The effect of trade on the environment: Evidence from a meta-analysis

Sylvanus Kwaku Afesorgbor*and Binyam Afewerk Demena†

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Abstract

The effect of trade on the environment is theoretically ambiguous as overall effect depends on three components, scale, technique and composition effects. The scale effect increases environmental emissions through increased economic activities, while the technique effect decreases emissions through environmentally-friendly technological innovations. The composition effect measures the changes in the overall structure of the economy. The net effect of trade on emission depends on which component dominates. This theoretical ambiguity has been extended to empirical analysis. Results from previous research are fraught with contrasting outcomes of whether trade is good or bad for the environment. This project revisits the trade-environment nexus by conducting a meta-analysis using 88 studies. Our results show that trade contributes to environmental emissions. Accounting for heterogeneity, the result remains robust only for CO_2 emissions compared to SO_2. Overall, the trade elasticity of emission effect remains robust when we decompose the analysis for different groups of countries, however, the emission-content of trade is more pronounced for developed compared to developing countries.

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*Department of Food, Agricultural and Resource Economics, University of Guelph, Canada. Email: safesorg@uoguelph.ca

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1 Introduction

The pace of international trade has risen exponentially over the last century. This is confirmed by the World Bank development indicators which indicate that world trade as percentage of GDP has risen from 24 percent in 1960 to about 50 percent in 2016. This increase in world trade is in both value and volumes. In particular, WTO trade statistics indicate international trade has surged from about $6 trillion in 1999 to over $17 trillion in 2017. One important global concern is how to ensure that the increasing pace of global trade does not adversely affect the environment. How trade affects the environment has generated a lot of policy concerns and public pressure because anecdotal evidence shows a simultaneous surge in trade and environmental emissions globally. The UN through its sustainable development goals (SDGs 12-15) emphasizes the possibility of a trade-off relationship between trade and the environment by highlighting the direct linkage between production, consumption and natural resources depletion. Trend in global greenhouse gas (GhG) emissions indicates that GhG emissions are about 55% higher than in 1990 and 40% higher than in 2000 (Olivier et al., 2017). The heighten global concerns, along with the anecdotal evidence have generated a keen research interest both from theoretical and empirical perspectives.

From the theoretical perspectives, trade policy can lead to endogenous change in environmental policy and this can lead to an increase or a decrease in environmental emissions (Copeland and Scott Taylor, 2003). Antweiler et al. (2001) provide a plausible mechanism through trade openness can partially improve environmental quality. Through what they called the technique effect, trade openness would cause a rise in income levels in line with the popular evidence provided by Frankel and Romer (1999). This effect indirectly triggers a fall in pollution as producers switch to cleaner technologies with low emission intensity. The positive consequence of trade on environment is basically due to a higher demand for more environmentally friendly products as income rises. This is mainly because the environment is considered as a normal good (Copeland and Scott Taylor, 2003). In constrast, environmentalists have also argued that increased global trade generates increased production through economies of scale.[1] The growth in production directly contributes to over exploitation of the environment through increased production and consumption of pollution-intensive goods (Aklin, 2016). The environmentalists argue that the fundamental of the free market economy lacks the necessary impetus to efficiently allocate these environmental resources in a way that ensures the negative externalities are internalized.

Increasingly, many studies have also provided evidential support for each side of theoretical position. However, available empirical literature has rather deepened the uncertainty because of almost an equal split among researchers about the effect of trade on the environment. The uncertainty about the trade-environment nexus was acknowledged by van Bergeijk (1991) in the past, while a number of recent studies such as Rose and Stanley (2005), Managi et al. (2009) and Li et al. (2015) are also reiterating it. These studies acknowledge the rapidly growing literature as well as the contradictory position within the empirical literature. Reviewing the past and recent literature confirms the uncertainty in the results. This emphasizes the fact the trade-emission debate has been lingering on for a long time without a consensus. Figure 1 highlights the discrepancy that is endemic in the empirical literature. It shows a 50-50 split between the results that the trade elasticity of emission can either be positive or negative. The discrepancy also extends to the statistical significance of the effect as we see 55% indicating significant compared to 45% indicating insignificance.

[1] See, for example, https://www.greenpeace.org/archive-international/en/news/Blogs/makingwaves/globalisation-dark-side/blog/57141/, accessed on 4th April 2019

[Insert Figure 1 here]

Empirically, there are individual studies that argue strongly that increasing level of global trade would have deleterious effect on the environment. For example, Cole and Elliott (2003) find that trade liberalization increases the emissions of nitrogen oxide (NO_2) and carbon dioxide (CO_2). This negative effect of trade on the environment is similarly supported in a recent study by Shahbaz et al. (2017a). They indicate that trade openness increases environmental emissions through significant expansions in industrial output. As a result of rapid globalization and the quest to be competitive in global markets, both developing and developed countries cause greater energy utilization leading to potential emissions of CO_2. Other empirical studies that find similar results that trade impedes air quality for both developing and developed countries (Li et al., 2015) and intensifies pollution in non-OECD countries compared to OECD countries Managi et al. (2009). Contrary this popular view, there are also studies such as Eiras and Schaefer (2001), Frankel and Rose (2005), Kohler (2013) find that trade liberalization can be beneficial to the environment.

The conflicting position has implications for environmental policies in many countries as countries may be selective of research to support their actions or in-actions for the environment. Individually, many countries have also recognized the strong linkage between globalization and the environment and are thus making frantic effort to ensure that their quest to remain competitive globally is not achieved at the expense of the environment. In contrast, there are also many countries that have not taken the needed actions to operationalize and formalize their environmental commitments of reducing emissions. Shahbaz et al. (2017a) attribute this inaction on the part of some countries to the complexity and lack of consensus on trade-environmental linkage.

