TTIP and the Environmental Kuznets Curve

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This paper uses data on emissions per capita of ten air pollutants and municipal waste to investigate the potential impact of the Transatlantic Trade and Investment Partnership (TTIP) on the empirical validity of the Environmental Kuznets Curve (EKC). Using a dataset of the twenty-eight EU members and of the U.S. over a twenty-five year period, the results in this paper provide robust and statistically significant evidence consistent with the EKC argument for CO_2, CH_4, and $HFCs/PFCs/SF_6$, respectively. Further, the paper finds a monotonically increasing relationship between income per capita and emissions per capita in the cases of *GHGs*, SF_6, and NO_2, respectively. In addition, this paper finds that the EKC's turning point values of each pollutant are sensitive to the econometric approach and/or to the employed control variables. Finally, the study reports statistically significant evidence suggesting a U-shaped relationship between emissions per capita of SO_2 or SO_x and income per capita.

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1 Introduction

Starting with the pioneering work of Grossman and Krueger (1991), countless empirical and theoretical studies have reported an inverted U-shaped relationship between various pollution measures and an income measure, known in the literature as the Environmental Kuznets Curve (EKC). A lot of these studies have tried to explain the existence of the EKC using the general combination of the scale and the technique effects. The former effect claims that as countries become richer, they tend to produce more, and therefore, pollute the environment more. However, as countries grow, the technique effect may start to kick in and eventually dominate the scale effect. The technique motive argues that as countries grow richer, their citizens become more sensitive towards environmental issues. Consequently, they may force their respective governments to implement more stringent environmental regulation and/or design policies that could cause firms to adopt environmentally friendly technologies. Thus, growth could eventually be beneficial to the environment.

Other studies, in addition to the above effects, have suggested other explanatory arguments in order to justify the existence of the EKC, including the composition effect, or the international trade motive, or the political economy argument among others. However, the majority of the studies in this literature have analyzed the empirical validity of the EKC by focusing on a different set of countries, time periods, and/or pollution measures. Thus, this paper uses for the first time the potential trade agreement between the U.S. and the EU to investigate the empirical validity of the EKC. Pascalau and Qirjo (2017b) note that there are ongoing high-level negotiations between the U.S. and the EU governments to create a common free trade area between the two regions. This potential trade agreement is labeled as the Transatlantic Trade and Investment Partnership (TTIP).[1]

This empirical study uses data on emissions per capita of ten air pollutants, including CO_2, CH_4, *GHGs*, $HFCs/PFCs/SF_6$, NO_x, NO_2, NH_3, SF_6, SO_2, and SO_x and municipal waste per capita for all TTIP members over twenty-five years, from 1989 to 2013. The study reports generally robust and statistically significant evidence suggesting an inverted U-shaped relationship between economic growth and emissions per capita of CO_2, CH_4, and $HFCs/PFCs/SF_6$. This implies that at first economic growth increases emissions per capita of the above air pollutants, but eventually growth reduces emissions levels. In other

[1] In the initial stages of the negotiations, this potential free market area was also known as the Transatlantic Free Trade Agreement (TAFTA). For more details over the ongoing negotiations of TTIP, see the various official reports available publicly online at https://ustr.gov/ttip and http://ec.europa.eu/trade/policy/in-focus/ttip/ for the U.S. and the EU respectively.

words, initially the scale effect dominates the technique effect, but then eventually for sufficiently high levels of income, the opposite occurs.

However, when the study adds the cube of income per capita, the results provide statistically significant evidence implying an N-shaped relationship between growth and emissions per capita of the above three air pollutants. Put differently, this result suggests that initially growth denigrates the environment, but continued growth may eventually cause countries to "grow out" of pollution problems. Nevertheless, the significant cubic term reveals that at some future point, the initial pollution concerns experienced when countries were poor may come back. Still, the good news is that the values of the N-shaped curve's trough turning points appear to be extremely high, independent of the econometric approach or of the additional control variables. Consequently, the values of these turning points suggest that from a practical point of view, one could certainly conclude that the relationship between the emissions per capita of the three air pollutants above and of income per capita is consistent with the EKC argument and it is not N-shaped. However, this study does not ignore the cubic term but uses it to calculate the actual values of all turning points (at the peak).

Mostly opposite to all previous studies, this paper reports statistically significant evidence suggesting a U-shaped relationship between emissions per capita of SO_2 and SO_x and income per capita. In particular, the study shows that economic growth initially benefits the environment, but as countries continue to become richer, growth could denigrate the environment because it may help increase emissions per capita of the above two air pollutants. However, growth eventually appears to benefit the environment because for extremely high income per capita levels, emissions per capita of SO_2 and SO_x seem to turn downwards again. Unfortunately, the values of this turning point of the above two air pollutants appear extremely large. Therefore, from a practical point of view the relationship between emissions per capita of these two air pollutants and income per capita displays a U-shaped pattern. Similarly to SO_2 and SO_x, the study finds a statistically significant U-shaped relationship between income per capita and *Municipal Waste*.

Consistent with the previous literature, the addition of control variables appears to diminish the omitted variables bias problem and in turn affects the turning points of CO_2, CH_4, and $HFCs/PFCs/SF_6$, respectively. In particular, the addition of a *Trade* measure (the sum of exports and imports over GDP) generally increases the turning point values, irrespective of the econometric approach. The paper also shows that the values of those turning points are sensitive to the used econometric techniques. More importantly, it confirms the existence of a omitted variable problem in the cases of *GHGs* and NO_2 in the case of the base specification. More specifically, the simple base[2] specification appears to credibly support the empirical validity of the EKC argument for *GHGs* and NO_2 . However, the presence of additional control variables in subsequent models leads to unrealistically large turning point values. The latter results realistically imply a monotonically increasing relationship between income per capita and emissions per capita for each one of these two air pollutants. The same result applies for SF_6 when one uses a random effects and/or the Driscoll-Kraay approach, respectively.

To get the results above, the study applies several econometric techniques. First, the paper uses the usual random and fixed effects approaches. Further, it employs specifications that are robust to contemporaneous cross-sectional dependence and to serial correlation effects, respectively. In addition, it runs several robustness checks to make sure the results stand, especially when endogeneity may pose an issue. In particular, robustness checks tackle the possible dual causality problem between each pollutant measure and income, or between the pollutant measures and *Trade*.

The rest of this paper is organized as follows. Section 2 provides a literature review on the theoretical explanations and empirical validity of the EKC. Section 3 describes the dataset. Section 4 presents the regression models. Section 5 briefly discusses the empirical methodology. Section 6 presents the empirical results. Section 7 provides some robustness checks. Finally, section 8 concludes.

2 Literature Review

Beginning with the pioneering work of Grossman and Krueger (1991), the last twenty-seven years have provided an important number of theoretical and empirical studies, which have attempted to yield evidence and/or explanations in favor of a U-shaped EKC. Plenty of empirical studies have found some consistently strong evidence for the existence of the EKC in the case of air pollutants such as SO_2.[3] However, for other air pollutants such as CO_2 or *GHGs* in general, a good number of empirical studies has found a monotonically increasing relationship between the emissions per capita of each of these two air pollutants and income per capita. This section provides a brief review of the theoretical and empirical literature on the EKC and also quickly points out some of the critiques in the literature in

[2]The base specification simply regresses the pollutant measure against a third-degree polynomial function of income.

[3]However, the relevant studies have found turning points that are quite different from each other, depending on the type of econometric methods, sample and time period, measurement unit (i.e., total concentrations or emission levels) that each study has used.

regards to the empirical validity of the EKC. For the most part, these critiques concern the interpretation of the results as well as the econometric specifications.

The last twenty-seven years of relevant research have put forth various theories to explain the EKC. For example, Panayotou (1993) was the first to label the inverted U-shaped relationship between growth and pollution as the EKC. Moreover, Panayotou (1995) offered the earliest most detailed explanations of the EKC. The income elasticity of demand, which is simply known as the income interpretation of the EKC represents one of the early theories to explain the bell-shaped EKC. This theory considers environmental quality as a luxury good. Thus, as individuals and countries become richer, they tend to demand more environmentally clean goods (or less pollution-intensive goods). Beckerman (1992), Lopez (1994) and Gawande et al. (2001) represent some of the theoretical models that take this approach.

Others have developed theoretical models that generate the EKC assuming that pollution is caused only by production or only by consumption. For example, Selden and Song (1994) show that theoretically, production alone may explain the existence of the EKC assuming environmental degradation in an infinity lived agent economy. Brock and Taylor (2010) provides a more recent model under the same assumption. McConnell (1997), John et al. (1995), and John and Pecchenino (1994) use overlapping generation models to support the existence of the EKC in an economy where pollution is generated only from consumption activities.

Grossman and Krueger (1995) claim that a possible explanation of the shape of the EKC relates to the composition changes that occur in an economy during its various stages of economic development. Consequently, countries pollute more during their early industrialization stages, where capital accumulation is the primary source of growth. However, as countries advance towards the post-industrialization stages of development, whereby human capital accumulation is the primary source of growth, economic growth is associated with lower pollution levels.

Another branch of the literature has used the threshold model to explain the inverted U-shaped EKC. According to this theory, poor countries have lax environmental regulations simply because they have very low economic activity. Thus, as they grow, they keep increasing their pollution levels until they reach a threshold level of growth where the country becomes sensible on environmental issues and starts developing/imposing more stringent environmental regulations. Therefore, further growth in these countries could now be associated with less pollution. Copeland and Taylor (1994), Selden and Song (1994), and Stokey (1998) provide some examples in this direction.

The economies of scale effect represents an equally well-known explanation of the shape of the EKC. In this framework, economies of scale in pollution control can cause relatively large economies to reach the turning point of the EKC faster than the smaller ones. The intuition here relates to the positive relationship between the size and efficiency of pollution controls in a country. Andreoni and Levinson (2001) provides more details.

Other studies have added other variables that are positively associated with growth in order to explain the environmental degradation and growth relationship illustrated by the EKC. For example, Anderson and Leal (2001) and Yandle and Morriss (2001) show that the existence of weak property rights in various poor countries is important in explaining the down-sloping portion of the EKC. Torras and Boyce (1998) show theoretically and empirically that income inequality within a country can influence a country's attitude towards the environment. They show that the more equal societies tend to be more environmentally friendly. (Roca, 2003) show that political economic factors may play an important role in explaining the existence of the EKC. He argues that decisions about environmental quality are rather political and less individualistic. In this theory, the inverted U-shaped relationship between growth and pollution cannot be simply explained by income growth alone, but by other factors such as strong political lobbying. Kadekodi and Agarwal (2001) show theoretically that the EKC may derive from the prices of goods and factors associated with energy consumption and capital to labor ratios. Many other studies have examined the role of trade on the environment and on the existence of the EKC.[4]

Grossman and Krueger (1991) is the first empirical study to emphasize the inverted U-shaped relationship between income per capita and SO_2, fine smoke, and suspended particles, respectively. A year later, Shafik and Bandyopadhyay (1992) verify empirically the shape of the EKC for CO_2 and SO_2. Two years later, Panayotou (1993) provides empirical evidence of the EKC for NO_x and SO_2. In the following years, many researchers have used different datasets, pollutants, econometric techniques, and regression models to prove empirically the validity of the shape of the EKC. Twenty-seven years later, the empirical evidence on the EKC is mixed.[5] Table 1 provides a brief overview of some of the previous empirical studies that have found some evidence for the existence of the EKC. These studies are listed alphabetically according to the abbreviation of the pollutant (and alphabetically according to author's last names for the same pollutant). As one can easily observe, Table 1 suggests there are more studies that have used SO_2 and CO_2 than NO_x, NO_2, CH_4, $GHGs$, $HFC/PFC/SF_6$, NH_3, and SF_6, respectively. This relates to the fact that

[4]Copeland and Taylor (2004) provide an extensive and excellent comprehensive review of the international trade and environmental literature. Cole (2003) and Pascalau and Qirjo (2017b) add a brief literature review on this topic.

[5]For an extensive literature review on the empirical validity of the EKC see Stern (1998), Stern (2004), Stern (2015), Copeland and Taylor (2004), Yandle et al. (2004)

there has been more data available for the first two air pollutants than for the rest. To the best of our knowledge, there are no studies that confirm the existence of the EKC for municipal waste.[6]

All studies mentioned in Table 1 suggest that, at least partly, the differences in turning points could be due to the different sample sizes used. Further, one can conclude that in the case of CO_2, the lowest turning point is indicated in Shafik and Bandyopadhyay (1992) and the highest one is described in Anjum et al. (2014). However, there are also many other studies that empirically have found a monotonic relationship between growth and pollution. For example, Shafik (1994), Frankel and Rose (2005), Wagner (2008), Vollebergh et al. (2009), Stern (2010) to name a few, have found a monotonically increasing relationship between income per capita and CO_2 emissions. In addition, Anjum et al. (2014) indicates that the relationship between CO_2 emissions and income per capita is practically a monotonically increasing one due to the extremely high value of the turning point. Anjum et al. (2014) and Stern and Common (2001) find the same result for SO_2, while Al Sayed and Kun Sek (2013) find it for *GHGs*. Moreover, Shafik and Bandyopadhyay (1992) show a monotonically increasing relationship between CO_2 emissions and income per capita. They also find the same increasing relationship between municipal waste and income per capita. Shafik (1994), Cole et al. (1997), and Mazzanti and Zoboli (2009) confirm empirically the same result for municipal waste.

