothesis, economic development.

JEL: F.18, O.13, Q.53, Q.56, C.33.

INTRODUCTION

Over the past twenty years, tackling environmental degradation and economic development challenges are two of the greatest concerns in economic debates. Since the beginning of the new millennium, countries have found themselves in a new global context in which the preservation of environmental quality and the fight against climate change and global warming have become priorities. A willingness to reduce greenhouse gas emissions in order to mitigate global warming is the objective of successive negotiations and agreement between UN member states (Kyoto Protocol, COP21 Paris Agreement). However, the ambitious goal may hamper latecomer countries in developing and following the same path as those already developed. To respond to development concerns, international organizations, primarily the International Monetary Fund (IMF) and World Bank, are now agreed on the virtues of economic and export diversification. For instance, they recommend low-income countries to diversify their exports in order to reduce dependency on commodity exports and to stabilize export earnings. However, the consequences of such an export diversification strategy may conflict with environmental priorities. The economic growth strategy for developing countries may or may not conflict with the objective of environmental preservation. This context leads us to question whether such a growth strategy is good or bad for the environment. From that point, this article will attempt to analyze the effect of the export diversification on environmental degradation. Using a panel of 98 developed and developing countries for the period 1995-2013, we derive a general relationship that allow us to answer such a crucial question.

Environmental concerns and economic growth strategy such as export diversification are related to economic development but, as far as we know, they are addressed independently in the economic literature. Some responses to these environmental concerns may be found in the environmental and economic literature. Environmental degradation seems to follow an inverted U-shaped relationship with economic development. Numerous studies, based on the environmental Kuznets curve (EKC)[1] concept, have followed in the wake of the pioneering

[1] The EKC is named for Kuznets (1955) who suggested that inequality rises and falls as an economy follows its development path.

studies by Grossman and Krueger (1993) on the environmental impact of the North American Free Trade Agreement (NAFTA) and Shafik and Bandyopadhyay's (1992) background study for the World Development report. These studies use various indicators of environmental degradation, such as deforestation**,** air and water quality and sanitation. More specifically, the EKC hypothesis suggests that, in the early stages of economic development, pollution increases with economic activity until a threshold income is reached; this rise in income is followed by a demand for environmental quality. The income turning point is then mostly given. For Shafik and Bandyopadhyay (1992), the turning point income for local air pollutant concentration is 3,000 USD and 4,000 USD, while Panayotou (1993)'s turning point income for sulphur dioxide emissions is between 3,800 USD and 5,500 USD and for Grossman and Krueger (1995) the turning point income for different pollutants is less than 8,000 USD. For emissions of CO2, which is one of the main greenhouse gases, large-scale empirical studies have been conducted, whether by country, region or on a global scale (Apergis and Payne, 2009; Guangyue and Deyong, 2011 among others).

The increase in economic scale has two sources: economic growth itself and trade (Copeland and Taylor, 2004). Antweiler, Copeland and Taylor (2001) show that the EKC hypothesis is valid for countries following trade liberalization by attributing the rise in the curve to economic growth driven by capital accumulation and the fall to technological progress. Moreover, the theoretical model and empirical studies divide income growth and trade impacts on pollution into scale, technique and composition effects, as established by other studies (Copeland and Taylor, 1994, 2004; Hettige et al., 2000). The scale effect, which is the consequence of a simple increase in economic activity, increases pollution levels proportionally. The technique effect appears later, when the economy is performing better and leads to greater technological progress by improving environmental quality. The composition effect, finally, reflects the composition of production in the economy, which has a more ambiguous impact on pollution. For a country opened up to trade, there can be two possible impacts of the trade-induced composition effect on the concentration of pollution, depending on the country's comparative advantages as determined by its factor endowment and pollution policy (Antweiler et al., 2001). The factor endowments hypothesis postulates that a high-income country with sufficiently abundant capital will have a comparative advantage in exporting dirty (polluting) goods (Mani and Wheeler, 1998). Conversely, the pollution haven hypothesis suggests that, after trade liberalization, the difference in income between two countries leads to a configuration in which the poorer country will have the comparative advantage in the production of dirty goods because of lax pollution policy (Low and Yeats, 1992; Wagner, 2010). This last concept should be differentiated from the pollution haven effect, which stipulates that stronger pollution regulation in a country impacts the choice of location and the trade flows of polluting industries (Copeland and Taylor, 2004; Levinson and Taylor, 2008). In a North-South configuration with capital mobility and trade costs, Rieber and Tran (2009) add a relocation effect for polluting industries and discuss the efficiency of unilateral or harmonized environmental regulation for global welfare.

However, trade liberalization as experienced by some developing countries has in recent decades given rise to unwanted consequences. Declining terms of trade (Prebisch (1950) and Singer (1950)), the natural resources curse (Auty, 1990; Sachs and Warner, 1999, 2001) and the volatility of export earnings (IMF, 2014) are discussed in the development literature. A solution has been put forward in a number of empirical studies and recommended by the leading international organizations (IMF,2014): export diversification could, it is suggested, stabilize export earnings and contribute to a better macroeconomic equilibrium. Imbs and Wacziarg (2003), who originally conducted the study, show that there is a robust non-linear relationship between production diversification and economic development. More specifically, there is an initial stage in which a country begins to develop and diversify across sectors until a threshold income is reached, at which point the country starts the second stage of specialization. The study has been extended logically to export diversification by others (Cadot et al., 2013; IMF, 2014; Klinger and Lederman, 2004 among others) and the U-inverted relationship still holds. The turning point has been located at 22,500 USD by Klinger and Lederman (2006) and at 25,000 USD by Cadot et al. (2013). Thus, export diversification, at the same level as trade openness, might have consequences for environmental quality.