This therefore points to the fact having a consensus in the literature on the effect of trade on the environment may have wider political economy implications for many governments because trade-environment nexus is a sensitive and policy-relevant concern. The closest attempt made in the literature to derive a general consensus on trade-environmental linkage was done almost a decade ago by Kirkpatrick and Scrieciu (2008). Although Kirkpatrick and Scrieciu conclude that trade liberalization is bad for the environment, they employ just a conventional narrative review that relies on simple summaries instead of systematic and objective review like meta-analysis. A meta-analytical review is an important tool to objectively review literature and also explain the heterogeneity in the previous studies. By using meta-analysis, we can to filter out the personal biases and influences of the authors by controlling for biasing factors in econometric models (Stanley and Doucouliagos, 2012). Apart from the methodological challenge of Kirkpatrick and Scrieciu, the literature has also grown rapidly since their study was published in 2008.

These two opposing strands in the empirical literature make it necessary to re-visit the subject by conducting a thorough re-evaluation of trade's effect on the environment using a statistically rigorous approach. In response to the uncertainty, the main objective of this paper is to derive a general consensus in literature by employing a rigorous and systematic review of previous empirical studies. Using the tool of meta-analysis, we attempt to objectively determine whether the increasing level of international trade is good or bad for the environment. Specifically, the paper has three main objectives. First, to identify whether there is any genuine empirical impact of trade on environment beyond publication bias. Stanley and Doucouliagos (2012) indicate that publication selection bias is a potential source of spurious regression as there is a high tendency of over-representation of statistical significance as a result of the preference for significant results in hypothesis testing.

Second, to estimate the average effect size (ES) or magnitude of the trade-emission elasticity which would provide the underlying estimate of the effect of trade on emissions.This is important because policy-makers are particularly interested in knowing how changes in one variable (trade openness) would affect an outcome variable (emissions)., so it is imperative to identify the economic and statistical significance of the elasticities (Stanley and Doucouliagos, 2012). For instance, Copeland and Scott Taylor (2003) estimate that if trade liberalization increases economic activity by 1%, pollution concentrations would increase between the range of 0.25 - 0.5% while an increase in income per capita decreases pollution concentration by 1.25 - 1.5%. Through the size, we can derive the true and practical importance of trade-environment elasticities and thus to correctly determine partial effect of policies on outcome variables.

Third, the paper seeks to explain the heterogeneity in previously published empirical studies. The individual studies differ in various dimensions, including sampled countries, sample size, environmental pollutants (CO2, SO2, NOx), econometric models (linear or non-linear, random and fixed effects), and types of data (panel or cross-sectional). These differences can drive the heterogeneous results in the literature. Taking stock of the literature shows substantial heterogeneity in terms of different pollutants, countries, econometric methods, time period and empirical results.

The next section of the paper provides a theoretical underpinning for the study by looking at some of the possible mechanisms through which trade can affect the environment Section 3 discusses the data and the empirical strategy adopted in accordance with the Meta-Analysis Economic Research Network (MAER-NET) reporting guidelines. In Section 4, we provide and discuss the results from the standard empirical tools of the funnel asymmetric test (FAT) and precision effect test (PET). Section 5 concludes the paper and offers some policy implications.

2 Relationship between trade and the environment

A conceptual framework on trade and the environment linkage was developed by Grossman and Krueger (1993). They link how the formation of North America Free Trade Agreement (NAFTA) would affect the environment. They explain that the net effect of trade on environmental emissions would depend on these three components; scale, technique and composition effects. Using a general equilibrium model, Copeland and Scott Taylor (2003) develop a theoretical model that decomposes the net effect into the three components after taking into consideration the possible exogenous and endogenous variations that are likely to exist between trade and the environment policies.

According to Copeland and Scott Taylor, the scale effect measures the increase in environmental emissions as a result of an increase in value of production in the economy, holding constant the mix of goods and production techniques. This scale effect is an adverse effect of trade on the environment as the scaling up of the endowments of the economy also scale up the scale of production and emissions proportionately. The technique effect refers to improvements in the production methods through the adoption of climate-friendly technologies under exogenous pollution policy. However, under endogenous pollution policy, increasing level of income as a result of the gain from trade in line with Frankel and Romer (1999) leads the general public to demand for less pollution-intensive products thereby lower emissions. The composition effect measures the share of polluting goods in the total or national output. Depending on whether the pollution-intensive sector expands (contracts), this may be harmful (helpful) for the environment. The composition effect is ambiguous as this depends on changes in the structure of the economy. The net effect of trade on the environment depends on these three components and this effect can either be positive or negative depending on which of the effect dominates the others.

Since, the overall effect depends on these three effects, this introduces a theoretical uncertainty about the effect of trade on the environment. Empirically, a number of studies have tested this theoretical exposition by decomposing the trade effect on the environment into these three different components. For instance, Antweiler et al. (2001) confirm that the impact of trade on the environment can be positive or negative. Using the sulfur dioxide concentration, they show that trade-induced technique effect on pollutant concentration outweighs the scale effect, while the composition effect netting-off itself. Cole and Elliott (2003) also indicate that the net effect of trade in terms of sign and size on the environment depends to a large extent on the specific type of pollutant. In particular, they find that trade liberalization increases NO_x and CO_2 while it decreases the emission of SO_2.