However, some of the relevant studies have criticized the econometric methodology employed and/or the interpretation of the EKC. For example, Arrow et al. (1995) criticize the EKC studies in that they assume that the economy is sustainable. Along with Stern et al. (1996), Peters and Hertwitch (2008) and Kander et al. (2015) argue that the shape of the EKC is mainly related to the trade effect rather than to the income growth and pollution relationship. They claim that the EKC is bell shaped because of international trade theories such as the Ricardian or the Heckscher-Ohlin model, respectively. Thus, developing countries are on the increasing portion of the EKC because they have a comparative advantage in pollution-intensive goods, while developed countries have a comparative advantage in environmentally friendly goods. However, Pascalau and Qirjo (2017b) find that this is not the case under the potential implementation of TTIP.

Other studies (see for example Cole (2003) and Stern (2015)) have emphasized the differences between the mean and median income. The turning points of all studies described in Table 1 are in mean income per capita. However, we know that for almost all countries in the world the national median income per capita is less than the respective

[6] To preview, the results of this paper do not support the existence of the EKC for municipal waste, SO_2 or SO_x, respectively.

mean income per capita. Thus, one has to be careful interpreting the turning points of the EKC, especially when they are relatively high.

As Cole (2003) indicates, the empirical validity of the inverted U-shaped EKC does not mechanically imply that growth cures the environment. National and/or international economic policies of a country may not relate to its various investments and regulations directly responsible for reducing national pollution.

Plenty of studies have criticized the empirical validity of the EKC that was tested using simple least squares. This criticism relates to the possible existence of the dual causality between emissions and income per capita. Stern (1998), Stern (2004), and Cole (2003) provide more evidence on this critique. These studies have also pointed out that the simultaneous causality bias may have contaminated the previous empirical studies of the EKC, especially those reporting very low turning points. Stern (1998), Stern (2004), and Stern (2015) are also concerned with the studies that employ regressions that grant zero or negative pollution levels.

Dinda (2004), Stern (2004), Romero-Avila (2008), and Chow and Li (2014) among others have also stressed other issues related to heteroscedasticity, unit roots and spurious correlations, serial dependence and cross-correlation, respectively.

3 Data Description and their Sources

This paper employs data from 1989 until 2013 covering the twenty-eight EU members and the U.S., respectively. Pascalau and Qirjo (2017b) use the same dataset in a different context and provide a complete description and set of definitions of all pollutants and explanatory variables. This section details only the variables needed for this paper's results.

In this direction, Table 2 presents the data sources and their unit of measurements. For example, the Edgar database supplies the data for CO_2 measured in Mg per capita, while the UNFCCC supplies the data for *GHGs* measured in *Tg* in CO_2 equivalent per capita emissions. Table 2 also lists the other pollutant measures and their sources.

The study finds real *GDP* per capita by dividing a country's *GDP* expressed in 2005 U.S. Dollars to its population. In order to avoid the possible dual causality problem between pollution and income, the paper constructs and employs the three-year moving average of lagged real *GDP* per capita instead of a contemporaneous measure. We simply call this measure income per capita and denote it with *I*.[7] The paper uses bilateral nominal

[7]More specifically, the paper constructs it as: $I_{it} = 0.6 * I_{it-1} + 0.3 * I_{it-2} + 0.1 * I_{it-3}$. The empirical section demonstrates the better measurement properties of this weighting scheme over an equally weighted one.

exchange rates to measure *GDP* in real 2005 U.S. Dollars.

The PENN World Tables 8.0 supply the capital to labor ratio data.[8] The paper denotes it with *KL* and measures it in current PPPs 2005 billion U.S. Dollars by dividing the physical capital stock to the labor force (the latter being measured in thousands).[9]

The IMF database provides data on the volume of bilateral trade (imports and exports) between each EU member and the U.S. and on each country's real GDP measured in 2005 U.S. Dollars. In particular, the paper denotes this measure of trade intensity with *T* and measures it by dividing the sum of exports and imports to GDP. In the case of the U.S., *T* sums each EU country's exports to the U.S. to find the imports of the US from the EU, and each EU country's imports from the U.S. to find the exports of the U.S. towards the EU.[10]

The annual ratio of the stock of inward Foreign Direct Investment to the physical stock of capital in each country provides a relative *FDI* measure. The IMF (2015) database supplies again the data for the stock of inward *FDI*, measured in real 2005 U.S. Dollars. The PENN World Tables 8.0 provide the data for the physical stock of capital, also expressed in 2005 constant U.S. Dollars.

LPC denotes land area per capita. The CIA World Factbook (2015) sources the land information in square kilometers.[11] The population, on the other hand, varies over time and across countries. The IMF (2015) database provides the population in millions. *LPC* writes as the annual log-ratio of the land area of each country to its population.

Several sources, including the European Commission, Eurostat, LIS (Luxembourg Income Study), OECD, Transmonee, World Bank, country specific Statistical Yearbooks, CIA, Frangos and Filios (2004) for Greece GINI data, IFS, and the UN, respectively provide the data for the GINI coefficient. With all this, the GINI variable still misses some observations for some countries. To fill in these missing data, the study employs the Amelia II program using the following variables in the bootstrapping procedure: real GDP, Employment, Total Population, and the Labor Force, respectively.

The global government effectiveness proxy represents a simple average of six measures including Voice and Accountability, Political Stability, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. Kaufmann et al. (2011) provides

[8]Feenstra et al. (2015) provides a statistical overview and analysis of the data in PENN Tables 8.0.

[9]Alternative measures exist. In particular, one could measure the national labor force by using the national persons engaged or the national working hours or an education index (i.e., the latter comes from Barro/Lee data set in the PENN World Tables). However, irrespective of the alternatives measure one could use, the main results stand. These are available upon request from the authors.

[10]Thus, for each EU member i, $T_i = \left(\frac{X_i+M_i}{GDP_i}\right)$, where X_i and M_i denote each EU country's exports and imports with the U.S., respectively. In the case of the U.S., $X_{U.S.} = \sum_i M_i$ and $M_{U.S.} = \sum_i X_i$, respectively. Thus, the measurement unit is as a percentage of *GDP*.

[11]The CIA World Factbook is public and available online at https://www.cia.gov.

more details on these measures. As with the GINI variable, the study employs the Amelia II program to fill in the missing variables using real GDP, Employment, Total Population, and the Labor Force, respectively in the bootstrapping procedure.

4 Three Estimating Equations

This study uses subscripts t and i to indicate the years and countries, respectively. $E(Z_{it})$ denotes per capita emission levels of pollutants, where Z_{it} denotes the specific pollutant.[12] As a first step in the analysis of the existence of the EKC, the study examines only the relationship between per capita emission levels of each pollutant and income per capita levels together with the latter's squared and cubic terms. This represents Model 1 (*M1*) and writes as:

$$E(Z_{it}) = \theta_i + \xi_t + \alpha_1 I_{it} + \alpha_2 I_{it}^2 + \alpha_3 I_{it}^3 + \epsilon_{it} \tag{1}$$

where θ_i denotes the country-specific constant term, ξ_t denotes the time-specific constant term, and ϵ_{it} denotes an idiosyncratic measurement error term in country i in year t. I denotes the effect of lagged income per capita on pollution. In order to investigate the existence of EKC, this study includes I^2 that is the square of lagged income per capita. Moreover, it also includes the cube of income per capita to examine the impact of extremely high income levels on pollution. Therefore, if α_1 is positive and statistically significant and α_2 is negative and statistically significant, while α_3 is statistically insignificant, one may confirm the existence of an inverted U-shaped EKC in the typical TTIP country for a particular pollutant. In other words, this implies that an increase in national income per capita may initially denigrate the environment, but subsequently help reduce pollution. Put differently, the existence of the EKC assures that due to economic growth, the scale effect will initially dominate the technique effect but then eventually become dominated by the latter.

Model 2 (*M2*) adds several control variables to those in *M1,* such as trade, FDI, measurements of the composition of growth, and a proxy for population, respectively. Antweiler et al. (2001) and Frankel and Rose (2005) provide the theoretical foundation for the inclusion of trade.[13] Model 2 investigates the existence of the EKC while controlling for

[12] $E(Z_{it}) \in \left[CO_{2_{it}}, CH_{4_{it}}, GHGs_{it}, (HFC/PFC/SF_6)_{it}, NH_{3_{it}}, NO_{2_{it}}, NO_{x_{it}}, SO_{2_{it}}, SF_{6_{it}}\ SO_{x_{it}}, MW_{it}\right]$.

[13] Note that Pascalau and Qirjo (2017b) focus exclusively on the effect of international trade on the environment due the implementation of TTIP, where in addition to the above trade variables, that paper also looks at the effects of other globalization factors on the environment, such as the existence of a common currency, official language or sea access. Pascalau and Qirjo (2017b) provide more details.

the trade effect that splits out into the factor endowment hypothesis (FEH), the pollution haven hypothesis based on population density variations (PHH2), and the pollution haven hypothesis based on national income differences (PHH1).[14] *Trade* captures the direct effect of trade liberalization on pollution due to the implementation of TTIP. A positive β_1 means that there are gains from trade on the environment in a typical TTIP member. Instead, a negative β_1 supports a race to the bottom hypothesis over environmental degradation in an average TTIP member.

$$\begin{aligned} E\left(Z_{it}\right) \quad = \quad & \theta_i + \xi_t + \alpha_1 I_{it} + \alpha_2 I_{it}^2 + \alpha_3 I_{it}^3 + \beta_1 T_{it} + \beta_2 T\left(RKL\right)_{it} + \beta_3 T\left(RKL\right)_{it}^2 \\ & + \beta_4 T\left(RI\right)_{it} + \beta_5 T\left(RI\right)_{it}^2 + \beta_6 T\left(RLPC\right)_{it} + \beta_7 T\left(RLPC\right)_{it}^2 + \gamma_1 KL_{it} \\ & + \gamma_2 KL_{it}^2 + \gamma_3 I\left(KL\right)_{it} + \gamma_4 FDI_{it} + \gamma_5 LPC_{it} + \gamma_6 (LPC)^2{}_{it} + \epsilon_{it} \end{aligned} \quad (2)$$

T(RKL) measures the FEH by using the interaction of trade intensity with the relative capital to labor ratio.[15] A positive β_2 supports the FEH by indicating that countries with a higher capital to labor ratio pollute the environment more due to the implementation of TTIP. This result applies because those countries have a comparative advantage in the capital-intensive goods, and therefore, according to the Heckscher-Ohlin theory, they export capital-intensive goods and import labor-intensive goods. Most of the countries in the dataset are labor abundant when compared to the U.S. There are only three countries in the dataset that are capital abundant relative to the U.S. These countries are Austria, Italy, and Luxembourg, respectively. *T(RKL)^2* captures the diminishing FEH at the margin.

T(RI) measures the PHH1 by interacting trade intensity with relative income per capita. A negative β_4 is consistent with the PHH1. This implies that the relatively richer countries pollute the environment less because of the higher likelihood to employ stringent environmental regulations. Most of the countries in our dataset are poor relative to the U.S. Thus, only Denmark, Luxembourg, and Sweden are richer than the U.S. The interaction of trade intensity with the squared relative income per capita, denoted by *T(RI)^2*, accounts for the diminishing PHH1 at the margin.

[14]In short, the FEH states that a capital-abundant country has a comparative advantage in the production of capital-intensive goods, which tend to pollute more than the labor-intensive goods do. The pollution haven hypothesis based on national income differences (henceforth, PHH1), states that one should observe an environmental degradation in the poor countries relative to the rich ones. The pollution haven hypothesis based on national population density variations (henceforth, PHH2) dictates that the countries with more land per capita should produce more pollution-intensive goods. All these three hypotheses (FEH, PHH1, and PHH2) are theoretically valid in accordance with the classical Heckscher-Ohlin theory of international trade.

[15]In all cases, the relative measures divide the respective measure for each EU country to that of the U.S. Thus, *RKL, RI*, and *RLPC* will be 1 in the case of the U.S.