Recently, a small number of studies have started investigating the effect of export diversification on CO2 emissions. Gozgor and Can (2016) analyze the impact of Turkish export diversification on its CO2 emissions and show a positive relationship. Apergis, Can, Gozgor and Lau (2018), in a study of 19 developed countries, found that export concentration leads to a reduction in CO2 emissions.

To the best of our knowledge, no study has yet examined the effect of export diversification on a large group of developed and developing countries. The question is whether the recommendations of international organizations conflict with the objectives of environmental preservation. Indeed, there would be some economic interest in analyzing the relationship between export diversification or concentration and CO_2 emissions.

As stylized facts, in the empirical literature, the two variables have an inverted U-shaped relationship with economic development. As far as export structure is concerned, countries in the early stages of development will diversify their exports; then, once a threshold income has been reached, the country will begin specializing in specific export products. As far as pollution levels are concerned, the first stage of development is accompanied by an increase in pollution; in the second stage, the country begins to decrease its pollution as it follows its development path. It can be presumed that export diversification is accompanied by an increase of pollution and that export concentration is accompanied by a fall in pollution volume. In both cases, we expect a monotonical relationship for the whole sample: a positive relationship between CO_2 emissions and export diversification, or in other words, a negative relationship between CO_2 emissions and export concentration. It seems, however, that the two directions of changes in export structure are the outcomes of two different forces. Export diversification leads to composition and scale effects in which, apparently, developing countries invest in dirty industries. Conversely, export concentration for developed countries would give rise to composition and technique effects, with firms specializing in goods that use cleaner technologies.

To investigate the facts, this manuscript seeks to contribute to the debate by analyzing the effect of export diversification or concentration on greenhouse gas emissions for countries at different income levels in the context of an EKC. Going deeper, our contribution to the existing literature is twofold. Firstly, by taking the CO_2 emissions as an indicator of the greenhouse gas emissions, we attempt to verify the validity of the environmental Kuznets curve hypothesis as shown by numerous previous studies in environmental literature. Secondly, we want to contribute to export diversification literature by analyzing whether, for poorer and developing countries, a growth strategy such as export diversification, although recommended by international organizations for its benefits, would lead to an increase in level of negative externalities such as environmental degradation and air pollution.

By putting all the countries into a single sample, our aim is to derive a more general relationship. The idea is that we will augment the Kuznets curve by taking into account the level of diversification. The augmented environment Kuznets curve will serve as the basis for an empirical model that can be used to analyze the impact of economic development and export diversification on CO_2 emissions. More specifically, given that we want to investigate the whole of the EKC, we will empirically analyze the impact of export diversification on the volume of CO_2 emissions using data from 98 developing and developed countries for the period 1995-2013. By using short-run (system GMM) and long-run (PMG) estimation methods, together with the validity of the environmental Kuznets curve hypothesis, we find that the effect of export diversification on the volume of CO_2 emissions per capita is positive and robust.

The article is organized as follows. The second section will briefly present the stylized facts. In the third section we will outline the data and methodology used, followed by the empirical results. The final section offers some concluding remarks.

STYLIZED FACTS

In this section, we briefly present the stylized facts pertaining to export structure and CO_2 emissions. The environmental Kuznets curve hypothesis, which links environmental degradation, in the case of CO_2 emissions, to economic development, might be highlighted in our first figure. Figure 1 presents our data from 98 countries over the period 1995-2013 and the scatter plot displays values for the level of the CO_2 emission in tons per capita and the gross domestic product (GDP per capita in constant 2010 USD).

Insert Figure 1 here

Economic development, approximated by GDP per capita, and CO_2 emissions per capita are matched graphically for selected country-year observations that we will use later for the empirical analysis, with the addition of a quadratic trend. The U-shaped relationship is observed. In the first stage, economic development is associated with increasing CO_2 emissions per capita; a second stage then starts in which an increase in GDP per capita is linked with reduced CO_2 emissions. The turning point income seems to be around 40,000 USD. This figure seems to be consistent with the EKC hypothesis. Indeed, in the EKC literature, many studies have focused on the CO_2 emissions as an indicator of environmental degradation and have shown that the U-shaped relationship between economic development and the carbon dioxide is verified. Most of these studies attempt to identify the effects of various variables such as energy consumption, trade and urbanization within an environmental Kuznets Curve context (Ben Jebli et al., 2015a, 2015b, 2016; Bilgili et al., 2016; Cole, 2003; Gozgor, 2017; Schmalensee et al., 1995; Wang, et al. 2015 among others). Douglas and Selden (1995) emphasize a nuanced result in their study: they show that as the country get richer, there is a diminishing marginal propensity to emit carbon dioxide, however, the global emissions of carbon dioxide keeps growing at an annual rate of 1.8 percent. In the empirical literature, the EKC has been tested for different pollutants and greenhouse gas emissions, as noted in the introduction, and turning points are found (Grossman and Krueger, 1995; Panayotou, 1993; Shafik and Bandyopadhyay, 1992). More specifically, emissions of sulfur dioxide are the other commonly used indicator for measuring air pollution: a wide range of empirical studies finds that the EKC hypothesis hold for the Organisation for Economic Cooperation and Development (OECD) countries (Cole et al.1997; Selden and Song, 1994; Stern and Common, 2001 among others)