In addition, endogenous variations in income per capita can have an influence on environmental policies across countries. This effect is captured by pollution haven hypothesis (PHH) which suggests that low-income countries would be made dirtier while high-income countries are made cleaner with international trade (Antweiler et al., 2001). Through the international movement of foreign investments, dirty capital-intensive production techniques would move from high-income countries to low-income. This mechanism was confirmed by Copeland and Scott Taylor (2003) in their pollution haven models of international trade in which they explain that trade may encourage pollution-intensive production processes to move from regions with high environmental standards to regions with low environmental standards. They explain further that the PHH relies on two key assumptions. First, the existence of different pollution regulations determines the production costs and industry location. Second, this different income levels lead to different environment regulations in countries as the environmental quality is considered a normal good. Although current empirical work by Eskeland and Harrison (2003) finds that foreign investors from developed countries move to sectors with high levels of pollution in developing countries, they find a weak evidence for PHH. They find that foreign firms pollute less than their domestic peers.

The PHH has direct implication for the effect of trade on environment as the effect would depend on the specific country or level of development of the country. Antweiler et al. (2001) emphasize this point by stating that it is implausible to only focus on how trade affects the environment, but rather suggest that trade should be conditioned on a country's characteristics. In evaluating the effect of NAFTA on the environment, Grossman and Krueger (1993) indicate that differential effect of the FTA for the US and Mexico. They explain that through the mechanism of comparative advantage, increased trade among the NAFTA member countries would lead to an expansion of the labor-intensive sector in Mexico while leading to an expansion of the capital-intensive sector in the US. With labor-intensive production being a less pollution-intensive sector, emission is possibly going to be lowered in Mexico. Conversely, the US may see an increase in emission because of capital-intensive production is more pollution-intensive.

This example provides a nuance that the effect of trade on the environment could be conditioned on a country's level of development. Different studies focus on a specific country as a case study or use a group of countries to assess the impact of trade on emission. The use of varying set of countries indicates countries at different level of development. Using a large sample of developing and developed countries, Kim et al. (2019) confirm the heterogeneous results of trade on CO_2 emission for different permutations of trade flows in terms of North-North, North-South, South-North and South-South trade. They find that for developed countries' trade with the North or the South, increases in trade flows lead to a reduction in CO_2 emission. Whereas for developing countries, their trade with the North leads to an increase in emissions, however trade among themselves rather mitigates emissions. These differential results point to the fact the effect of trade on environmental emissions can be influenced by various institutional, economic and political factors. Since, these factors differ for many countries and from one empirical studies to the other as they evaluate the effect of trade on emissions using different set of countries, different proxies to control for institutional, economic and political factors. Thus, to effectively account for this variation in the different studies, it is very important to employ multivariate meta-regression technique . By so doing, we can explain how country characteristics affect the trade effect on the environment as well as how different sets of control variables influence the reported results.

3 Data and Empirical strategy

3.1 Data

To conduct a meta-analysis, we collect data from previous empirical studies that estimate the trade impact on the environment. Following the MAER-Net reporting guidelines of Stanley et al. (2013), we identify the empirical studies that estimate the trade effect on the environment. To do this, we employ a search method from the economics and energy literature that commences with keywords such as trade, environment, econometrics from bibliographic databases including Google Scholar, Web of Science and Scopus. In addition, we use the snowballing technique by looking at the bibliographies of other studies. The search produces a large number of studies, over 17,900 individual studies from different publishers such as ScienceDirect, Wiley, Springer, Econpapers, Taylor and Francis and SSRN. The search period was between May to August 2018. The large number of the studies confirm that trade-environment nexus is a topical issue and hence conducting a meta-analysis is long overdue. However, we restrict the selection to journal articles and unpublished working papers that employed econometric approach in determining the effect of trade on the environment.[2]

In the identification of the relevant papers, we realize that some studies although adopt an econometric approach, but restrict their estimations to only Granger causality test rather than elasticities. Thus, we eliminate such studies from the identified sample of studies. Through the reading of the abstracts, we finally identify about 88 studies that were relevant for meeting our study objectives. Overall, the studies produce 779 elasticities. Table 1A in the appendix provides information of the studies used in our meta-analysis.

Data on elasticities (coefficients), standard errors (t-statistics), sample size, econometric methods and empirical settings (city or country) from the identified empirical papers were then collected. A typical econometric model estimated by the studies from which we collect the necessary statistics uses the log-log regression as specified in eqn.(1). The model is estimated at country level, where i and t capture the country and time respectively. The dependent variable is captured by $Emission_{it}$ which measures the

[2]The top five outlets in which the studies were published include Energy Policy – 11 studies, Renewable and Sustainable Energy Reviews – 9 studies , Environmental Science and Pollution Research - 6 studies, Economic Modeling - 5 studies and Natural Hazards – 4 studies

emissions of different environmental pollutants. The empirical studies use different types of environmental pollutants and these consist of 66% of the studies using CO_2, 19% using SO_2, while the remaining used other pollutants. Our main variable interest is the trade openness index which produces, δ that captures the trade-emission elasticity.

$$ln(Emission_{it}) = \beta_0 + \beta_1 ln(GDPpc)_{it} + \beta_2 + [ln(GDPpc_{it}]^2 + \beta_3 ln(\mathbf{C})_{it} + \delta ln(\frac{X+M}{GDP})_{it} + \alpha_i + \alpha_t + \epsilon_{it} \quad (1)$$

The main variable of interest in eqn.(1) is trade. The conventional approach, $\frac{export(X)+import(M)}{GDP}$ of measuring trade is dominant in the empirical studies. The studies selected mostly measure trade using the conventional definition of trade openness, hence making them comparable. However, some studies compute the trade openness as ratio or percentage.[3] In terms of the functional form, there were studies that employ log-linear form and thus instead estimated semi-elasticities rather than elasticities. With such studies, we employ the Delta method in Gujarati (2009) to transform these effect sizes and their standard errors from semi-elasticities into full elasticities using the means, thus making the estimates comparable. If semi-elasticity is reported (i.e., a log-linear functional form when the dependent variable is in log form whereas the independent variable is in level), we use the sample mean for the trade variable to convert the semi-elasticity into a full elasticity. A similar approach was used in a recent meta-analysis paper by Iršová and Havránek (2013).