T(RLPC), which is the interaction of trade intensity with relative land per capita, captures PHH2. A positive β_6 supports the PHH2, indicating that the sparsely populated countries pollute the environment more following the implementation of TTIP, as compared with the densely populated ones. Most of the countries in our dataset are densely populated relative to the U.S. Only Finland and Sweden are more sparsely populated relative to the U.S. $T(RLPC)^2$, which represents the interaction of trade intensity with the squared relative land per capita, measures the diminishing PHH2 at the margin.

In addition to the trade variable, *M2* includes the direct and the general composition of growth, the inverse measurement of population density, and a measure of *FDI*, respectively. The relevant EKC literature supports the inclusion of these additional variables. *KL* denotes the capital to labor ratio and measures the direct composition of growth. The square of the capital to labor ratio captures the diminishing effect of capital abundance at the margin. *I(KL)* denotes the product of capital to labor ratio and income per capita. This product measures the general composition of growth. *LPC* denotes land per capita and captures an inverse measurement of population density.

Finally, in addition to all the variables in *M2*, *M3* adds a measure of national inequality (the *GINI* coefficient) and a global government effectiveness *(GE)* proxy to capture the political economy effect of growth on pollution.

$$\begin{aligned} E\left(Z_{it}\right) \quad = \quad & \theta_i + \xi_t + \alpha_1 I_{it} + \alpha_2 I_{it}^2 + \alpha_3 I_{it}^3 + \beta_1 T_{it} + \beta_2 T\left(RKL\right)_{it} + \beta_3 T\left(RKL\right)_{it}^2 + \beta_4 T\left(RI\right)_{it} \\ & + \beta_5 T\left(RI\right)_{it}^2 + \beta_6 T\left(RLPC\right)_{it} + \beta_7 T\left(RLPC\right)_{it}^2 + \gamma_1 KL_{it} + \gamma_2 KL_{it}^2 + \gamma_3 I\left(KL\right)_{it} \\ & + \gamma_4 FDI_{it} + \gamma_5 LPC_{it} + \gamma_6 (LPC)^2{}_{it} + \delta_1 GINI_{it} + \delta_2 GE_{it} + \epsilon_{it} \end{aligned} \tag{3}$$

The slopes of GINI (δ_1) and GE (δ_2) measure the political economy effect of income per capita on pollution. Other empirical studies have also included political economy variables in addition to income variables when evaluating the EKC. For example, Cole (2003) and Torras and Boyce (1998) use the *GINI* coefficient and the literacy rate as political economic variables and show that generally, high income inequality is denigrating the environment. Previous empirical studies (e.g., Torras and Boyce (1998)) have shown that environmental quality can be considered a normal good since high-income countries can afford and are willing to develop stringent environmental regulations. In this context, a better and more efficient government should benefit the environment.

5 Empirical Methodology

Tables 3 through 35 present the results that employ the usual random and fixed effects approaches. In particular, Tables 3 through 13 show the results corresponding to *M1*, Tables 14 through 24 show the ones corresponding to *M2*, while Tables 25 through 35 show the ones corresponding to *M3*, respectively. In addition to the usual heteroskedastic robust standard errors, this paper employs specifications that are robust to contemporaneous cross-sectional dependence and serial correlation effects, respectively. In particular, the study allows up to an MA(2) process for the errors using the Driscoll-Kraay approach. As indicated in the environmental literature, the serial correlation may be considered because the pollution and economic variables usually display monotonic trends.

Since the Breusch-Pagan Lagrange Multiplier (BP/LM) test points to a rejection of the null hypothesis that the variances across countries are constant (i.e., no random effects), the paper does not include the OLS results.

Concerning the main results of this paper, the four specifications of random effects, fixed effects, fixed effects with cross-sectional dependence, and fixed effects with Driscoll-Kraay standard errors, respectively yield coefficients that are similar in terms of their sign and significance. The following results provide supportive evidence for these statements.

6 Empirical Results

6.1 Model 1 *(M1)*

First, the paper investigates the results produced by applying *M1* to each pollutant. Tables 3-13 show these results for CO_2, SO_2, *MW*, SO_x, CH_4, *HFCs/PFCs/*SF_6, *GHGs*, NO_2, NO_x, SF_6, and NH_3, respectively. Each table reports in order, the estimation results from using fixed and random effects, fixed effects with standard errors robust to cross-sectional dependence, and finally, fixed effects with standard errors robust to both cross-sectional and serial correlation effects, respectively.[16]

First, Table 3 shows that the fixed, random, cross-correlation and Driscoll-Kraay specifications yield similar findings. The results show that α_1 is positive and strongly statistically significant, α_2 is negative and strongly statistically significant, while α_3 is positive and strongly significant albeit of very small magnitude. The very low coefficient of α_3 indicates an extremely high value of the trough (this is the turning point where emissions per capita

[16]This paper uses Driscoll-Kraay standard errors, where the serial correlation effects are modeled using an MA(2) process.

of CO_2 start to increase as a typical TTIP country member becomes richer). Consequently, since the trough appears extremely far from the income per capita of the richest country in the dataset, one may reasonably conclude that the relationship between income per capita and emissions per capita of CO_2 is practically inversely U-shaped for a typical TTIP member. In other words, the magnitude and the sign of the coefficients confirm empirically the existence of the EKC. To confirm this finding, the first panel on the left in Figure 1 plots the mean CO_2 projections at the mean levels of income per capita for each country following the fixed effects specification. Thus, this Figure clearly indicates a concave projected curve that yields a turning point at approximately $35,000 U.S. Dollars, where the average sample income is $22,720 U.S. Dollars.[17] This average is slightly higher than the median sample income level of $17,700 U.S. Dollars. Thus, given the income numbers at the end of 2013, it appears that most Western European countries with the exception of Greece, Spain, and Italy were past the turning point, whereby CO_2 emissions were in the decreasing region. In contrast, all the former Eastern European countries are well below the turning point of the EKC. In addition, each Table reports the turning points (when possible) for all the econometric techniques that this study uses. Under *M1*, one may easily confirm that the value of the turning point depends on the econometric approach. In particular, for CO_2, the turning point varies from $21,495 to $35,756 U.S. Dollars. Therefore, as section 2 explains and Table 1 reports, despite the robustness and statistical significance of the EKC, the value of the turning point is sensitive to the empirical specification employed.[18]

Contrary to most of the previous empirical studies, Tables 4 and 6 show that the coefficients of interest imply, on average, a robust and strongly statistically significant U-shaped relationship between income per capita and emissions per capita of SO_2 and SO_x. The reader may also turn to Figure 3 for a visual presentation of the U-shaped curves of the EKC in the case of these two air pollutants.

Opposite to most of the previous empirical studies, Table 5 finds some statistically significant evidence consistent with the EKC argument for Municipal Waste. However, the values of the turning point seem quite large and vary from $89,431 to $89,981 U.S. Dollars. This finding leads towards a realistically monotonically increasing relationship between Municipal Waste and income per capita. The last panel in Figure 3 visually illustrates this monotonically increasing relationship. However, the reader should note that the coefficient of income per capita (α_1) is significant only for the Driscoll-Kraay approach, which yields

[17]Throughout the paper, all Dollar measures refer to 2005 real U.S. Dollars.

[18]The paper uses all three coefficients α_1, α_2 and α_3 to compute the turning points, irrespective of their statistical significance.

a negative and significant coefficient.

At least algebraically, the rest of the tables yield support for the EKC. In addition, as in the case of CO_2, the results imply that the turning point values are sensitive to the employed empirical method. Thus, Table 7 shows a pattern for α_1, α_2, α_3 in the case of CH_4 that is similar to that of CO_2. The turning point varies from $14,648 to $17,541 U.S. Dollars for CH_4. The top right panel of Figure 1 confirms the existence of the EKC in the case of methane with a turning point of approximately $15,000 U.S. Dollars, that is roughly the annual mean income of a typical EU country. In addition, the results for *HFCs/PFCs/*SF_6, *GHGs,* and NO_2 follow the same pattern as in the cases of CO_2 and CH_4, respectively. Tables 8 reports that the turning point for *HFCs/PFCs/*SF_6 ranges from $28,449 to $32,147 U.S. Dollars. The turning point of *GHGs* varies from $22,091 to $25,563 U.S. Dollars, while the turning point of NO_2 ranges from $19,322 to $20,848 U.S. Dollars, respectively. Figures 2 and 3 display visually the empirical projections of these air pollutants using the fixed effects specification. In these Figures, the turning point for *GHGs* appears to be around $18,000 U.S. Dollars, while in the cases of NO_2 and *HFCs/PFCs/*SF_6, the turning points have a magnitude of $16,000 and $29,000 U.S. Dollars, respectively. This evidence confirms that almost all Western-EU countries have passed the respective turning points of the above air pollutants, while all Eastern-EU members still require some time to get closer to these turning points.

All econometric approaches in Table 11 support the validity of the EKC for NO_x. The values of the turning point vary from $33,411 to $43,744 U.S. Dollars depending on the specification. The top-right panel of Figure 2 illustrates the projected mean of emissions per capita of NO_x implying the possible existence of the EKC with a turning point of approximately $44,000 U.S. Dollars.

Tables 12 and 13 support the EKC hypothesis in the cases of SF_6 and NH_3, respectively only under certain econometric approaches. In the case of NH_3, the EKC argument appears statistically significant only under the Driscoll-Kraay specification with a turning point of $16,171 U.S. Dollars. The reader should note that the bottom right panel of Table 2 that shows the relationship between the projected average income per capita and the respective per capita emissions of NH_3, reports a very low turning point at $3,033 U.S. Dollars. However, this result is not statistically significant. In the case of SF_6, the values of the turning point are very sensitive to the employed econometric specification. For instance, the turning point varies from $44,478 U.S. Dollars to an unreasonably large value. The turning point produced by the fixed effects specification suggests a monotonically increasing relationship between income per capita and per capita emissions of SF_6. Moreover, the projection in the Figure for SF_6 appears to show that in this case, the value of the turning point is beyond the income of the richest country in the dataset (Luxembourg).

6.2 Model 2 (*M2*)

Tables 14 through 24 display the results corresponding to *M2*. The results show that the statistical significance and the existence of the EKC verify for fewer air pollutants than in the case of *M1*. Still, in the cases of CO_2, CH_4, and $HFCs/PFCs/SF_6$, α_1, α_2, and α_3 maintain their sign and significance. In addition, in the case of NO_x, while one still finds evidence in favor of the EKC, the coefficient of squared income per capita loses its significance under all specifications. Again, similar to *M1*, the turning point values appear sensitive to the econometric techniques that the study uses. Moreover, comparing the results of *M2* to those of *M1*, one may confirm the existence of an omitted variable bias problem. Thus, the *M2* results indicate that the turning point values generally increase under every econometric specification.

Consistent with previous studies, it appears that the omitted variable bias problem is an important issue when analyzing the empirical validity of the EKC. Thus, in the case of *M2,* the values of the turning points at the peak of the EKC for *GHGs* and NO_2 are extremely large (starting from 10^{100} and even higher) under all specifications. These extremely large values imply a monotonically increasing relationship between income per capita and emissions per capita of *GHGs* and NO_2, respectively. Therefore, in the case of the latter two air pollutants, the additional control variables in *M2* suggest that the EKC argument loses its empirical validity.

The findings for SO_x and SO_2 appear to follow the evidence from above and show a loss of support for the EKC. Thus, for these two air pollutants, α_1 appears negative and α_2 appears positive, respectively implying a U-shaped relationship between income per capita and emissions per capita. These results go in the opposite direction required by the EKC. In addition, the *M2* results imply a U-shaped relationship between income and municipal waste. However, the coefficient of income per capita (α_1) is significant only under the Driscoll-Kraay approach. In the case of NH_3, *M2* shows no evidence to support the EKC. Moreover, the results indicate a monotonically increasing relationship (but generally not statistically significant) between income per capita and emissions of NH_3.

It should also be noted that similar to *M1* under the fixed effects specification, *M2* suggests a monotonically increasing relationship between emissions of SF_6 and income. This is true across all of the four econometric methods.