Focusing now on export structure, numerous empirical studies show a robust inverted U-shaped relationship between economic development and export diversification (Cadot et al, 2011,2013; IMF, 2014; Klinger and Lederman, 2004). To measure export diversification, we choose to calculate the Theil index for every single country-year observation due to its widespread use (Cadot et al, 2011,2013; IMF, 2014). The Theil index is a concentration index; consequently, it is inversely proportional to the degree of export diversification. In other words, for a given country and year, a lower level of the Theil index indicates a higher level of export diversification and, conversely, a higher level of the Theil index shows a weaker level of export diversification. Figure 2 shows a non-monotonic relationship between export diversification and economic development. More specifically, the U-shaped relationship between export concentration and economic development is observed. We can observe the two stages: an initial phase of diversification for the less advanced countries until a threshold income is reached, and a second phase of concentration for the more advanced countries. The turning point income is located at approximately 40,000 USD.

Insert Figure 2 here

When the two curves are put together, it can be seen that export diversification occurs when CO2 emissions are increasing, and that export concentration coincide with a decrease in pollution. From a comparison of the two curves, we can deduce, a priori, a positive relationship between export diversification and CO_2 emissions. In the next sections, to test the relationship, we will analyze the effect of export diversification and concentration on CO_2 emissions for developed and developing countries in the context of an Environmental Kuznets Curve hypothesis, which we call the augmented environmental Kuznets curve hypothesis. Our purpose is to ascertain whether the strategy of export diversification, on which there is a consensus in economic development literature, conflicts with the environmental priorities set by nations. For our study, we will analyze the impact of export diversification (or concentration) on CO_2 emissions for 98 countries over the period 1995-2013.

DATA, SPECIFICATION AND METHODOLOGY

Data

For our analysis, we use annual data from the 98 developed and developing countries listed in Table 1. Following the World Bank classification of countries by income, we selected countries from each group in order to analyze a generalized relationship between CO_2 emissions and export structure. Our study covers the period 1995-2013.

Insert Table 1 here

The variables used are the following: carbon dioxide emissions (CO_2; metric tons per capita); real GDP per capita (GDP, approximated by the GDP per capita in constant 2010 USD). The data comes from the World Bank’s World Development Indicator (WDI). In our study, the CO_2 emissions data is limited to the year 2013 because of the availability in the WDI database. To measure export diversification, we use the Theil indexes (DIV), which measure the concentration of exports. Thus, a positive impact of export diversification on CO_2 emissions will imply a negative sign for the Theil index coefficient. They are calculated annually for each country from the export lines of trade data taken from the CEPII’s BACI database. The BACI database gives bilateral trade flows using the Harmonized System of 6-digit disaggregation and begins at the year 1995, which is the lower limit of our study period. Thus, our study period is limited by the availability of our data. Furthermore, the highly disaggregated data gives us a better measure of the degree of export concentration. The descriptive statistics are reported in Table 2.

Insert Table 2 here

Equation Specification

Our objective is to assess the impact of export diversification in a context of EKC. By matching the two stylized facts, we expect the relationship between export diversification and CO2 emissions to be positive. Our analysis is performed in two stages.

We first check for the existence of the environmental Kuznets curve and then we investigate whether export diversification has an impact on CO2 emissions.

To check the validity of the EKC hypothesis, we follow the model traditionally used in empirical EKC studies:

$$ln(CO2)_{it} = \alpha_0 + a_1 ln(GDP)_{it} + a_2 (ln(GDP)_{it})^2 + \varepsilon_{it} \quad (1)$$

t is the time period (t= 1…T) and i is the cross-section unit of the panel (i=1…N). α_0 is the constant. The variables are transformed into the natural logarithm form. ε_{it} is the error term. We expect the coefficient a_1 to be positive in order to demonstrate a positive relationship between income and C02 emissions and the coefficient a_2 to be negative, to verify the nonlinear and inverted U-shaped relationship, according to the EKC hypothesis.

Secondly, we introduce the export diversification variable (DIV) into the equation:

$$ln(CO2)_{it} = \alpha_0 + a_1 ln(GDP)_{it} + a_2 (ln(GDP)_{it})^2 + a_3 ln(DIV)_{it} + \varepsilon_{it} \quad (2)$$

We expect the sign of the coefficient a_3 to be positive, thus showing a positive relationship between CO2 emissions and export diversification.

To measure the relationship and estimate the coefficients, we use various estimation methods.

Methodology

Taking into account the endogeneity problems that might exist between the variables, we apply the one-step system GMM estimator of Arellano and Bover (1995) and Blundell and Bond (1998) for a linear estimation in dynamic panel data. Indeed, the system GMM addresses the problem of endogeneity by treating each variable as endogenous, which instrumentalizes the variables by their own lag and relaxes the assumptions of heteroscedasticity and serial correlation. The consistency of the GMM estimator is verified by the Hansen J test for the validity of the overidentifying restriction and the Arellano-Bond tests for first-order AR(1) and second-order AR(2) autocorrelation in first differences: the null hypothesis for zero autocorrelation at AR(1) should be rejected and the null hypothesis for zero autocorrelation at AR(2) should not be rejected. The estimator is more efficient when T<N. The GMM model is presented in the autoregressive form:

$$y_{it} = \alpha y_{i,t-1} + \beta'_1 x_{it} + \beta'_2 x_{it-1} + \eta_i + \nu_{it}$$