In addition, the different studies used a varying set of control variables (C_{it}). Apart from including GDP per capita (pc) and its square term to test for Kuznets environment curve hypothesis, most studies also control for political, economic and institutional characteristics of the countries. These variables can also affect environmental quality in line with Torras and Boyce (1998) who show that literacy, political rights, and civil liberties tend to result in better environmental quality. In cases of panel regressions, the studies also control for individual country fixed effects (α_i) and time effects (α_t). However, there are also a studies that employ a time series model especially if they focused on a single country over different time dimension. In case of the time series estimation, the estimated model is similar to (1), but without the i dimension. Because of the similarity in the econometric model, especially the log-linear form, our coefficients are comparable across different studies. Although some studies employ different control variables, this could be accounted for by using the moderator regression analysis (MRA).

3.2 Empirical strategy

A meta-analysis involves collecting empirical estimates from previously published studies with the purpose of summarizing, integrating and synthesizing the combined ES of the contrasting studies (Stanley, 2005). The combination of different studies helps to derive more precision and investigates the discrepancies. Stanley (2001) indicates that combining the results taken from individual studies would give more insight and greater explanatory power. Historically, meta-analysis has long been a standard for evidence-based research in medicines (Stanley and Doucouliagos, 2012). Current application of meta-analysis approach in the trade as well as environmental literature include studies such as Afesorgbor (2017) and Cipollina and Salvatici (2010) examine the effect of regional trade agreements on trade; Rose and Stanley (2005) examine the effect of common currency on trade, while Cavlovic et al. (2000) examine the effect of income on the environment, Wehkamp et al. (2018) also conduct a meta-analysis on how forest governance affects deforestation and Choumert et al. (2013) look at whether environmental Kuznets curve exists between income and deforestation.

[3]Although not reported, our results remains robust when we decompose the results according to these different variants

[Insert Table 1 here]

For our empirical approach, we adopt two steps in line with the meta-analysis literature. In the first-step, we calculate the meta-average or the combined ES using both weighted and unweighted averages. According to Card (2015), to avoid the erroneous method of giving equal weight to estimates from different studies, it is important to also construct weighted averages using the variance as weights. Thus, in Table 1, we compute the simple and weighted average effect of trade openness on environmental emissions. The simple average shows a negative value contradicting that of the weighted average. However, in the presence of publication bias and heterogeneity, these mean values would be spurious.

$$\delta_j = \beta_0 + \beta_1 SE_j \tag{2}$$

To test and account for publication bias, we require the FAT-PET analysis which is specified in the eqn. (2), where j captures the individual studies. FAT is the funnel asymmetry test which is used to test the presence or absence of publication. In the FAT test, a simple regression of the effect sizes (δ_j) on standard errors (SE_j) is conducted. A significant parameter, β_1 indicates the presence of publication bias, because without publication bias, the effect sizes will be independent of the standard errors. Apart from econometric approach for testing publication bias, it can also be examined graphically (see the funnel plot in Figure 2). From, eqn. (2), we can also derive the precision effect test (PET) which indicates whether there is any genuine effect beyond publication bias. The coefficient, β_0 captures the PET and the size of the coefficient indicates the average effect of trade on environmental emission.

$$\delta_j = \beta_0 + \beta_1 SE_j + \beta_k \sum_{j=1}^{n} X_{kj} \tag{3}$$

In the second-step, a meta-regression or moderator analysis is conducted to determine how the differences in the individual studies affect the heterogeneity of the estimates. To do this, we augment eqn.(3) with the individual study characteristics (X_k). X_k represents the vector of variables that captures the individual heterogeneity in the studies (j). The MRA is relevant in order to filter out how the individual differences in the design of each empirical study affect the effect sizes reported. The relevant moderator variables are categorized into data,estimation and publication characteristics as well as macroeconomic, emissions and trade variables. Table 2 provides information on the detailed variables that were used for the moderator analysis.

[Insert Table 2 here]

In the estimation of these equations, there are some econometric concerns. First, there presence of outliers and this is evidenced by our funnel plot as we see the majority of the effect sizes are clustered around zero but some few estimates deviate from the rest. To deal with this and identify the possible outliers, we use the Hadi (1994) method to filter out simultaneously the effect sizes and their standard errors. This method has been identified as suitable for outliers in multivariate data and commonly used in various applications of meta-analysis (for recent literature, see Havranek and Irsova (2011); Demena and van Bergeijk (2017)). The application of this method resulted in the availability of 688 reported estimates for analysis after excluding 101 observations (13% of the reported elasticities). Second, the presence of heteroscedasticity makes ordinary least squares (OLS) econometrically infeasible to estimate the meta-regressions. Stanley and Doucouliagos (2012) indicate that since the effect sizes are coming from different studies, the variances of the effect sizes and the error terms would vary across studies and this violates the classical. Homoskedasticity is a relevant assumption in estimation of classical linear regression model. Thus, they strongly suggest using the weighted least squares (WLS) approach by dividing the equations by the standard errors of the effect sizes. Using the WLS approach solves the problem of heteroskedasticity as this makes the variance approximately constant. Mathematically, the WLS procedure means that eqn. (2) is equivalently estimated using eqn. (4). t_j is the t-statistics, while $\frac{1}{SE_j}$ is the precision of the effect size.