In regards to *Trad*e, the results report statistically significant evidence consistent with the FEH for CO_2, *GHGs,* and *HFCs/PFCs/SF*$_6$, respectively.[19] Therefore, a higher relative to the U.S. capital to labor ratio in a typical TTIP country implies higher emissions per capita of the above three pollutants. In addition, on average, the results support the PHH1 for CO_2 (only when using the Driscoll-Kraay approach*), GHGs,* CH_4 (only under random effects)*, HFCs/PFCs/SF*$_6$*,* NO_2*,* SF_6*,* and NH_3. Consequently, emissions per capita of these seven air pollutants decrease as a typical EU member gets richer relative to the U.S. as a result of TTIP. Further, the tables generally report statistically significant evidence in accordance with the PHH2 for *Municipal Waste, GHGs, HFCs/PFCs/SF*$_6$*,* CH_4*,* NO_2*,* SF_6*,* and NH_3, respectively. In other words, per capita emissions of these six air pollutants and per capita municipal waste decrease as the population density in a typical TTIP country increases more than the population density in the U.S. In conclusion, putting the above three effects together, as proxied by the trade intensity variable (T), we report robust and strong statistically significant evidence in support of the gains from trade argument due to the implementation of TTIP for CO_2*, GHGs,* and *HFCs/PFCs/SF*$_6$. Put differently, the implementation of TTIP could be beneficial towards the ongoing fight against global warming because it may help reduce emissions per capita of those particular pollutants. In rest, the results imply generally statistically significant evidence in support of the race to the bottom hypothesis for SO_2*,* SO_x*,* CH_4*,* SF_6*,* and NH_3. In other words, the implementation of TTIP may denigrate the environment because it may help increase emissions per capita of the latter five air pollutants in the typical TTIP member.[20]

Further, the results indicate generally statistically significant evidence in support of the direct composition of growth argument for CH_4, SF_6, NO_x, and SO_x implying a positive relationship between the national capital to labor ratio and emissions per capita.[21] Moreover, inconsistent with other empirical studies, this paper finds counter-intuitive results for the general composition of growth, implying a generally statistically significant but negative relationship between the interaction of national income with the capital to labor ratio and emissions per capita of NO_x*, GHGs,* and NH_3, respectively. In addition, similarly to previous work, the results report a positive and statistically significant relationship between population density and emissions per capita of CH_4*,* NO_x*,* SO_x*,* and *GHGs*. However, the opposite occurs for *Municipal Waste,* CO_2*,* SF_6, NO_2, SO_2, NH_3, SF_6 and *HFCs/PFCs/SF*$_6$*,* respectively. In addition, this study finds that FDI could benefit the environment because

[19]In the case of *HFCs/PFCs/SF*$_6$, FEH verifies only when using a fixed effects framework with standard errors robust to cross-correlation and serial correlation effects.

[20]Pascalau and Qirjo (2017b) provide further details and analysis of the trade and other globalization variables to analyze the implications of adopting TTIP.

[21]In the cases of SF_6, NO_x, and SO_x the results appear statistically significant only under the cross-correlation approach.

it may help reduce emissions of SO_2 and SF_6. This could relate to the idea that big multinational corporations, which are mostly the firms that can afford to provide FDI, usually apply more environmentally friendly technologies than the domestic firms. The latter may over time copy or adjust their technology due to competition or efficiency reasons, causing FDI to have a positive impact on the environment. On the other hand, the present study also reports that FDI may damage the environment because it may help increase emissions of CO_2 and *GHGs,* respectively.

6.3 Model 3 *(M3)*

M3 builds upon *M2* by adding two political economy variables such as a measure of income inequality, proxied by the *GINI* coefficient, and a measure of government effectiveness, proxied by an average rule of law index. The results in Tables 25 through 35 imply that the existence and the statistical significance of the EKC remain the same (as compared to *M1* and *M2*) only for emissions of CO_2, *HFCs/PFCs/*SF_6, and CH_4, respectively. The results also indicate the possible existence of the EKC for the emissions of NO_x but similar to *M2*, the income coefficients are not statistically significant. However, similar to *M1* and *M2*, the turning point values appear sensitive to the included econometric methods and variables. Thus, the turning point values of the four air pollutants mentioned above increase slightly under *M3*.

In rest, all four econometric specifications report unrealistically large turning point values for *GHGs*, SF_6, and NO_2. This finding effectively implies a monotonically increasing relationship between income and emissions of those three pollutants.

Similarly to *M1* and *M2*, *M3*'s results confirm a statistically significant U-shaped relationship between *Municipal Waste*, emissions of SO_x and SO_2 on one hand and income per capita on the other hand. However, in the case of *Municipal Waste*, only the random effects approach yields a significant EKC, with the caveat that the turning point is somewhat high at $73,369 U.S. Dollars. Analogously to *M2*, the results based on *M3* imply a monotonically increasing relationship between emissions per capita of NH_3 and income per capita.

Focusing on the new variables in *M3*, the evidence supports a positive relationship between income inequality as measured by the *GINI* coefficient and emissions per capita of NO_2 and SO_2, respectively. This evidence aligns with Torras and Boyce (1998). Consequently, high income inequality may play an additional negative role by denigrating the environment. However, additional empirical findings suggest that income inequality may surprisingly be beneficial to the environment because it may help reduce emissions of CO_2, *HFCs/PFCs/*SF_6, *GHGs,* NH_3, and Municipal Waste per capita, respectively. One may speculate that this surprising result could be caused by the simultaneous push and pull of politics and economics. While the wealthy favor and push for tax cuts, which contribute to income inequality, both the wealthy and the poor favor better environmental standards. We know that environmental quality is generally considered a normal good. Therefore, an income increase for the wealthy due to favorable tax cut policies may encourage them to provide political support towards stringent environmental regulations. While the wealthy can avoid living in the relatively more polluted areas, the poor often locate closer to industrial areas and experience more pollution. Consequently, enforcing more stringent environmental regulations helps everyone in a society.[22]

In regards to the global government effectiveness proxy, its coefficient does not appear significant for any one of the considered air pollutants. However, it appears that government effectiveness may affect municipal waste in a counter-intuitive manner. In particular, Table 27 reports statistically significant evidence suggesting that a more effective government may have a negative impact on the environment.

In a nutshell, a summary of the results in the three models above undoubtedly supports the EKC hypothesis for three air pollutants, namely CO_2, *HFCs/PFCs/*SF_6, and CH_4, respectively. In addition, results in the paper indicate that the values of the turning points are sensitive to the econometric approach. This argument is more apparent in the case of CO_2. Further, additional evidence suggests that the simple *M1* representation may suffer from an omitted variable bias problem. In particular, this bias appears more pronounced in the cases of *GHGs* and NO_2. However, the omitted variable bias problem appears to be less of an issue in models *M2* and *M*3, respectively.

7 Robustness Check

In order to avoid the potential dual causality problem between each pollutant measure and income per capita highlighted in Porter and Van der Linde (1995), this study employs from the very beginning a three-year moving average of income per capita with lagged periods written as $I_{it} = 0.6 * I_{it-1} + 0.3 * I_{it-2} + 0.1 * I_{it-3}$.[23]

Moreover, this study performs additional robustness checks following Pascalau and Qirjo (2017b) and similar to Frankel and Rose (2005). It employs another instrumental variable approach by instrumenting trade with a set of exogenous variables including lagged income, exchange rate, capital to labor ratio, price of export, price of imports,

[22]Pascalau and Qirjo (2017a) analyze this argument fully by building a theoretical model that reports further empirical evidence in support of this hypothesis.

[23]Antweiler et al. (2001) have initially suggested the three period lag structure.

land per capita, and four dummies for whether a country uses euro, or has sea access, or uses English as its official language, or was a poor country at the start of the sample, respectively. Following Pascalau and Qirjo (2017b), this study labels a country poor if its first reported annual income is less than the EU average for that specific year. The results are very similar to the ones reported here, and therefore, these additional results are not presented in this paper, but they are available upon request from the authors.

Further, to account for the possibility of dynamic panel effects, this empirical study re-estimates *M1* using a GMM approach. In particular, it employs an Arellano-Bond approach where it allows for two lags of the dependent variable and instruments them either with all lags available or only five lags, respectively. Further, this paper uses both a difference and system GMM approach, respectively. While not all specifications yield significant results and in some cases, the evidence seems weaker, it appears that for the most important pollutants the results are preserved. For instance, all four specifications support the EKC argument. The same strong evidence in favor of the EKC is found for the case of SF_6. Albeit weaker, the study still finds support for the EKC in the cases of CO_2, CH_4, $HFCs/PFCs/SF_6$, *GHGs,* and NO_2, respectively. However, as before it does not find evidence for the existence of the EKC in the cases of SO_2, Municipal Waste, SO_x, NH_3 and NO_x, respectively. The GMM results are not reported in this paper, but they are available from the authors upon request.

Finally, the current study also investigates the possible existence of unit roots by applying the Im-Pesharan-Shin test. After controlling for a deterministic time trend, all pollutant measures appear stationary with the exception of the SO_2 and CH_4 series. For the latter two, this study re-estimates the results using the first difference and it confirms the existence of the U-shaped relationship between emissions of SO_2 and income per capita. It also confirms the existence of the EKC argument for CH_4. In addition, for all pollutants, the explanatory variables appear stationary. Due to space limitations, the current version does not report the Im-Pesharan-Shin test results or the re-estimation results for SO_2 and CH_4, but they are available upon request from the authors.

8 Conclusion

The present study uses several theoretical specifications and several econometric techniques to prove, on average, the empirical validity of the EKC for ten air pollutants and municipal waste following the implementation of TTIP. The paper focuses on the current twenty-eight EU countries and on the U.S. The results in this paper provide robust and statistically significant evidence in favor of the EKC argument for three air pollutants, namely CO_2, CH_4, and $HFCs/PFCs/SF_6$. In addition, the study yields weaker empirical evidence in support of the EKC for NO_x. The results stand under various econometric specifications and various additional control variables.

However, similarly to previous studies, the findings in this paper confirm that the turning point values depend on the econometric approach. In particular, the study finds that the most basic representation of the first model may suffer from an omitted variable bias problem. However, this problem appears to be less of an issue in the subsequent two models the paper proposes. It is worth noting that the addition of control variables and especially, that of trade variables leads to unrealistically high turning point values (i.e., *GHGs* and NO_2). Realistically, these findings suggest a monotonically increasing relationship between income per capita and emissions per capita of *GHGs* and NO_2, respectively. The reader should keep in mind that in the absence of these control variables, the results appear to support the empirical validity of the EKC for *GHGs* and NO_2.[24]

However, the results in this paper do not support the existence of the EKC in the cases of SO_2 and SO_x. The evidence shows that for these two pollutants and *Municipal Waste*, a U-shaped relationship with income appears more likely.[25]

Finally, as described in the literature review, one should be careful when interpreting the empirical validity of the EKC for CO_2, CH_4, and *HFCs/PFCs/*SF_6, respectively, despite the robustness of the results. For instance, the empirical validity of the EKC for CO_2 does not mechanically imply that economic growth will eventually, on average, fight global warming. International economic policies of *(i)* the EU, *(ii)* and/or the U.S., and/or *(iii)* the possible implementation of TTIP, and/or *(iv)* the national economic policies of a typical TTIP member, may not be related to the various investments and regulations that are directly responsible for reducing per capita emissions of CO_2.

Further, the reader should be cautious about the difference between the use of mean versus median income per capita. The paper reports all turning points using mean income per capita. However, for all the countries in the dataset, the national median income per capita appears smaller than the mean income per capita. Thus, one has to be careful when interpreting the turning points of the EKC in the presence of extreme skewness.

[24]The same applies for SF_6 when one excludes the fixed effects approach from consideration.

[25]The results also provide weak empirical evidence suggesting that a higher income per capita leads to a monotonic increase in emissions per capita of NH_3.