We apply the panel unit root tests and cointegration tests and if the long-run relationship is observed, we run the pooled mean-group (PMG) (Pesaran et al., 1999) model which is based on an ARDL (Autoregressive distributed lag) model and estimates long-run coefficients when the variables are cointegrated. The PMG estimator constrains the long-run coefficients to be equal across the panel but allows the short-run coefficients to be specific to each group. The PMG model is written as:

$$\Delta y_{it} = \theta_i\left(y_{i,t-1} - \beta' x_{i,t-1}\right) + \sum_{j=1}^{p-1} \gamma_{ij}\, \Delta y_{i,t-j} + \sum_{j=1}^{q-1} \gamma'_{ij}\, \Delta x_{i,t-j} + \mu_i + \varepsilon_{it}$$

θ_i is the error correction speed of the adjustment parameter, $x_{i,t-1}$ are explanatory variables, β' is the estimated long-term parameter, γ_{ij} are parameters p to estimate, γ'_{ij} are parameters q to estimate, μ_i are fixed effects and ε_{it} are the error terms.

As a robustness check, we perform the two-step system GMM, which is asymptotically more efficient, with the Windmeijer (2005) robust standard errors by using the command xtabond2 (Roodman, 2009) in Stata. We also provide the Hansen J test and the Arellano-Bond tests for AR(1) and AR(2) autocorrelations. Moreover, by performing a specification test, we arbitrate between a traditional fixed-effect or random-effect model. After applying a preliminary test of cross-section dependence (Pesaran, 2004), we also apply the fixed-effect model with the standard-errors of Driscoll-Kraay (Driscoll and Kraay, 1998), which is suitable for panels in macroeconomics and international economics and makes it possible to take into account spatial cross-section dependence by using a non-parametric technique.

Preliminary tests

Cross-sectional dependence in macro-panel data is a type of correlation that highlights the interdependence between individuals. It can, for example, come from a common shock suffered by all countries with heterogeneous effects or spillover effects between countries.

We implement the test of cross-sectional dependence proposed by Pesaran (2004) in panel time-series data to investigate cross-sectional dependence in log CO2 emissions, log gross domestic product per capita and log export diversification. It is based on the pair-wise correlation coefficients and can be computed as:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \rightarrow N(0,1)$$

where $\hat{\rho}_{ij}$is the estimated correlation coefficient between the time-series for country i and j. Under the null hypothesis of no cross-sectional dependence, the statistics are normally distributed for T and N sufficiently large and robust in non-stationarity.

Insert Table 3 here

In the first column of Table 3, the statistics show that the null hypothesis of cross-sectional independence is rejected at the 1 per cent level of significance in our sample. Hence, cross-sectional dependencies exist in our data.

We also verify the stationarity of the variables with several tests of unit root hypothesis: the Levin-Lin-Chu (LLC) (2002) test assumes that all panels have the same autoregressive parameter, the Maddala and Wu (MW) (1999) test gives a chi-squared statistic and allows for autoregressive parameters to be heterogeneous but ignores cross-sectional dependence. Consequently, we compute a third unit root test, the Pesaran (2007) cross-sectional IPS (Im, et al., 2003) test which allows for the presence of cross-sectional dependence.

Results in the other columns of Table 3 (columns 2, 3 and 4) suggest that the variables could be stationary, depending on the test computed. However, a cointegration test is used to detect a long-run relationship. In order to examine the cointegration between the variables, we compute two groups of cointegration tests. The two types of tests are based on the null hypothesis of no cointegration among series, against the alternative that series are cointegrated. The first is the Pedroni's seven test statistics (Pedroni, 1999) which are four panels and three group mean cointegration statistics: panel-v, panel-rho, group-rho, panel-t (non-parametric), group-t (non-parametric), panel-adf (parametric t), and group-adf (parametric t). All test statistics are normalized to be distributed under N(0,1). The second is the Westerlund (2007) cointegration tests with bootstrap and reports test statistics of Ga, Gt, Pa and Pt. The evidence of cointegration will enable us to estimate a long-run relationship across variables.

Insert Table 4 here

The results in table 4 provide evidence of a long-run relationship among variables for equation (1) and (2). For the Pedroni statistics, the non-parametric tests of Pedroni reject the null of no integration. All Westerlund tests are very significant and reject the null of no integration.

EMPIRICAL RESULTS

Table 5 reports our main empirical results for equation (1) and equation (2). Focusing first on equation (1), we examine the validity of the EKC hypothesis. To do so, we regress the CO2 emissions on the GDP per capita and the squared GDP per capita and we expect that the coefficient of the GDP (a_1) will be positive, and the coefficient of the squared GDP (a_2) will be negative. We compute first the one-step system GMM to solve the problem of endogeneity by considering each variable as endogenous and the results give short-run estimates.

Insert Table 5 here

The results are given in column (1) and show that coefficient a_1 is significant and positive (0.16) and that coefficient a_2 is significant and negative (-0.01). Indeed, as we expected, the empirical findings show that the CO2 emissions have an inverted U-shaped relationship with GDP per capita. After we tested for cointegration of the variables, we find that the variables are cointegrated and thus there is a long-run relationship. In other words, in the long run, economic development will have an effect on CO_2 emissions. The PMG estimation enables us to provide the long-run coefficients. Our results in column (1) show that the environmental Kuznets curve hypothesis is still valid, however, for long-run estimation, the figures are higher (a_1= 6.51 and a_2= -0.34).