$$t_j = \beta_0 \frac{1}{SE_j} + \beta_1 \tag{4}$$

Another important empirical concern is the issue of within-study dependence which emanates from the practice of collecting multiple effect sizes from each study. To guard against this, we cluster the standard errors at the level of the individual study to address the issue of within-study correlation for all the different estimators. In addition, we also employ a fixed effect (FE) estimation that possibly also address the issue of individual within-variation. Apart from these, between-study dependence is also a concern as we have collected reported estimates across studies published by the same authors. This is an important concern as such reported estimates are likely to be correlated. Empirically, we have tested for the existence of between-study correlation applying the Breusch-Pagan Langrange multiplier (BP-LM) method. The BP-LM revealed between-study level effect of 558.32 with $p < 0.001$, statistically significant at 1% level for the presence between-study dependence. To account for this concern, we employ the mixed-effects multilevel (MEM) model as recommended by Stanley and Doucouliagos (2012). MEM is estimated through the restricted maximum likelihood. Importantly, the relevance of controlling for between-study correlation using the MEM has been emphasized in recent studies such as Demena and van Bergeijk (2017) and Havranek and Irsova (2011).

4 Results and discussion

4.1 Bivariate FAT-PET analysis

We present the bivariate results for the FAT-PET in Table 3. The results are estimated using three estimation techniques, OLS, FE and MEM, however, the MEM is our preferred method because it controls for both between and within heterogeneity. In all these estimations, we adjust for data by using the WLS and cluster at the individual study level. The results show that there is a genuine effect of trade on the environment. The positive effect size for the PET is consistent across the three different estimation methods. The positive coefficient indicates that trade openness leads to a significant increase in emission. Put differently, this means the more opened-economies contribute more in terms of global emissions. On the basis of the MEM estimator, the size of the coefficient indicates that a 1% increase in trade openness contributes to about 0.02% increase in environmental emissions. The magnitude of meta-average is also plausible as Cole and Elliott (2003) find that 1% increase in trade intensity increases emission for a median country by 0.04%. This confirms the race-to-bottom hypothesis that increases in trade stimulate the scale of economic activity and through the scale effect leads to an increase in emission. With increased global trade mostly accompanied with increases in capital-intensive production techniques that have high emission intensity (Copeland and Scott Taylor, 2003). The results therefore signals that the emission-increasing impacts of the scale and composition effects dominate the emission-reducing technique effect thereby resulting in a positive net effect that leads to an increased emission.

[Insert Table 3 here]

Turning to the FAT, our results indicate the absence of publication bias as the insignificance of the constant coefficient indicates that the effect sizes are independent of the standard errors. Thus, we can conclude objectively that there is no selection bias for significant effect sizes in the literature. The FAT result is also confirm by the funnel plot in Figure 2. The figure is a scatter plot of the relationship between the effect sizes and the their precision (Inverse of the standard errors). The figure is also symmetric from a pictorial point of view and that is in line with Stanley and Doucouliagos (2012) assertion that asymmetric funnel is an antecedent for publication bias.

[**Insert Figure 2 here**]

The level of development of a country also dictates the depth of integration of that country in global trade. Frankel and Romer (1999) provide a robust evidence by stating that countries that trade more experience higher economic growth as trade raise income by spurring the accumulation of physical and human capital and by increasing output for given levels of capital. Similarly, the level of development of a country is an important determinant of pollution. Copeland and Scott Taylor (2003) argue that changes in per capita income will lead to an increase in the demand for lower environmental emission. In line with these arguments, we decompose the results for studies that use countries at the different level of development. We classify the countries into two main groups; developing and developed on the basis of United Nations (UN) classification. To account for studies that used a mix of these groups, we add another category for studies that include both developing and developed countries. Table 4 presents the FAT-PET results for different groups of countries. Consistently we find that trade increases emission under the three different categories of countries. Although, the results are similar qualitatively in terms of sign of the PET coefficient, quantitatively, the size or magnitude differs. We find a pronounced effect for developed countries compared to developing countries. Intuitively, this makes sense as developed countries are more-opened economies, thus are expected to have a higher emission compared to developing countries.

[**Insert Table 4 here**]

4.2 Multivariate analysis

In addition to the bivariate analysis, we also conduct a multivariate or moderator analysis in order to account for the heterogeneity in the studies. This is important as the effect sizes reported in the empirical studies would depend on several factors such as different countries, pollutants, time period methodology and relevant explanatory variables. Stanley and Doucouliagos (2012) highlight that if the heterogeneity is non-random, then the results from bivariate analysis may be biased. Econometrically, we can account for the heterogeneity in line with the MAER-Net guidelines by Stanley et al. (2013) by coding explicitly any differences in dimensions such as data, estimation and publication of the empirical studies.