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Tables and Graphs

Table 1: Literature Review

Pollutant	Authors	Countries	Time Period	Econometric Technique	Turning Points
CH_4	Giles and Mosk (2003)	1 (New Zealand)	1895-1996	Fuzzy Regression Framework	8,000 (in 1990 U.S.$)
CH_4	This study	29	1989-2013	Fixed & Random Effects	14,648-19,584 (in 2005 U.S.$)
CO_2	Aldy (2005)	48 (U.S. States)	1960-99	Feasible GLS	14,700-23,870 (in 1999 U.S.$)
CO_2	Al Sayed and Kun Sek (2013)	40	1961-2009	Random & Fixed Effects	3,720-67,846 (in 2009 U.S.$)
CO_2	Anjum et al. (2014)	136	1971-2010	OLS	2,600,000 (in 2010 U.S.$)
CO_2	Chow and Li (2014)	132	1992-2004	Random & Fixed Effects	378,000 (in 2004 U.S.$)
CO_2	Cole et al. (1997)	7 regions	1960-91	OLS	22,500-34,700 (in 1985 U.S.$)
CO_2	Cole (2003)	32	1975-1995	Random & Fixed Effects	19,288-56,696 (in 1985 U.S.$)
CO_2	Dijkgraaf and Vollebergh (2005)	24 (OECD)	1960-97	Fixed Effects	13,959-15,704 (in 1985 U.S.$)
CO_2	Galeotti et al. (2009)	24 (OECD)	1960-98	Fixed Effects	16,488-15,698 (in 1990 U.S.$)
CO_2	Galeotti and Lanza (1999)	110	1960-96	Gamma & Weibull Specifications	13,260-22,000 (in 1985 U.S.$)
CO_2	Hill and Magnani (2002)	156	1970-90	Random & Fixed Effects	9,000-11,000 (in 1985 U.S.$)
CO_2	Holtz-Eakin and Selden (1995)	108	1951-86	Fixed Effects	35,428 (in 1986 U.S.$)
CO_2	McCarney and Adamowicz (2006)	143	1976-2000	Random Effects	31,485 (in 1995 U.S.$)
CO_2	Moomaw and Unruh (1997)	16	1950-92	Fixed Effects	12,813 (in 1985 U.S.$)
CO_2	Sachs et al. (1999)	150	1960-92	Fixed Effects	11,500-17,500 (in 1985 U.S.$)
CO_2	Schmalensee et al. (1998)	47	1950-90	Fixed Effects	10,000-17,000 (in 1985 U.S.$)
CO_2	Shafik and Bandyopadhyay (1992)	149	1960-90	OLS	4,000 (in 1985 U.S.$)
CO_2	Taskin and Zaim (2000)	52	1975-90	Non-parametric Kernel Regression	5,000-12,000 (in 1985 U.S.$)
CO_2	Tuan (1999)	6	1993; 95; 97	OLS	18,000 (in 1987 U.S.$)
CO_2	This study	29	1989-2013	Fixed & Random Effects	21,495-48,907 (in 2005 U.S.$)
GHGs	Al Sayed and Kun Sek (2013)	40	1961-2009	Random & Fixed Effects	1,748-38,087 (in 2009 U.S.$)
GHGs	This study	29	1989-2013	Random & Fixed Effects	22,091 -- > 1M (in 2005 U.S.$)
$HFC/PFC/SF_6$	Langeler (2015)	25	1991-2010	Fixed Effects	24,820 (in 2011 U.S.$)
$HFC/PFC/SF_6$	This study	29	1989-2013	Fixed & Random Effects	27,063-32,147 (in 2005 U.S.$)
NH_3	Egli (2002)	1 (Germany)	1966-98	Random & Fixed Effects	16,700 (in 1985 U.S.$)
NH_3	This study	29	1989-2013	Driscoll-Kraay Approach	34 -- > 1M (in 2005 U.S.$)
NO_2	Cole et al. (1997)	10	1970-92	Fixed Effects	15,100 (in 1985 U.S.$)
NO_2	Frankel and Rose (2005)	42	1995	OLS & 2SLS	7,665-9,075 (in 1990 U.S.$)
NO_2	Egli (2002)	1 (Germany)	1966-98	Random & Fixed Effects	14,700 (in 1985 U.S.$)

Pollutant	Authors	Countries	Time Period	Econometric Technique	Turning Points
NO_2	This study	29	1989-2013	Fixed & Random Effects	19,322 -- > 1M (in 2005 U.S.$)
NO_x	Cole (2003)	26	1975-90	Fixed & Random Effects	13,659-18,403 (in 1985 U.S.$)
NO_x	Cole et al. (1997)	10	1970-90	Fixed Effects	14,700-17,600 (in 1985 U.S.$)
NO_x	Hill and Magnani (2002)	156	1970-90	Random & Fixed Effects	8,000-13,000 (in 1985 U.S.$)
NO_x	Panayotou (1993)	55	late 80s	OLS	5,500 (in 1985 U.S.$)
NO_x	Selden and Song (1994)	30	1979-87	Fixed Effects	13,383 (in 1990 U.S.$)
NO_x	This study	29	1989-2013	Fixed & Random Effects	33,410-107,898 (in 2005 U.S.$)
SF_6	Sica and Sušnik (2014)	4 (Italian Provinces)	1990-2005	Random & Fixed Effects	36,127 (in 2005 U.S.$)
SF_6	This study	29	1989-2013	Fixed & Random Effects	44,478 -- > 1M (in 2005 U.S.$)
SO_2	Al Sayed and Kun Sek (2013)	40	1961-2009	Random & Fixed Effects	2,072-86,525 (in 2009 U.S.$)
SO_2	Anjum et al. (2014)	142	1971-2005	OLS	101,000 (in 2010 U.S.$)
SO_2	Cole (2003)	26	1975-90	Random & Fixed Effects	5,431-10,521 (in 1985 U.S.$)
SO_2	Cole et al. (1997)	11	1970-92	Random & Fixed Effects	6,900-9,800 (in 1985 U.S.$)
SO_2	Frankel and Rose (2005)	48	1995	OLS & 2SLS	4,133-8,406 (in 1990 U.S.$)
SO_2	Grossman and Krueger (1995)	32	1977; 82;88	Random Effects	4,053-5,965 (in 1990 U.S.$)
SO_2	Halkos (2003)	73	1960-1990	Random Effects	2,805-6,230 (in 1990 U.S.$)
SO_2	Harbaugh et al. (2002)	19	1971-92	Fixed Effects	6,500-9,840 (in 1985 U.S.$)
SO_2	Hill and Magnani (2002)	156	1970-90	Random & Fixed Effects	8,000-13,000 (in 1985 U.S.$)
SO_2	List and Gallet (1999)	50 U.S. states	1929-1994	Random and Fixed Effects	22,675 (in 1990 U.S. $)
SO_2	Kaufmann et al. (1998)	23	1974-89	Random & Fixed Effects	14,730 (in 1990 U.S.$)
SO_2	Panayotou (1997)	30	1982-84	Random & Fixed Effects	5,965 (in 1990 U.S.$)
SO_2	Panayotou (1993)	55	1987-88	OLS	3,137 (in 1990U.S.$)
SO_2	Selden and Song (1994)	30	1979-87	Fixed Effects	10,321-10,620 (in 1990 U.S.$)
SO_2	Shafik (1994)	31	1972-88	OLS	3,670 (in 1985 U.S.$)
SO_2	Shafik and Bandyopadhyay (1992)	149	1960-90	OLS	3,000-4,000 (in 1985 U.S.$)
SO_2	Stern (2002)	64	1973-90	Random & Fixed Effects	8,394 (in 1990 U.S.$)
SO_2	Stern and Common (2001)	73	1960-90	Random & Fixed Effects	101,166 (in 1990 U.S.$)
SO_2	Torras and Boyce (1998)	42	1977-91	OLS	3,360-3,890 (in 1985 U.S.$)
SO_2	This study	28	1989-2013	Random & Fixed Effects	U-Shaped

Table 2: *Data Sources and their unit of measurement*

Variable	*Source*	*Unit of Measurement*
CO_2 (Carbon Dioxide)	EDGAR (2015)	Mg per Capita
CH_4 (Methane)	CAIT (2015)	Gg per capita
GHGs	UNFCCC (2015)	Tg in CO_2 equiv. per capita
HFCs/PFCs/SF_6	UNFCCC (2015)	Tg in CO_2 equiv. per capita
NH_3 (Ammonia)	NEC/NFR (2015)	Gg per capita
NO_2 (Nitrogen Dioxide)	UNFCCC (2015)	Gg per capita
NO_x (Nitric Oxide)	NEC/NFR (2015)	Gg per capita
SF_6 (Sulfur Hexafluoride)	UNFCCC (2015)	Gg in CO_2 equiv. per capita
SO_2 (Sulphur Dioxide)	Stern (2006)	Kg per capita
SO_x (Sulphur Oxide)	EEA (2015)	Gg per capita
Municipal Waste	Eurostat (2015)	Kg per capita
Real GDP per capita (I)	IMF (2015)	Real (2005) U.S. Dollars
Capital to Labor Ratios (KL)	PENN World Tables 8.0	Real (2005) PPPs U.S. Dollars
Trade Intensity (T)	IMF (2015)	Percentage (0-100)
FDI Stock/Capital Stock (FDI)	IMF (2015)	Percentage (0-100)
Land area per capita (log) (LPC)	CIA World Factbook (2015)	log of (Km^2per capita)
Government Effectiveness (GE)	Kaufmann et al. (2011)	[-2.5, 2.5]
GINI	Eurostat, European Commission, LIS, OECD, Transmonee, etc...	Percentage [0-100]

Table 3: CO_2 Results - Model M1

	FE	RE	Cross Correlation	Serial Correlation
Inc.	.232***	.257***	.232***	.174***
Inc. squared	–.005***	–.005***	–.005***	–.004***
Inc. cube	.000***	.000***	.000***	.000**
Constant	7.202***	6.810***	6.149***	8.165***
Turning Point ('000)	35.756	27.239	35.756	21.495
N	638.000	638.000	638.000	638.000
R2	.236		.956	
R2 adj.	.168			
bic	1841.594	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 4: SO_2 Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	–2.349***	–1.784***	–2.349***	–.973
Inc. squared	.028***	.022***	.028***	.017**
Inc. cube	–.000***	–.000***	–.000***	–.000**
Constant	56.707***	48.941***	58.571***	31.047***
Turning Point ('000)	N.A.	N.A.	N.A.	N.A.
N	638.000	638.000	638.000	638.000
R2	.241		.786	
R2 adj.	.174			
bic	4602.093	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 5: Municipal Waste Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	.209	1.978	.209	–4.446*
Inc. squared	.094**	.076**	.094**	.136**
Inc. cube	–.001***	–.001***	–.001***	–.001**
Constant	350.881***	327.430***	374.799***	456.112***
Turning Point ('000)	89.431	89.981	89.431	N.A.
N	638.000	638.000	638.000	638.000
R2	.307		.836	
R2 adj.	.245			
bic	7041.642	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 6: SOx Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	–2.763***	–2.527***	–2.763***	–2.050***
Inc. square	.045***	.043***	.045***	.040***
inc. cube	–.000***	–.000***	–.000***	–.000***
Constant	83.938***	80.898***	72.530***	76.831***
Turning Point ('000)	N.A.	N.A.	N.A.	N.A.
N	638.000	638.000	638.000	638.000
R2	.537		.830	
R2 adj.	.496			
bic	5147.987	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 7: CH4 Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	.030***	.032***	.030***	.039***
Inc. square	–.001***	–.001***	–.001***	–.001***
Inc. cube	.000***	.000***	.000***	.000***
Constant	1.171***	1.154***	.912***	1.062***
Turning Point ('000)	14.648	15.089	14.648	17.541
N	638.000	638.000	638.000	638.000
R2	.548		.963	
R2 adj.	.507			
bic	–885.283	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 8: HFC/PFC/SF6 Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	.015***	.013***	.015***	.012***
Inc. square	–.000***	–.000***	–.000***	–.000***
Inc. cube	.000***	.000***	.000***	.000***
Constant	–.077**	–.052*	–.111**	–.039
Turning Point ('000)	32.147	29.479	32.147	28.449
N	638.000	638.000	638.000	638.000
R2	.225		.702	
R2 adj.	.156			
bic	–1436.812	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 9: GHG Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	.182***	.210***	.182***	.177***
Inc. square	–.005***	–.005***	–.005***	–.005***
Inc. cube	.000***	.000***	.000***	.000***
Constant	9.940***	9.517***	9.693***	10.128***
Turning Point ('000)	22.091	25.5634	22.091	22.191
N	638.000	638.000	638.000	638.000
R2	.345		.956	
R2 adj.	.287			
bic	1892.947	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 10: NO2 Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	.107***	.113***	.107***	.115***
Inc. square	–.003***	–.003***	–.003***	–.003***
Inc cube	.000***	.000***	.000***	.000***
Constant	2.634***	2.541***	2.289***	2.650***
Turning Point ('000)	19.322	20.516	19.322	20.848
N	638.000	638.000	638.000	638.000
R2	.521		.933	
R2 adj.	.479			
bic	613.800	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 11: NOx Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	1.905***	1.503***	1.905***	1.150***
Inc. square	–.023**	–.017*	–.023***	–.017***
Inc. cube	.000	–.000	.000	.000
Constant	25.696***	30.058***	–4.755	40.976***
Turning Point ('000)	43.744	43.424	43.744	33.411
N	638.000	638.000	638.000	638.000
R2	.285		.870	
R2 adj.	.222			
bic	5329.442	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 12: SF6 Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	4.518***	3.151***	4.518***	3.519***
Inc. square	–.073***	–.061***	–.073***	–.065***
Inc. cube	.000***	.000***	.000***	.000***
Constant	–33.447***	–14.526**	5.440	–8.408
Turning Point ('000)	>1,000	44.478	>1,000	50.255
N	638.000	638.000	638.000	638.000
R2	.174		.633	
R2 adj.	.100			
bic	5427.103	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 13: NH3 Results - Model M1

	FE	RE	Cross correlation	Serial correlation
Inc.	.000	.043	.000	.106**
Inc. square	–.003***	–.003***	–.003***	–.004***
Inc. cube	.000***	.000***	.000***	.000***
Constant	12.957***	12.331***	12.694***	11.516***
Turning Point ('000)	0.03368	7.074	0.03368	16.171
N	638.000	638.000	638.000	638.000
R2	.576		.950	
R2 adj.	.538			
bic	2107.055	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively.