Focusing now on the empirical results of equation (2) in columns (2), we intend to verify if the augmented EKC hypothesis is valid. More precisely, we want to verify if the coefficient of the GDP per capita variable is still positive, the coefficient of the squared GDP per capita variable still has a negative sign and, in addition, if the export diversification impact positively the CO_2 emissions as we expect. The estimates show that the environmental Kuznets curve hypothesis for CO_2 emissions is still verified for the one-step system GMM method and the coefficients do not seem to change much: the GDP per capita coefficient is highly significant and positive (a_1=0.30) and the coefficient associated with the squared GDP per capita is significant and negative (a_2=-0.17). Thus, the results show a non-linear relationship between CO_2 emissions and GDP per capita. Moreover, the findings suggest that the added variable, the measure of export diversification, is a highly significant determinant of CO_2 emissions. It should be remembered that the Theil index is a concentration index. Thus, a positive relationship between export diversification and CO_2 emission will be indicated by a significant and negative sign of the Theil index coefficient, and conversely, a negative relationship between export concentration and CO_2 emission will be indicated by the same negative sign. As we expected, the coefficient of the variable (a_3) is highly significant and has a negative sign: a 1 per cent increase in export diversification as measured by the Theil index leads to an increase of 0.15 per cent in CO_2 emissions (in metric tons per capita). In the long run, the augmented EKC is still verified. For a long-run relationship, the PMG estimates give similar results but the estimated coefficient of GDP per capita and squared GDP per capita in logarithm are reduced because, in the long run, it is partly captured by the diversification effect. In other words, export diversification is a significant determinant of CO_2 emissions in the long run: the 1 per cent increase in export diversification, measured by the Theil index, would generate an increase of 0.31 per cent in CO_2 emissions (in metric tons per capita).

Insert Table 6 here

In addition to the main results, we make some robustness checks with other estimation methods presented in Table 6. The fixed effects method with the robust standard errors are performed and the Driscoll-Kraay standard errors are given in addition to assume the cross-sectional dependence. Furthermore, the two-step system GMM with the Windmeijer (2005) robust standard errors gives a robustness check to the one-step system GMM because it is more asymptotically efficient. The three outcomes in columns (1) are consistent with the EKC hypothesis: estimated coefficients associated with the GDP per capita are significant and positive (for fixed-effects, a_1 = 1.88 and for two-step system GMM, a_1= 0.16) and estimated coefficients associated with the squared GDP per capita are significant and negative (for fixed-effects, a_2 = -0.08 and for two-step system GMM, a_2= -0.011). They show a non-linear effect of the economic development (GDP per capita) on the CO2 emissions. The difference between the coefficient results is due to the fact that for the two-step system GMM, the lagged dependent variable partially captures the endogeneity of the explanatory variables.

The three results in columns (2) are also in line with the principal findings. GDP per capita estimated coefficients are significant and positive (for fixed effects estimates, a_1 = 1.69 and for two-step system GMM estimates, a_1= 0.29), squared GDP per capita coefficients are significant and negative (for fixed effects estimates, a_2 = -0.07 and for two-step system GMM estimates, a_2= -0.017), and moreover, estimated coefficients a_3 are significant and negative and show a positive effect of export diversification on CO2 emissions (for fixed effects estimates, a_3 = -0.37 and for two-step system GMM estimates, a_3= -0.14). The results show U-shaped relationship between CO2 emissions and the economic development, measured by GDP per capita, and, in addition, export diversification, measured by the Theil index, has a positive effect on CO2 emissions for countries at any level of economic development. Therefore, the augmented EKC is still valid.

As we observed in the stylized facts and as numerous empirical studies show (Cadot et al, 2011,2013; IMF, 2014; Klinger and Lederman, 2004), countries in the first stages of development diversify their export basket until a threshold level of income is reached and then begin to concentrate their exports. For CO2 emissions, the relationship with economic development is also non-linear and is U-shaped as shown in the EKC literature. The first part of the development process is characterized by an increase in emissions until a certain point, after which the second part of the development process sees a reduction in CO2 emissions. In this contribution, we seek to investigate the impact of the export diversification and concentration on air pollution in the process of economic development at country level. Analysis of the empirical findings enables us to make strong interpretations of the impact of export diversification or concentration on CO_2 emissions when we compare the environment literature with that on export diversification.

It should be remembered that the changes in export structure can be two directions, depending on the country's level of development. Less advanced countries would diversify their exports and more advanced countries would concentrate their export basket. Thus, our results show that, for the less developed countries, export diversification leads to an increase in CO_2 emissions; conversely, for the developed countries, export concentration leads to a decrease in the level of CO_2 emissions. As export diversification (or concentration) measures the changes in the export sectoral structure in the most highly disaggregated line, its evolution will implicitly show a country's preferential composition of factors in accordance with its comparative advantage. Furthermore, in the literature, poorer countries are characterized by lax pollution regulation, while richer countries are more stringent in environmental regulation (Antweiler et al., 2001; Rieber and Tran, 2009)**.** Given the results, it appears that developing countries, by diversifying their exports, invest in new goods in polluting industries and that the increase in export activity increases their pollution levels: here, the composition effect is accompanied by a scale effect. Conversely, developed countries, by concentrating their exports, will select the sectors in which there is a comparative advantage and specialize in goods with cleaner technologies, thereby bringing about a reduction in their emissions: the composition effect is followed by a technique effect. Thus, as we noted in the introduction, for poorer countries, a development strategy based on export diversification leads to a deterioration in environmental quality.