To capture these dimensions, we use dummy variables as defined in Table 1 that could potentially explain the effect sizes. However, because of the high dimensionality of the moderator variables, we employ the general-to-specific (G-to-S) approach. The G-to-S approach begins with the inclusion of the potential moderator variables in the equation (3) and then removing the least significant variable one at time until only statistically significant variables remain (Stanley and Doucouliagos, 2012). According to them, the G-to-S approach has an added advantage of improving the degree- of-freedom and also avoid the situation of multicollinearity. Table 5 report the results for the multivariate analysis.

[**Insert Table 5 here**]

The genuine effect of trade on the environment remains robust even after accounting for various dimension of heterogeneity. The PET finds a positive and significant coefficient for the trade-emission elasticity. Thus, confirming the robustness of the result that trade spurs environmental emission. The result for FAT also confirms the absence of publication bias. In terms of how the different moderator variables affect the effect sizes. First of all, the estimation methods employed have a negative and significant effect. This means that studies that employ OLS or FE tend to report lower effect sizes. Similarly, the double logarithmic functional form leads to less pronounced effect of trade openness on environmental emission. Conversely, including country fixed effects in the regression models also produces a greater effect size. Similarly, studies that define trade openness in terms of exports plus imports as a percentage of GDP as compared to ratio find a more pronounced effect of trade on emission. Importantly, we find that the choice of the pollutant matters and has an underlying effect on the trade-emission elasticity. Studies that use CO_2 as a pollutant find larger effect compared to studies that used SO_2 finding a less pronounced effect. Controlling for urbanization also produces a lesser effect size. For the publication characteristics, our results show that year of publication has a negative and significant. In that the more recent studies produce lower effect size. Apart from these, studies that have been reviewed and published in journal tend to have a greater impact. Lastly, the quality of the paper in terms of the number of citations has a negative and significant effect on the effect size.

[**Insert Table 6 here**]

4.3 Robustness

We conduct two main robustness checks by running the multivariate analysis for different groups of countries and also for different pollutants. Table 6 presents the results for different groups of countries. Consistently, we find that there is a genuine underlying effect of trade on environment irrespective of the country of study. From the qualitative point of view, the results indicate trade-emission elasticity is positive and significant for both developing and developed economies. Quantitatively, we again find the trade-emission elasticity is more pronounced for developed countries than for developing countries. For studies that mixed these groups of countries (both), although the effect is positive and this not significant. Our second robustness estimates the multivariate regression for different pollutants. Interesting we find that trade-emission elasticity is positive and strongly significant a study used CO_2 as dependent variable. Although, the trade-emission elasticity is positive for SO_2 the effect is not statistically significant. This differential effect on CO_2 and SO_2 is in line with Frankel and Rose (2005). They argue CO_2 has a free-rider problem as its adverse effects transcend national borders. Thus, individual countries are less committed to reduce the carbon emissions, especially for the reason of remaining competitive in the global market.

[**Insert Table 7 here**]

5 Conclusion

Without doubt, the effect of trade on the environment is a controversial topic. Although there is a rapidly growing literature of the linkage between trade and the environment, there is no iota of certainty about the underlying and true effect as there is a wide range of conclusions from even similar studies. Thus, the simple question of whether trade is good or bad for the environment has received a great deal of attention both theoretically and empirically, however, we are far from reaching a definite conclusion or consensus. This paper makes the first attempt to synthesize the trade-emission effect size by employing the tool of meta-analysis which is the most objective and quantitatively rigorous approach to do a systematic review of empirical literature.

Our results, first of all discount the presence of publication bias in the literature. This means that, the personal bias of researchers, reviewers and editors does not follow any systematic trend in the literature. After accounting for publication bias, we find that trade increases emission level. Specifically, employing the FAT-PET analysis in the accordance with the MAER-Net guidelines, we find that a 1% increase in trade openness of a country leads to between 0.04 – 0.06% increase in the level of emission. The magnitude of the effect size depends on whether a country is developed or developing as we find a more pronounced effect for developed economies. Overall, increase in trade intensity would increase environmental emissions due to a large scale effect that dominates technique effect. This finding supports the view that globalization creates competition, resulting in the adoption of loose-environmental production techniques. The increased production coupled with increased global demand indirectly contribute to the exploitation of the environment and the depletion of natural resources. The results are consistent for different pollutants as well as for different grouping of countries (developing and developed countries).

With a large heterogeneity among the empirical studies, it is imperative that we account for differences in the study designs of the previous empirical studies. By accounting for the heterogeneity, we can also explain how specific differences such as data, publication, estimation and other variations affect the validity of the results. Using moderator regression analysis and general to specific modeling approach, we find that the positive effect of trade on environmental emission is strongly robust. For the various dimensions of the study that affect the effect sizes, we find that estimation techniques (OLS or FE) significantly reduces the trade-emission elasticity. In addition, the functional form of the regression model, the inclusion of country fixed effects, the definition of trade openness as exports and imports as percentage of GDP, the type of pollutant, the inclusion of urbanization as an additional control variables, the year of publication, the number of citations and whether a study has been published or not all have significant effect on the effect size.

The findings of the study may have some an interesting policy implications as trade and the environment linkage is a sensitive subject for policy-makers. Our results that trade certainly contributes to increased global emission highlight the importance of making trade policies more compatible with sustainable environment policies. This emphasizes that environmental taxes should be aligned with a firm's participation in global trade. This also reinforces the relevance of including the distribution component in the calculations of carbon taxes. The results also put WTO in the limelight as it may be required that they play a directly active role in clamping down environmental emissions. WTO could use the gains associated with global trade as effective bargaining strategies or an incentive to demand environmental accountability from countries hoping to benefit from global trading systems.