Table 14: CO_2 Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc.	.231***	.285***	.231***	.155**
Inc. squared	–.004***	–.004***	–.004***	-.003**
Inc. cube	.000***	.000***	.000**	.000*
Trade	–39.814***	–30.424**	–39.814**	–28.439
Trade × RKL	170.864***	145.498***	170.864***	152.074***
Trade × RKL^2	–131.289***	–109.405***	–131.289***	–126.166***
Trade × RI	–37.042	–31.198	–37.042	–36.680*
Trade × RI^2	36.495***	24.499*	36.495	39.297***
Trade × RLPC	–28.707	–24.910	–28.707	–40.221
Trade × $RLPC^2$	28.933*	23.703	28.933*	39.344*
KL	–.009	–.006	–.009	–.006
KL^2	.000***	.000**	.000***	.000**
KL × I	–.000	–.000	–.000	–.000
FDI	2.073***	1.907**	2.073*	2.510**
LPC	49.554***	10.599*	49.554***	46.830*
LPC^2	–2.359***	–.514	–2.359***	–2.185
Constant	–246.859***	–46.997	–249.784***	–235.600**
Turning point ('000)	42.925	48.907	42.925	36.425
N	638.000	638.000	638.000	638.000
r2	.363		.963	
r2_a	.291			
bic	1809.047	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 15: SO2 Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc.	–2.448***	–1.826***	–2.448***	–.535
Inc. squared	.017**	.006	.017***	.000
Inc. cube	–.000	–.000	–.000***	–.000
Trade	607.201***	402.180***	607.201***	406.400
Trade × RKL	–1173.471***	–650.989**	–1173.471***	–732.015
Trade × RKL^2	421.910***	132.642	421.910***	218.739
Trade × RI	611.081***	372.531*	611.081***	315.174
Trade × RI^2	–220.224*	–57.172	–220.224***	–100.784
Trade × RLPC	–1087.395***	–884.576***	–1087.395***	–1071.463
Trade × $RLPC^2$	639.461***	574.652***	639.461***	516.416
KL	–.041	–.037	–.041	–.004
KL^2	–.000	–.000	–.000	–.000
KL × I	.001	.002*	.001	.003
FDI	–23.049***	–5.897	–23.049***	–13.398
LPC	–694.506***	–25.959	–694.506***	–501.210
LPC^2	34.976***	1.249	34.976***	25.083
Constant	3469.227***	187.357	3510.297***	2504.206
Turning point ('000)	N.A.	N.A.	N.A.	N.A.
N	638.000	638.000	638.000	638.000
r2	.386		.827	
r2_a	.316			
bic	4551.056	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 16: Municipal Waste Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc.	–3.292	–.258	–3.292	–7.164**
Inc. squared	.151**	.089	.151***	.000
Inc. cube	–.001**	–.001***	–.001***	–.001***
Trade	424.189	–523.665	424.189	931.654
Trade × RKL	–1128.860	1498.810	–1128.860	–2362.378
Trade × RKL^2	–606.212	–2212.540**	–606.212	–129.779
Trade × RI	956.353	–520.105	956.353	2601.834**
Trade × RI^2	–67.018	1012.790	–67.018	–1000.512**
Trade × RLPC	2300.916*	2960.276**	2300.916*	1674.626
Trade × $RLPC^2$	–2257.778**	–2343.978***	–2257.778***	–1159.934
KL	.428	.522	.428	.814
KL^2	–.001	–.001	–.001	–.001
KL × I	–.009	–.000	–.009	–.010
FDI	–24.123	65.353	–24.123	–34.685
LPC	–4556.851***	–536.675**	–4556.851***	–4679.885***
LPC^2	228.540***	28.262**	228.540***	235.544***
Constant	22778.750***	2833.073***	23047.673***	23345.325***
Turning point ('000)	N.A.	N.A.	N.A.	N.A.
N	638.000	638.000	638.000	638.000
r2	.400		.858	
r2_a	.332			
bic	7033.103	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 17: SOx Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc	–3.417***	–2.730***	–3.417***	–2.344
Inc. squared	.062***	.046***	.062***	.000
Inc. cube	–.000***	–.000***	–.000***	–.000
Trade	569.493***	348.714*	569.493***	445.818
Trade × RKL	–480.609	24.662	–480.609	–199.781
Trade × RKL^2	15.502	–229.421	15.502	–104.837
Trade × RI	–12.486	–226.869	–12.486	–261.001
Trade × RI^2	8.359	143.389	8.359	118.379
Trade × RLPC	–617.157**	–292.495	–617.157**	–607.488
Trade × $RLPC^2$	298.100	90.589	298.100	214.885
KL	.099	.087	.099*	.107
KL^2	–.000	–.000	–.000	–.000
KL × I	–.000	.000	–.000	.001
FDI	–10.790	2.612	–10.790	–2.587
LPC	–903.886***	–181.615***	–903.886***	–790.870
LPC^2	48.377***	10.242***	48.377***	42.603
Constant	4262.802***	867.713***	4293.285***	3707.431
Turning point ('000)	N.A.	N.A.	N.A.	N.A.
N	638.000	638.000	638.000	638.000
r2	.580		.845	
r2_a	.532			
bic	5170.186	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 18: CH4 Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc.	.033***	.036***	.033***	.036
Inc. squared	–.001***	–.001***	–.001***	-.001
Inc. cube	.000***	.000***	.000***	.000
Trade	4.080**	.362	4.080**	3.521
Trade × RKL	–6.732*	.806	–6.732*	–5.187
Trade × RKL^2	2.876	–.862	2.876	2.180
Trade × RI	–4.327	–5.307*	–4.327	–5.821
Trade × RI^2	.013	.921	.013	.771
Trade × RLPC	3.347	10.349***	3.347	3.828
Trade × $RLPC^2$	–1.869	–6.143***	–1.869	–2.654
KL	.002**	.001	.002**	.001
KL^2	–.000	–.000	–.000	–.000
KL × I	–.000	–.000	–.000	–.000
FDI	–.148	–.010	–.148	–.129
LPC	–5.926***	–.606	–5.926***	–5.877
LPC^2	.316***	.042	.316***	.313
Constant	28.439***	2.891	28.270***	28.297
Turning point ('000)	18.145	18.802	18.145	19.584.
N	638.000	638.000	638.000	638.000
r2	.605		.967	
r2_a	.560			
bic	–888.138	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. The standard errors for the Serial Correlation estimation could not be computed due to the high singularity of the matrix. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 19: HFC/PFC/SF6 Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc	.024***	.017***	.024***	.020***
Inc. squared	–.000***	–.000***	–.000***	-.000***
Inc. cube	.000***	.000***	.000***	.000***
Trade	–1.823*	–1.072	–1.823**	–1.913**
Trade × RKL	3.617	1.786	3.617**	3.027**
Trade × RKL^2	–2.784**	–2.315*	–2.784**	–2.022**
Trade × RI	–5.548***	–3.911**	–5.548***	–4.296**
Trade × RI^2	3.559***	2.889***	3.559***	2.752**
Trade × RLPC	2.147	2.052	2.147	2.889**
Trade × $RLPC^2$	–.311	–.540	–.311	–.563
KL	–.000	–.000	–.000	–.001
KL^2	.000	.000	.000**	.000***
KL × I	–.000	–.000	–.000	–.000*
FDI	.070	–.018	.070	–.001
LPC	5.153***	.011	5.153***	4.255***
LPC^2	–.284***	–.004	–.284***	–.241***
Constant	–23.263***	.175	–23.559***	–18.541***
Turning point ('000)	27.458	29.030	27.458	27.545
N	638.000	638.000	638.000	638.000
r2	.394		.767	
r2_a	.325			
bic	–1510.076	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 20: GHG Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc	.216***	.260***	.216***	.168**
Inc. squared	–.004***	–.004***	–.004***	-.003***
Inc. cube	.000***	.000***	.000***	.000**
Trade	–58.280***	–48.571***	–58.280***	–48.453***
Trade × RKL	178.070***	153.927***	178.070***	163.021***
Trade × RKL^2	–133.401***	–113.248***	–133.401***	–131.346***
Trade × RI	–53.070**	–47.754*	–53.070	–50.103**
Trade × RI^2	36.888**	26.339*	36.888	36.933***
Trade × RLPC	71.429***	67.379***	71.429***	58.250**
Trade × RLPC^2	–30.307*	–26.327*	–30.307**	–16.706
KL	–.004	–.002	–.004	.001
KL^2	.000***	.000***	.000***	.000***
KL × I	–.001***	–.001***	–.001***	–.001*
FDI	1.573**	1.618**	1.573	2.104*
LPC	54.217***	17.337***	54.217***	54.562***
LPC^2	–2.775***	–.987***	–2.775***	–2.752***
Constant	–252.308***	–66.496**	–254.989***	–256.929***
Turning point ('000)	>1,000	>1,000	>1,000	>1,000
N	638.000	638.000	638.000	638.000
r2	.464		.964	
r2_a	.403			
bic	1849.485	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 21: NO2 Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc	.129***	.142***	.129***	.131***
Inc. squared	–.003***	–.003***	–.003***	-.003***
Inc. cube	.000***	.000***	.000***	.000***
Trade	1.575	1.544	1.575	1.061
Trade × RKL	15.465	13.351	15.465	17.224
Trade × RKL^2	–8.601	–5.397	–8.601	–9.964
Trade × RI	–42.833***	–38.711***	–42.833***	–42.249**
Trade × RI^2	15.372***	11.016**	15.372**	14.732
Trade × RLPC	52.414***	55.077***	52.414***	51.838***
Trade × RLPC^2	–30.367***	–31.644***	–30.367***	–28.972***
KL	–.002	–.002	–.002	–.001
KL^2	.000	.000	.000*	.000
KL × I	–.000**	–.000**	–.000***	–.000***
FDI	–.545*	–.615**	–.545*	–.461
LPC	15.016***	4.760**	15.016***	15.652***
LPC^2	–.735***	–.245*	–.735***	–.765***
Constant	–73.074***	–20.771*	–74.178***	–76.388***
Turning point ('000)	>1,000	>1,000	>1,000	>1,000
N	638.000	638.000	638.000	638.000
r2	.618		.946	
r2_a	.575			
bic	553.703	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 22: NOx Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc	2.310***	1.679**	2.310***	1.543*
Inc. squared	–.024	–.020	–.024	-.010
Inc. cube	.000	–.000	.000	.000
Trade	363.247	327.937	363.247	376.868*
Trade × RKL	–776.939	–601.623	–776.939	–766.217
Trade × RKL^2	417.011	278.444	417.011	419.587
Trade × RI	–52.298	–343.199	–52.298	–96.284
Trade × RI^2	–150.313	99.945	–150.313	–122.551
Trade × RLPC	362.417	327.375	362.417	392.400
Trade × $RLPC^2$	–256.918	–205.625	–256.918	–266.235
KL	.175	.169	.175*	.111
KL^2	–.000	–.000	–.000	–.000
KL × I	–.001	.001	–.001	–.002
FDI	–12.718	4.272	–12.718	–11.404
LPC	–592.162***	–9.036	–592.162**	–676.422
LPC^2	28.228***	.303	28.228**	32.458
Constant	3041.961***	68.320	3028.915**	3477.103
Turning point ('000)	59.591	41.136	59.591	103.217
N	638.000	638.000	638.000	638.000
r2	.316		.876	
r2_a	.238			
bic	5385.459	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 23: SF6 Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc.	5.360***	4.324***	5.360***	4.015
Inc. squared	–.068***	–.056***	–.068***	-.053
inc. cube	.000***	.000***	.000***	.000
Trade	751.931***	641.916***	751.931***	819.233
Trade × RKL	–1211.515**	–1155.866**	–1211.515***	–1436.967
Trade × RKL^2	570.183**	547.665**	570.183***	718.397
Trade × RI	–1866.763***	–1477.827***	–1866.763***	–1706.725
Trade × RI^2	770.762***	610.743***	770.762***	713.547
Trade × RLPC	428.491	719.749**	428.491*	417.120
Trade × RLPC^2	128.479	–153.058	128.479	137.213
KL	.122	.068	.122**	.103
KL^2	–.000	–.000	–.000	–.000
KL × I	–.001	–.001	–.001	–.002
FDI	–35.991***	–43.574***	–35.991**	–41.971
LPC	453.342**	53.520	453.342***	326.807
LPC^2	–24.333**	–3.861	–24.333***	–17.990
Constant	–2140.669**	–192.448	–2124.099***	–1486.960
Turning point ('000)	>1,000	>1,000	>1,000	>1,000
N	638.000	638.000	638.000	638.000
r2	.358		.715	
r2_a	.285			
bic	5349.635	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. The standard errors for the Serial Correlation estimation could not be computed due to the high singularity of the matrix. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 24: NH3 Results - Model M2

	FE	RE	Cross correlation	Serial correlation
Inc	.009	.143***	.009	.089**
Inc. squared	.001	–.000	.001	.000
inc. cube	.000	.000	.000	.000
Trade	37.550**	27.632	37.550*	29.934*
Trade × RKL	–33.127	–25.163	–33.127	–13.989
Trade × RKL^2	5.368	16.164	5.368	–3.694
Trade × RI	–100.696***	–82.220***	–100.696**	–110.924**
Trade × RI^2	38.302**	13.251	38.302*	41.702
Trade × RLPC	74.071***	123.512***	74.071**	78.213**
Trade × $RLPC^2$	–38.128**	–72.407***	–38.128*	–42.430***
KL	.003	.003	.003	.002
KL^2	.000***	.000**	.000***	.000***
KL × I	–.001***	–.001***	–.001***	–.001***
FDI	–.809	–.985	–.809	–.527
LPC	70.129***	14.565**	70.129***	75.987**
LPC^2	–3.264***	–.708*	–3.264***	–3.571*
Constant	–354.735***	–63.692**	–358.690***	–383.127**
Turning point ('000)	N.A.	>1,000	N.A.	N.A.
N	638.000	638.000	638.000	638.000
r2	.673		.961	
r2_a	.635			
bic	2025.941	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2.