In the literature, the policy goal of reducing pollution directly concerns pollution regulation or trade costs, but the outcomes are said to be limited in terms of welfare (Copeland and Taylor, 1994; Rieber and Tran, 2009). Our results lend support to the policy implication that investing and financing in technological progress and human capital will help to develop and enhance the technique effect and thus favors a reduction in pollution.

CONCLUDING REMARKS

In a global context in which global warming is increasingly threatening and there is unanimous agreement on the benefits of an export diversification strategy for poorer economies, this article has attempted to assess the impact of export diversification and concentration on levels of greenhouse gas emissions (CO_2) in the context of an environmental Kuznets curve. With system GMM, PMG and robustness estimations, in order to obtain a generalized relationship, we have analyzed 98 developing and developed countries within the period 1995-2013. Our first results tended to show the validity of the environmental Kuznets curve hypothesis. In a second stage, as we expected, the environmental Kuznets curve is still valid and, in addition, we found that export diversification has a positive effect on CO_2 emissions. More precisely, export diversification generates an increase in CO_2 emissions per capita for the less developed countries, which emphasizes the dominance of composition and scale effects, while export concentration leads to a decrease of CO_2 emissions per capita for advanced economies, which is led by composition and technique effects. In other words, our analysis suggests that the economic growth strategy such as export diversification, although recommended by major international organizations, is then necessarily followed by an increase in negative externality which is, in this case, CO_2 emissions. The impact is highly robust. Our results do not differ from those the other two studies (Apergis et al.,2018; Gozgor and Can, 2016). Gozgor and Can (2016) found that, in the long run, greater export diversification across products generates higher CO_2 emissions for Turkey. In our sample, Turkey is an upper middle-income economy. Apergis et al. (2018) demonstrate that concentration of export products for developed countries causes a decrease in CO_2 emissions. From the environmental Kuznets curve augmented by export diversification, our study generalized the results by putting developed and developing countries in the same sample, thereby producing a more general relationship: we call it the augmented EKC. Further research should examine whether export diversification could have the same impact on other types of greenhouse gas emissions and environmental degradation.

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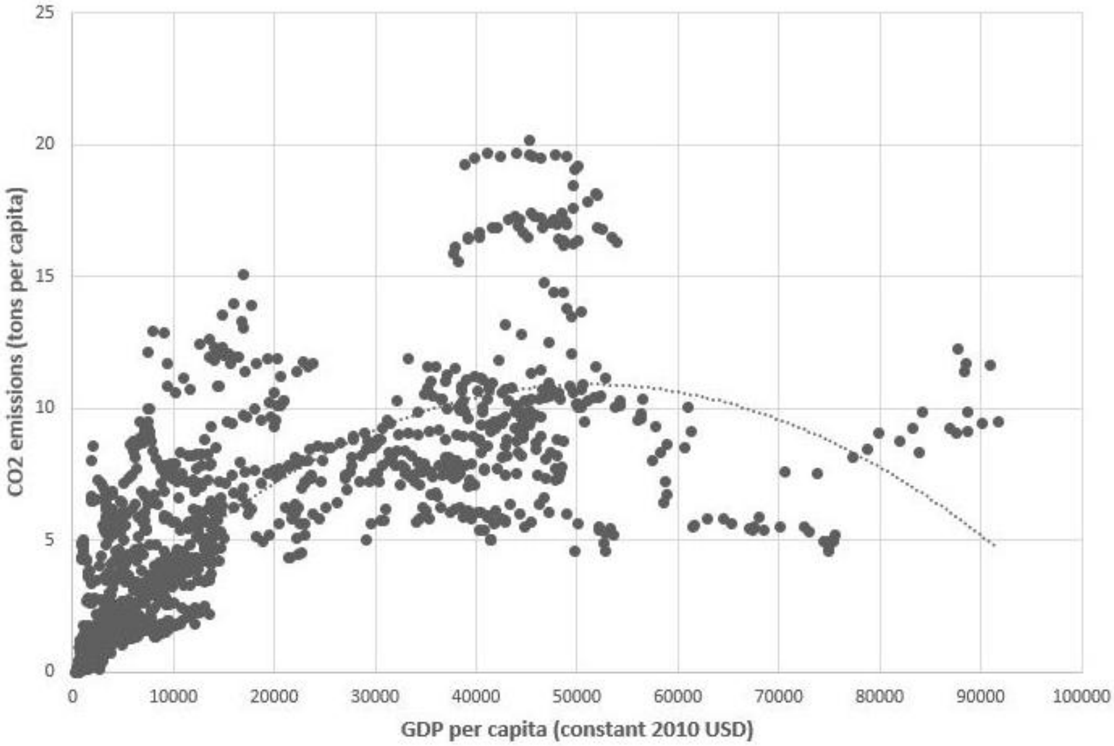
FIGURES AND TABLES