References

Afesorgbor, S. K. 2017. Revisiting the effect of regional integration on african trade: evidence from meta-analysis and gravity model. *The Journal of International Trade & Economic Development*, *26*(2), 133–153.

Akin, C. S. 2014. The impact of foreign trade, energy consumption and income on co2 emissions. *International Journal of Energy Economics and Policy*, *4*(3), 465.

Aklin, M. 2016. Re-exploring the trade and environment nexus through the diffusion of pollution. *Environmental and Resource Economics*, *64*(4), 663–682.

Ali, H. S., Law, S. H., and Zannah, T. I. 2016. Dynamic impact of urbanization, economic growth, energy consumption, and trade openness on CO2 emissions in Nigeria. *Environmental Science and Pollution Research*, *23*(12), 12435–12443.

Aller, C., Ductor, L., and Herrerias, M. J. 2015. The world trade network and the environment. *Energy Economics*, *52*, 55–68.

Al-Mulali, I., Usama Ozturk, and Lean, H. H. 2015. The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on pollution in Europe. *Natural Hazards*, *79*(1), 621–644.

Al-mulali, U. 2012. Factors affecting CO2 emission in the Middle East: A panel data analysis. *Energy*, *44*(1), 564–569.

Al-Mulali, U., Saboori, B., and Ozturk, I. 2015. Investigating the environmental kuznets curve hypothesis in vietnam. *Energy Policy*, *76*, 123–131.

Al-Mulali, U., Solarin, S. A., and Ozturk, I. 2016. Investigating the presence of the environmental Kuznets curve (EKC) hypothesis in Kenya: an autoregressive distributed lag (ARDL) approach. *Natural Hazards*, *80*(3), 1729–1747.

Antweiler, W., Copeland, B. R., and Taylor, M. S. 2001. Is free trade good for the environment? *American Economic Review*, *91*(4), 877–908.

Atici, C. 2009. Carbon emissions in Central and Eastern Europe: environmental Kuznets curve and implications for sustainable development. *Sustainable Development*, *17*(3), 155–160.

Atici, C. 2012. Carbon emissions, trade liberalization, and the Japan–ASEAN interaction: A group-wise examination. *Journal of the Japanese and International Economies*, *26*(1), 167–178.

Aung, T. S., Saboori, B., and Rasoulinezhad, E. 2017. Economic growth and environmental pollution in Myanmar: an analysis of environmental Kuznets curve. *Environmental Science and Pollution Research*, *24*(25), 20487–20501.

Ayeche, M. B., Barhoumi, M., and Hammas, M. A. 2016. Causal linkage between economic growth, financial development, trade openness and CO2 emissions in European Countries. *American Journal of Environmental Engineering*, *6*(4), 110–122.

Baghdadi, L., Martinez-Zarzoso, I., and Zitouna, H. 2013. Are RTA agreements with environmental provisions reducing emissions? *Journal of International Economics*, *90*(2), 378–390.

Bernard, J., and Mandal, S. 2016. The impact of trade openness on environmental quality: An empirical analysis of emerging and developing economies. *WIT Transactions on Ecology and the Environment*, *203*, 195–208.

Boutabba, M. A. 2014. The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy. *Economic Modelling*, *40*, 33–41.

Bouznit, M., and Pablo-Romero, M. d. P. 2016. CO2 emission and economic growth in Algeria. *Energy Policy*, *96*, 93–104.

Card, N. A. 2015. *Applied meta-analysis for social science research.* Guilford Publications.

Cavlovic, T. A., Baker, K. H., Berrens, R. P., and Gawande, K. 2000. A meta-analysis of environmental Kuznets curve studies. *Agricultural and Resource Economics Review*, *29*(1), 32–42.

Çetin, M., and Ecevit, E. 2017. The impact of financial development on carbon emissions under the structural breaks: Empirical evidence from Turkish economy. *International Journal of Economic Perspectives*, *11*(1), 64–78.

Charfeddine, L., and Khediri, K. B. 2016. Financial development and environmental quality in UAE: Cointegration with structural breaks. *Renewable and Sustainable Energy Reviews*, *55*, 1322–1335.

Choi, E., Heshmati, A., and Cho, Y. 2010. An empirical study of the relationships between CO2 emissions, economic growth and openness.

Choumert, J., Motel, P. C., and Dakpo, H. K. 2013. Is the Environmental Kuznets Curve for deforestation a threatened theory? A meta-analysis of the literature. *Ecological Economics*, *90*, 19–28.

Cipollina, M., and Salvatici, L. 2010. Reciprocal trade agreements in gravity models: A meta-analysis. *Review of International Economics*, *18*(1), 63–80.

Cole, M. A., and Elliott, R. J. 2003. Determining the trade–environment composition effect: The role of capital, labor and environmental regulations. *Journal of Environmental Economics and Management*, *46*(3), 363–383.

Copeland, R., Brian, and Scott Taylor, M. 2003. *Trade and the environment. Theory and evidence.* Princeton University Press, Princeton and Oxford.

Demena, B. A., and van Bergeijk, P. A. 2017. A meta-analysis of FDI and productivity spillovers in developing countries. *Journal of Economic Surveys*, *31*(2), 546–571.

de Sousa, J., Hering, L., Poncet, S., et al. 2015. *Has trade openness reduced pollution in China?* (Tech. Rep.).

Dogan, E., and Seker, F. 2016. An investigation on the determinants of carbon emissions for OECD countries: empirical evidence from panel models robust to heterogeneity and cross-sectional dependence. *Environmental Science and Pollution Research*, *23*(14), 14646–14655.