Table 25: CO2 Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	.223***	.288***	.223***	.155**
Inc. squared	–.004***	–.005***	–.004***	-.003***
inc. cube	.000***	.000***	.000**	.000
Trade	–32.557**	–26.481*	–32.557	–22.654
Trade × RKL	159.281***	138.465***	159.281***	142.797***
Trade × RKL^2	–124.885***	–104.771***	–124.885***	–120.827***
Trade × RI	–43.620*	–33.317	–43.620	–42.921**
Trade × RI^2	39.327***	24.333*	39.327	41.711***
Trade × RLPC	–41.369**	–30.643	–41.369*	–52.913*
Trade × $RLPC^2$	37.176**	26.549*	37.176**	47.192**
KL	–.014**	–.010	–.014**	–.010
KL^2	.000***	.000**	.000***	.000**
KL × I	–.000	–.000	–.000	–.000
FDI	1.618**	1.414*	1.618	2.136*
LPC	55.304***	11.103*	55.304***	52.067**
LPC^2	–2.579***	–.519	–2.579***	–2.384*
GINI	–.118***	–.081***	–.118***	–.103***
GE	.138	.169	.138	.276**
Constant	–277.071***	–48.558	–280.449***	–263.621**
Turning point ('000)	38.550	46.873	38.550	32.224
N	638.000	638.000	638.000	638.000
r2	.394		.965	
r2_a	.322			
bic	1791.099	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 26: SO2 Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	–2.369***	–1.825***	–2.369***	–.548
Inc. squared	.017**	.008	.017***	.000
Inc. cube	–.000	–.000*	–.000**	–.000
Trade	550.686***	356.400***	550.686***	357.975
Trade × RKL	–1079.464***	–555.195**	–1079.464***	–655.294
Trade × RKL^2	370.095**	69.690	370.095***	174.267
Trade × RI	654.212***	377.380*	654.212***	370.180
Trade × RI^2	–238.590**	–46.641	–238.590***	–122.062
Trade × RLPC	–990.962***	–834.454***	–990.962***	–963.763
Trade × RLPC^2	576.676***	556.057***	576.676***	450.093
KL	–.009	–.007	–.009	.032
KL^2	–.000	–.000	–.000	–.000
KL × I	.001	.002	.001	.002
FDI	–19.968***	–1.907	–19.968***	–10.132
LPC	–742.072***	–10.513	–742.072***	–544.909
LPC^2	36.879***	.367	36.879***	26.724
GINI	.887***	.703***	.887***	.876
GE	.124	.016	.124	–2.617
Constant	3714.268***	96.749	3758.401***	2739.134
Turning point ('000)	N.A.	N.A.	N.A.	N.A.
N	638.000	638.000	638.000	638.000
r2	.407		.833	
r2_a	.337			
bic	4542.059	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 27: Municipal Waste Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	–3.480	.742	–3.480*	–6.609**
Inc. squared	.142**	.060	.142***	.000
Inc. cube	–.001**	–.001**	–.001***	–.001***
Trade	764.499	–324.262	764.499	1111.576
Trade × RKL	–1646.676	1147.497	–1646.676	-2594.927
Trade × RKL^2	–318.779	–1904.971*	–318.779	23.034
Trade × RI	594.085	–750.100	594.085	2241.774**
Trade × RI^2	90.310	1011.808	90.310	–860.923*
Trade × RLPC	1692.754	2920.673***	1692.754	1192.537
Trade × RLPC^2	–1861.955**	–2431.529***	–1861.955**	–878.404
KL	.151	.244	.151	.564
KL^2	–.000	–.000	–.000	–.001
KL × I	–.007	.001	–.007	–.009
FDI	–48.539	38.526	–48.539	–54.201
LPC	–4305.808***	–539.366**	–4305.808***	–4525.180***
LPC^2	219.475***	28.862**	219.475***	230.697***
GINI	–5.730***	–5.364***	–5.730***	–4.108**
GE	14.469*	14.602*	14.469*	26.944**
Constant	21427.082***	2967.206***	21671.607***	22451.400***
Turning point ('000)	N.A.	73.369	N.A.	N.A.
N	638.000	638.000	638.000	638.000
r2	.422		.863	
r2_a	.354			
bic	7022.594	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 28: SOx Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	–3.415***	–2.627***	–3.415***	–2.382
Inc. squared	.061***	.043***	.061***	.000
Inc. cube	–.000***	–.000***	–.000***	–.000
Trade	596.467***	359.456*	596.467***	473.835
Trade × RKL	–518.971	12.536	–518.971	–248.954
Trade × RKL^2	36.919	–213.677	36.919	–77.976
Trade × RI	–46.902	–257.246	–46.902	–278.641
Trade × RI^2	23.428	149.994	23.428	125.174
Trade × RLPC	–666.890**	–281.142	–666.890**	–662.335
Trade × $RLPC^2$	330.462	74.573	330.462	250.059
KL	.073	.067	.073	.097
KL^2	–.000	–.000	–.000	–.000
KL × I	.000	.000	.000	.001
FDI	–13.051	.919	–13.051*	–3.804
LPC	–885.954***	–168.073***	–885.954***	–764.890
LPC^2	47.792***	9.527***	47.792***	41.540
GINI	–.476	–.379	–.476	–.429
GE	1.993	1.378	1.993	–.055
Constant	4162.548***	814.876***	4190.766***	3573.426
Turning point ('000)	N.A.	N.A.	N.A.	N.A.
N	638.000	638.000	638.000	638.000
r2	.582		.846	
r2_a	.533			
bic	5179.336	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 29: CH4 Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	.033***	.036***	.033***	.037***
Inc. squared	–.001***	–.001***	–.001***	-.001***
Inc. cube	.000***	.000***	.000***	.000***
Trade	4.027**	.001	4.027**	3.571**
Trade × RKL	–6.551*	1.538	–6.551*	–5.241
Trade × RKL^2	2.780	–1.249	2.780	2.220
Trade × RI	–4.481	–5.372*	–4.481	–5.954
Trade × RI^2	.085	.997	.085	.823
Trade × RLPC	3.386	10.998***	3.386	3.676
Trade × RLPC^2	–1.894	–6.553***	–1.894	–2.568
KL	.002**	.001	.002**	.001*
KL^2	–.000	.000	–.000	–.000
KL × I	–.000	–.000	–.000	–.000
FDI	–.156*	–.003	–.156	–.136
LPC	–6.038***	–.548	–6.038***	–5.835***
LPC^2	.323***	.039	.323***	.312***
GINI	.000	.002	.000	–.001
GE	.029*	.023	.029	.011
Constant	28.904***	2.562	28.727***	28.044***
Turning point ('000)	18.174	18.827	18.174	19.568
N	638.000	638.000	638.000	638.000
r2	.607		.967	
r2_a	.561			
bic	–878.272	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 30: HFC/PFC/SF6 Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	.024***	.017***	.024***	.020***
Inc. squared	–.000***	–.000***	–.000***	-.000***
Inc. cube	.000***	.000***	.000***	.000***
Trade	–1.668	–1.193	–1.668*	–1.756**
Trade × RKL	3.392	1.984	3.392*	2.779**
Trade × RKL^2	–2.659**	–2.416*	–2.659**	–1.879**
Trade × RI	–5.737***	–3.860**	–5.737***	–4.473**
Trade × RI^2	3.641***	2.880***	3.641***	2.820***
Trade × RLPC	1.863	2.333*	1.863	2.542**
Trade × RLPC^2	–.127	–.808	–.127	–.349
KL	–.000	–.000	–.000	–.001*
KL^2	.000	.000	.000**	.000***
KL × I	–.000	.000	–.000	–.000
FDI	.057	–.026	.057	–.011
LPC	5.260***	–.052	5.260***	4.396***
LPC^2	–.288***	–.000	–.288***	–.246***
GINI	–.003	–.000	–.003	–.003**
GE	.010	.014	.010	.008
Constant	–23.852***	.451	–24.160***	–19.299***
Turning point ('000)	27.063	28.310	27.063	27.116
N	638.000	638.000	638.000	638.000
r2	.398		.769	
r2_a	.327			
bic	–1501.163	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 31: GHG Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	.213***	.268***	.213***	.174**
Inc. squared	–.004***	–.004***	–.004***	-.003**
Inc. cube	.000***	.000***	.000***	.000**
Trade	–54.231***	–46.094***	–54.231**	–46.126**
Trade × RKL	171.865***	149.657***	171.865***	159.917***
Trade × RKL^2	–129.959***	–109.848***	–129.959***	–129.347***
Trade × RI	–57.289**	–50.334**	–57.289	–54.475**
Trade × RI^2	38.718***	26.521*	38.718	38.628***
Trade × RLPC	64.218***	64.572***	64.218**	52.165**
Trade × $RLPC^2$	–25.613	–24.897	–25.613*	–13.129
KL	–.008	–.005	–.008	–.002
KL^2	.000***	.000***	.000***	.000***
KL × I	–.000***	–.000***	–.000**	–.000*
FDI	1.288*	1.387*	1.288	1.865
LPC	57.236***	16.869**	57.236***	56.577***
LPC^2	–2.885***	–.955***	–2.885***	–2.817***
GINI	–.068***	–.047*	–.068***	–.052**
GE	.159	.200	.159	.317*
Constant	–268.502***	–63.607**	–271.467***	–268.452***
Turning point ('000)	>1,000	>1,000	>1,000	>1,000
N	638.000	638.000	638.000	638.000
r2	.473		.965	
r2_a	.411			
bic	1851.688	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 32: NO2 Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	.131***	.143***	.131***	.134***
Inc. squared	–.003***	–.003***	–.003***	-.003***
Inc. cube	.000***	.000***	.000***	.000***
Trade	.808	.285	.808	.079
Trade × RKL	16.932	15.881	16.932	19.173
Trade × RKL^2	–9.402	–6.878	–9.402	–10.958
Trade × RI	–42.655***	–38.627***	–42.655***	–42.297***
Trade × RI^2	15.308***	11.203**	15.308**	14.753
Trade × RLPC	53.614***	56.569***	53.614***	53.409***
Trade × $RLPC^2$	–31.149***	–32.377***	–31.149***	–30.055***
KL	–.002	–.002	–.002	–.001
KL^2	.000	.000	.000*	.000*
KL × I	–.000**	–.000**	–.000***	–.000**
FDI	–.526*	–.555**	–.526*	–.450
LPC	14.230***	4.632**	14.230***	14.709***
LPC^2	–.700***	–.241*	–.700***	–.722***
GINI	.011	.015*	.011*	.011*
GE	.062	.072	.062	.076*
Constant	–69.256***	–20.472*	–70.342***	–71.781***
Turning point ('000)	>1,000	>1,000	>1,000	>1,000
N	638.000	638.000	638.000	638.000
r2	.620		.947	
r2_a	.575			
bic	563.855	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 33: NOx Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	2.324***	1.640**	2.324***	1.526**
Inc. squared	–.024	–.019	–.024	-.010
Inc. cube	.000	–.000	.000	.000
Trade	347.489	341.938	347.489	369.224*
Trade × RKL	–752.125	–631.007	–752.125	–755.687
Trade × RKL^2	403.276	297.151	403.276	412.940
Trade × RI	–37.299	–347.148	–37.299	–82.910
Trade × RI^2	–156.789	100.471	–156.789	–127.733
Trade × RLPC	390.103	315.417	390.103	411.870
Trade × RLPC^2	–274.940	–199.406	–274.940	–277.763
KL	.186*	.171	.186*	.120
KL^2	–.000	–.000	–.000	–.000
KL × I	–.001	.001	–.001	–.002
FDI	–11.689	4.591	–11.689	–10.666
LPC	–604.400***	–5.586	–604.400**	–683.090
LPC^2	28.689***	.151	28.689**	32.679*
GINI	.259	–.109	.259	.164
GE	–.406	–1.235	–.406	–.932
Constant	3106.697***	53.995	3094.678**	3514.824
Turning point ('000)	61.097	41.135	61.097	107.898
N	638.000	638.000	638.000	638.000
r2	.316		.876	
r2_a	.236			
bic	5397.821	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