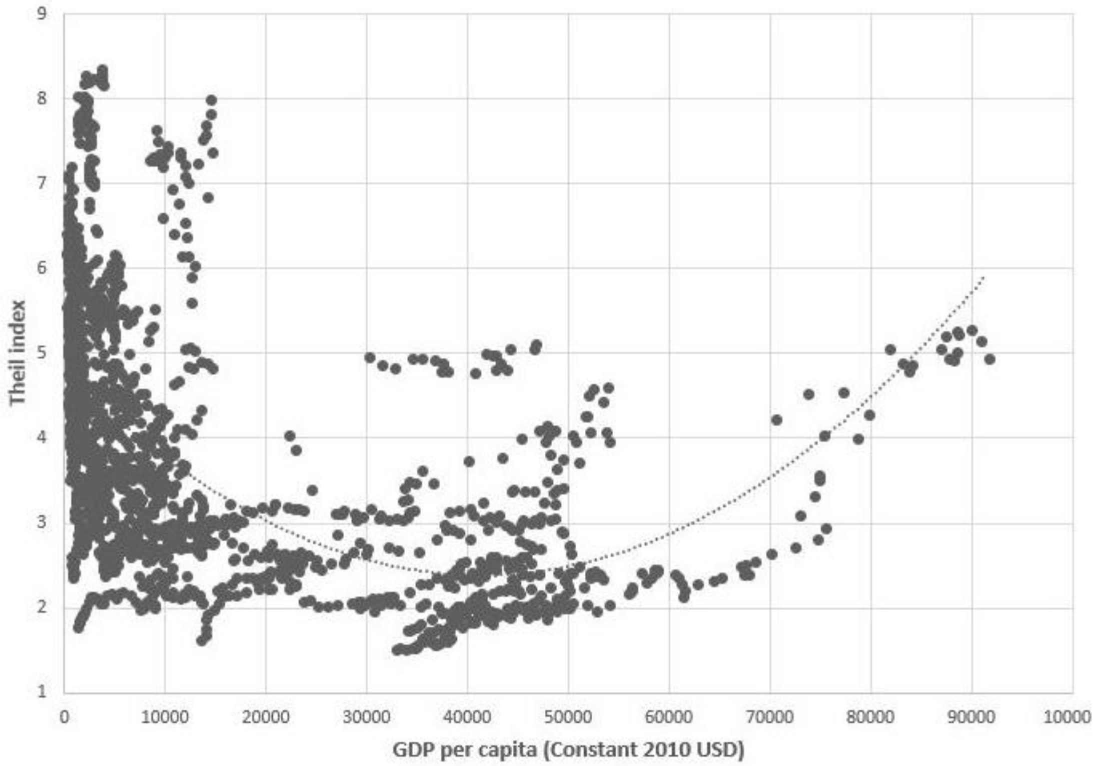
FIGURES

Figure 1. Relationship between economic development and CO2 emissions (1995-2013)



Source: Author's calculations using WDI database (with quadratic trend).

Figure 2. Relationship between economic development and export diversification (1995-2013)



Source: Author's calculations using WDI database for GDP per capita and BACI database for Theil index (with quadratic trend).

TABLES

Table 1. List of countries

HIC (33 Countries)	Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Rep., Latvia, Lithuania, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States, Uruguay.
UMIC (26 Countries)	Albania, Argentina, Bosnia and Herzegovina, Brazil, Bulgaria, China, Colombia, Costa Rica, Croatia, Cuba, Dominican Republic, Ecuador, Gabon, Jamaica, Macedonia, FYR, Malaysia, Mauritius, Mexico, Panama, Paraguay, Peru, Romania, South Africa, Thailand, Turkey, Venezuela, RB.
LMIC (29 Countries)	Angola, Armenia, Bangladesh, Bolivia, Cambodia, Cameroon, Congo, Rep., Cote d'Ivoire, El Salvador, Georgia, Ghana, Guatemala, Honduras, India, Indonesia, Kenya, Kyrgyz Republic, Morocco, Myanmar, Nicaragua, Nigeria, Pakistan, Philippines, Sri Lanka, Tajikistan, Tunisia, Ukraine, Vietnam, Zambia.
LIC (10 Countries)	Benin, Congo, Dem. Rep., Ethiopia, Mozambique, Nepal, Senegal, Tanzania, Togo, Uzbekistan, Zimbabwe.

Source: World bank, country classification for the 2018 fiscal year.

Notes: To select developed and developing countries, we refer to the classification of the countries as defined by the World Bank: HIC or high-income countries have a GNI per capita of 12,236 USD or more in 2016; UMIC or upper-middle-income countries have a GNI per capita between 3,956 USD and 12,235 USD; LMIC or lower-middle-income countries have a GNI per capita between 1,006 USD and 3,955 USD; and finally, LIC or low-income countries are defined as economies with a GNI per capita of 1,005 USD or less.

Table 2. Summary of descriptive statistics and sources

Variable		Observation	Mean	Standard-	Min.	Max.

	Data source			Deviation		
$ln(CO2)$	World Bank, WDI	1 862	0.728	1.427	-4.058	3.006
$ln(GDP)$	World Bank, WDI	1 862	8.530	1.516	5.139	11.43
$ln(DIV)$	Author's calculations; CEPII, BACI	1 862	1.300	0.376	0.421	2.123

Table 3. Pesaran (2004) cross-sectional dependence test and unit root tests

Variables	CD-test	Unit root tests		
	(1)	LLC (2)	MW (3)	CIPS (4)
$lnCO2$	15.46***	-0.73	178.7	-4.14***
$lnGDP$	214.6***	-1.15	265.8***	1.26
$lnGDP^2$	214.6***	-0.19	246.3***	1.68
$lnDIV$	28.10***	-4.13***	323.5***	-4.39***

Notes: * Significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent. For cross-sectional dependence (CD) test in column 1, the null hypothesis doesn't reject the cross-section independence (the test statistics are normalized to be distributed under N(0,1)): hence, the alternative hypothesis is in favor of a cross-section dependence for the dependent and the explanatory variables. The Levin Lin and Chu (2002), the Maddala and Wu (1999) and the Pesaran (2007) tests verify for the panel unit root (respectively in columns (2), (3) and (4)) and the null hypothesis doesn't reject the existence of a unit root.