Table 34: SF6 Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	5.437***	4.315***	5.437***	4.183***
Inc. squared	–.070***	–.058***	–.070***	-.056
Inc. cube	.000***	.000***	.000***	.000***
Trade	745.686***	616.098***	745.686***	793.927***
Trade × RKL	–1189.768**	–1113.428**	–1189.768***	–1378.789***
Trade × RKL^2	558.672**	529.238**	558.672***	690.881***
Trade × RI	–1886.139***	–1463.738***	–1886.139***	–1731.613***
Trade × RI^2	779.734***	608.995***	779.734***	723.281***
Trade × RLPC	432.677	757.424***	432.677*	445.174
Trade × RLPC^2	125.722	–188.359	125.722	114.652
KL	.105	.046	.105*	.083
KL^2	–.000	–.000	–.000	–.000
KL × I	–.001	–.001	–.001	–.002
FDI	–37.031***	–44.349***	–37.031**	–42.807*
LPC	439.758**	51.835	439.758***	301.334**
LPC^2	–23.558**	–3.754	–23.558***	–16.701***
GINI	.007	–.051	.007	.164
GE	3.595	3.168	3.595	4.564*
Constant	–2084.432**	–185.004	–2068.926***	–1371.451**
Turning point ('000)	>1,000	>1,000	>1,000	>1,000
N	638.000	638.000	638.000	638.000
r2	.361		.717	
r2_a	.286			
bic	5359.884	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

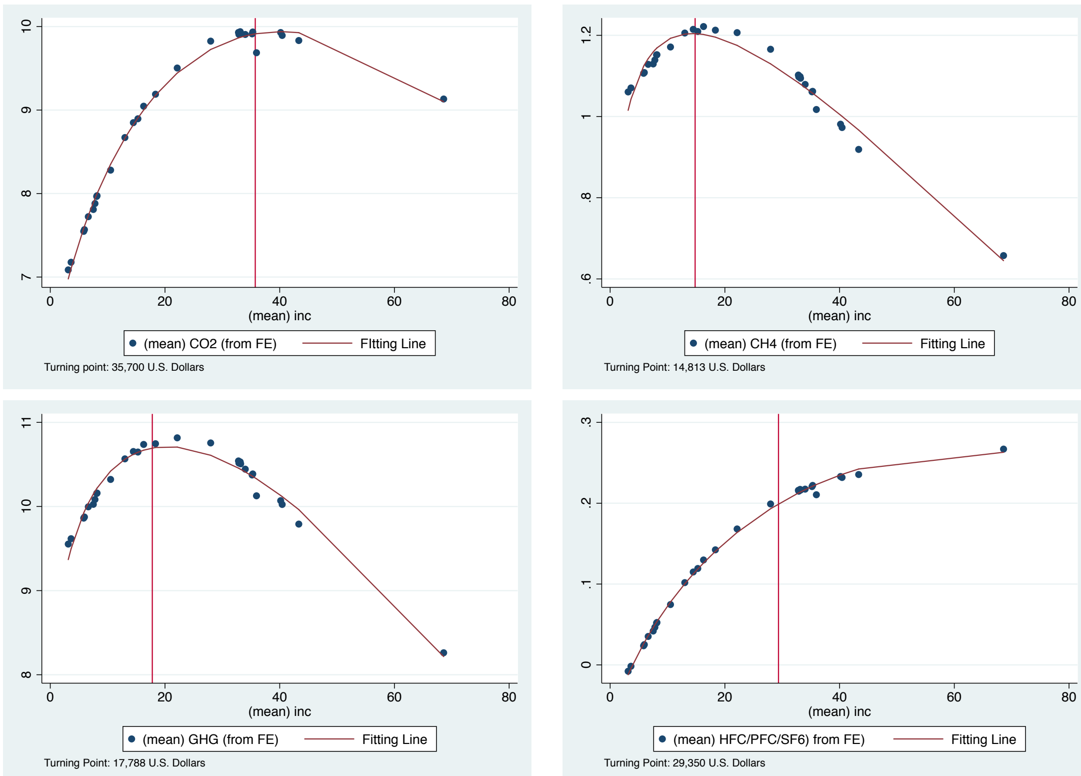
Table 35: NH3 Results - Model M3

	FE	RE	Cross correlation	Serial correlation
Inc.	.010	.140***	.010	.088**
Inc. squared	.001	–.000	.001	.000
Inc. cube	.000	.000*	.000	.000
Trade	40.438**	28.203	40.438**	33.282**
Trade × RKL	–37.152	–25.592	–37.152	–19.518
Trade × RKL^2	7.619	15.538	7.619	–.566
Trade × RI	–104.556***	–83.539***	–104.556***	–114.062**
Trade × RI^2	39.995**	14.671	39.995*	42.914
Trade × RLPC	68.699***	119.851***	68.699**	71.117**
Trade × RLPC^2	–34.633*	–70.377***	–34.633	–37.994**
KL	.000	.002	.000	–.000
KL^2	.000***	.000**	.000***	.000***
KL × I	–.001***	–.001***	–.001***	–.001***
FDI	–1.061	–1.118	–1.061	–.721
LPC	71.989***	14.995**	71.989***	79.041**
LPC^2	–3.323***	–.723*	–3.323***	–3.690*
GINI	–.052*	.011	–.052**	–.057***
GE	.239	.299	.239	.107
Constant	–365.257***	–66.756**	–369.465***	–399.280**
Turning point ('000)	N.A.	>1,000	N.A.	N.A.
N	638.000	638.000	638.000	638.000
r2	.676		.962	
r2_a	.638			
bic	2032.268	.	.	.

Inc. is a three-period moving average of lagged real GDP per capita. In particular, $I_{it} = 0.6I_{it-1} + 0.3I_{it-2} + 0.1I_{it-3}$. The lag structure intends to avoid the possible dual causality problem between pollution and income. The turning points computation uses the level, square, and cubic coefficients. *, **, and *** denote significance at the usual 1%, 5%, and 10% levels, respectively. All the other variables are in their contemporaneous values. Trade is the sum of exports and imports (between trading partners, the US on one side and each EU member on the other side) over GDP. All relative variables denoted by R in front of them are constructed relative to the US. KL denotes the capital to labor ratio that also measures the direct composition of growth. FDI/K is the ratio of the stock of inward FDI to the physical stock of capital. It is also used as a proxy to measure PHH. LPC denotes the land area per capita. KL × I denotes the general composition of growth. Trade × RKL and Trade × $(RKL)^2$ measure FEH. Trade × RI and Trade × $(RI)^2$ measure PHH1. Trade × RLPC and Trade × $(RLPC)^2$ measure PHH2. GINI measures within-country income inequality. GE denotes government effectiveness.

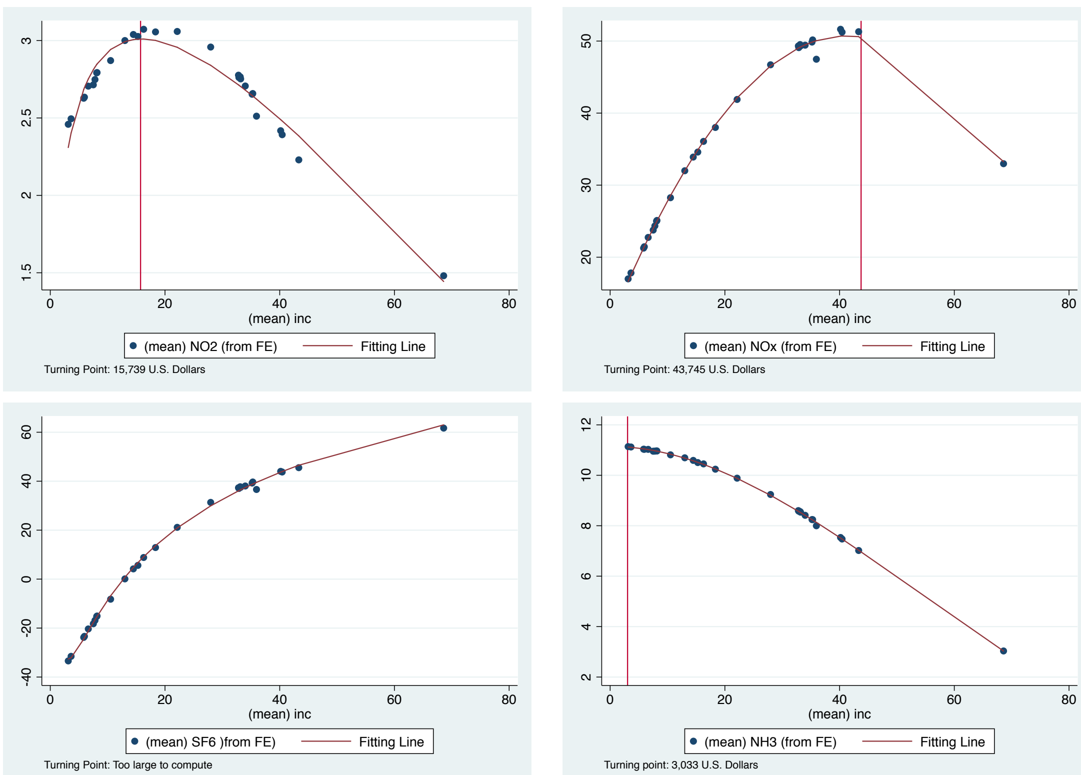
Graphs

Figure 1: Empirical Kuznets Curves and Turning Points



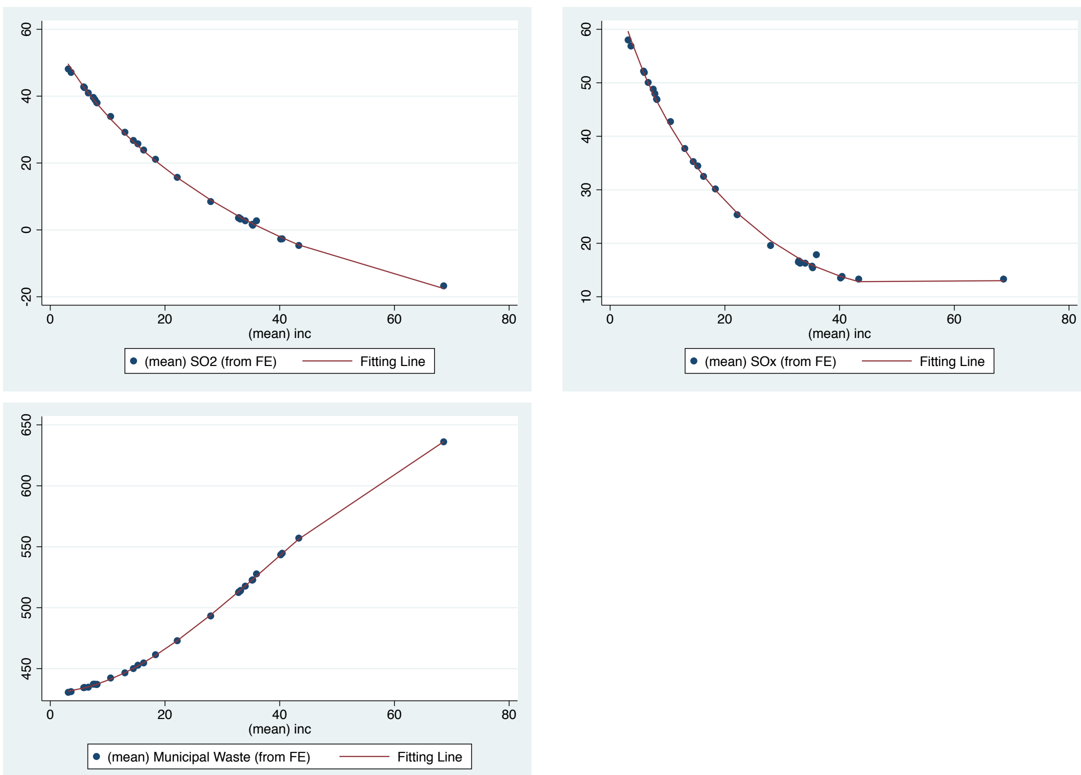
All the graphs in this Figure are based on the base representation in Model *M1*.

Figure 2: Empirical Kuznets Curves and Turning Points



All the graphs in this Figure are based on the base representation in Model *M1*.

Figure 3: Empirical Kuznets Curves and Turning Points



All the graphs in this Figure are based on the base representation in Model *M1*.