Table 4. Cointegration tests

		Equation (1)	Equation (2)
Pedroni	Panel v	2.28**	0.68
	Panel-Rho	-2.35***	0.09
	Panel-PP	-7.63***	-7.75***
	Panel-ADF	1.06	0.86
	Group-Rho	1.12	3.69
	Group-PP	-7.40***	-8.36***
	Group-ADF	0.37	2.22
Westerlund	Gt	-2.04***	-2.25***
	Ga	-5.66***	-5.91**
	Pt	-21.50***	-19.13***
	Pa	-6.02***	-5.85***

Notes: * Significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent. Pedroni's panel cointegration and Westerlund's panel cointegration tests are computed on Stata with the commands 'xtpedroni' and 'xtwest'. The lags in the Pedroni's tests are automatically determined while there are no lags in the Westerlund tests. Robust critical values are obtained through bootstrapping for Westerlund's panel cointegration tests. The null hypothesis for both group of cointegration tests is for no cointegration.

Table 5. Main estimation results

Dependent variable: $lnCO2$	**One-Step System GMM** Short-run estimates (1)	(2)	**PMG** Long-run estimates (1)	(2)
$L.lnCO2$	1.01***	0.96***		
	(0.021)	(0.019)		
$lnGDP$	0.16*	0.30***	6.51***	2.90***
	(0.088)	(0.096)	(0.31)	(0.22)
$lnGDP^2$	-0.010**	-0.017***	-0.34***	-0.14***
	(0.004)	(0.005)	(0.02)	(0.01)
$lnDIV$		-0.15***		-0.31***
		(0.047)		(0.05)
$Constant$	-0.57	-1.01**		
	(0.412)	(0.414)		
Observations	1,764	1,764	1,764	1,764
Number of i	98	98	98	98
Number of t	18	18	18	18
Hansen statistics	0.527	0.990		
Arellano-Bond test for AR(1)	0.000	0.000		
Arellano-Bond test for AR(2)	0.307	0.317		

Notes: * Significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent. Number of i is the number of countries, number of t is the number of years. The standard errors of the one-step system GMM estimations are robust. For the one-step system GMM estimations, lags of dependent and independent variables are used as instruments. For the diagnostic statistics, p-values are given. Hansen J statistics are tests of overidentifying restrictions and show that the instruments are valid by not rejecting the null hypothesis. Results of the tests for AR(1) and AR(2) are the p-values of tests for first and second-order autocorrelation in first differences: the null hypothesis of absence of first-order serial correlation AR(1) is rejected and the null hypothesis of no second-order serial correlation AR(2) is not rejected.

Table 6. Results for robustness check estimations

Dependent variable: $lnCO2$	**Fixed-Effects** Robust standard-errors (1)	(2)	Driscoll-Kraay standard-errors (1)	(2)	**Two-Step System GMM** (1)	(2)
$L.lnCO2$					1.01***	0.96***
					(0.02)	(0.02)
$lnGDP$	1.88***	1.69***	1.88***	1.69***	0.16*	0.29***
	(0.49)	(0.47)	(0.12)	(0.07)	(0.089)	(0.098)
$lnGDP^2$	-0.08***	-0.07**	-0.08***	-0.07***	-0.011**	-0.017***
	(0.03)	(0.03)	(0.01)	(0.00)	(0.005)	(0.005)
$lnDIV$		-0.37***		-0.37***		-0.14***
		(0.13)		(0.07)		(0.047)
$Constant$	-9.04***	-7.91***	-9.04***	-7.91***	-0.589	-0.962**
	(2.11)	(2.03)	(0.47)	(0.30)	(0.41)	(0.43)
Observations	1,862	1,862	1,862	1,862	1,764	1,764
Number of i	98	98	98	98	98	98
Number of t	19	19	19	19	18	18
R-squared	0.39	0.41	0.39	0.41		
Sargan-Hansen Statistics	0.000	0.000				
Hansen J statistics					0.527	0.990
Arellano-Bond test for AR(1)					0.000	0.000
Arellano-Bond test for AR(2)					0.305	0.315

Notes: * Significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent. Number of i is the number of countries, number of t is the number of years. For the diagnostic statistics, p-values are given. The Sargan-Hansen statistics test the overidentifying restriction which is a fixed vs random effects specification test when the robust standard-error is used. The p-values show that the alternative hypothesis is not rejected, and the fixed-effects estimators are favored over the random effect estimators. The standard errors of the fixed-effect and the two-step system GMM estimations are robust. Additionally, we compute the Driscoll-Kraay (Driscoll and Kraay, 1998) standard-errors with the fixed-effects in order to take into account cross-sectional dependence. For the two-step system GMM estimations, lags of dependent and independent variables are used as instruments: Hansen J statistics are tests of overidentifying restrictions and show that the instruments are valid by not rejecting the null hypothesis. Results of the tests for AR(1) and AR(2) are the p-values of tests for first and second-order autocorrelation in first differences: the null hypothesis of absence of first-order serial correlation AR(1) is rejected and the null hypothesis of zero second-order autocorrelation AR(2) is not rejected.