Dogan, E., Seker, F., and Bulbul, S. 2017. Investigating the impacts of energy consumption, real GDP, tourism and trade on CO2 emissions by accounting for cross-sectional dependence: A panel study of OECD countries. *Current Issues in Tourism*, *20*(16), 1701–1719.

Dogan, E., and Turkekul, B. 2016. CO 2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. *Environmental Science and Pollution Research*, *23*(2), 1203–1213.

Eiras, A., and Schaefer, B. 2001. Trade: The best way to protect the environment. *The Heritage Foundation*(1480).

Eskeland, G. S., and Harrison, A. E. 2003. Moving to greener pastures? Multinationals and the pollution haven hypothesis. *Journal of development economics*, *70*(1), 1–23.

Farhani, S., Chaibi, A., and Rault, C. 2014. CO2 emissions, output, energy consumption, and trade in Tunisia. *Economic Modelling*, *38*, 426–434.

Farhani, S., and Ozturk, I. 2015. Causal relationship between CO2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia. *Environmental Science and Pollution Research*, *22*(20), 15663–15676.

Farzanegan, M. R., and Markwardt, G. 2012. *Pollution, economic development and democracy: evidence From the MENA countries* (Tech. Rep.). Joint Discussion Paper Series in Economics.

Fotros, M. H., and Maaboudi, R. 2011. Trade openness and CO2 emissions in Iran, 1971-2008.

Frankel, J. A., and Romer, D. H. 1999. Does trade cause growth? *American economic review*, *89*(3), 379–399.

Frankel, J. A., and Rose, A. K. 2005. Is trade good or bad for the environment? Sorting out the causality. *Review of economics and statistics*, *87*(1), 85–91.

Gani, A. 2012. The relationship between good governance and carbon dioxide emissions: Evidence from developing economies. *Journal of Economic Development*, *37*(1), 77.

Grossman, G. M., and Krueger, A. B. 1993. *Environmental impacts of a North American free trade agreement* (Tech. Rep.). National Bureau of Economic Research.

Gu, Z., and Li, J. 2014. A Comparative analysis on carbon emission Eeffect of trade in Eastern, Middle and Western Regions in China. In *3rd international conference on science and social research (icssr 2014).*

Gujarati, D. N. 2009. *Basic econometrics.* Tata McGraw-Hill Education.

Hadi, A. S. 1994. A modification of a method for the detection of outliers in multivariate samples. *Journal of the Royal Statistical Society. Series B (Methodological)*, 393–396.

Hakimi, A., and Hamdi, H. 2016. Trade liberalization, FDI inflows, environmental quality and economic growth: a comparative analysis between Tunisia and Morocco. *Renewable and Sustainable Energy Reviews*, *58*, 1445–1456.

Havranek, T., and Irsova, Z. 2011. Estimating vertical spillovers from FDI: Why results vary and what the true effect is? *Journal of International Economics*, *85*(2), 234–244.

He, J., and Richard, P. 2010. Environmental Kuznets curve for CO2 in Canada. *Ecological Economics*, *69*(5), 1083–1093.

Hossain, M. S. 2011. Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. *Energy Policy*, *39*(11), 6991–6999.

Hossain, N. A., and Hasanuzzaman, S. 2012. *The Impact of energy consumption, urbanization, financial development, and trade openness on the environment in Bangladesh: An ARDL Bound Test Approach.*

Hossain, S. 2012. An econometric analysis for CO2 emissions, energy consumption, economic growth, foreign trade and urbanization of Japan. *Low Carbon Economy*, *3*(3).

Iršová, Z., and Havránek, T. 2013. Determinants of horizontal spillovers from FDI: Evidence from a large meta-analysis. *World Development*, *42*, 1–15.

Islam, F., and Shahbaz, M. 2012. *Is there an environmental Kuznets curve for Bangladesh?* (Tech. Rep.). University Library of Munich, Germany.

Jalil, A., and Feridun, M. 2011. The impact of growth, energy and financial development on the environment in China: a cointegration analysis. *Energy Economics*, *33*(2), 284–291.

Jalil, A., and Mahmud, S. F. 2009. Environment Kuznets curve for CO2 emissions: a cointegration analysis for China. *Energy policy*, *37*(12), 5167–5172.

Jamel, L., and Maktouf, S. 2017. The nexus between economic growth, financial development, trade openness, and CO2 emissions in European countries. *Cogent Economics & Finance*, *5*(1), 1341456.

Jayanthakumaran, K., Verma, R., and Liu, Y. 2012. CO2 emissions, energy consumption, trade and income: a comparative analysis of China and India. *Energy Policy*, *42*, 450–460.

Jebli, M. B., and Youssef, S. B. 2015. The environmental Kuznets curve, economic growth, renewable and non-renewable energy, and trade in Tunisia. *Renewable and Sustainable Energy Reviews*, *47*, 173–185.

Jorgenson, A. K. 2007. Does foreign investment harm the air we breathe and the water we drink? A cross-national study of carbon dioxide emissions and organic water pollution in less-developed countries, 1975 to 2000. *Organization & Environment*, *20*(2), 137–156.

Jorgenson, A. K. 2009. Foreign direct investment and the environment, the mitigating influence of institutional and civil society factors, and relationships between industrial pollution and human health: A panel study of less-developed countries. *Organization & Environment*, *22*(2), 135–157.

Kang, Y.-Q., Zhao, T., and Yang, Y.-Y. 2016. Environmental Kuznets curve for CO2 emissions in China: A spatial panel data approach. *Ecological indicators*, *63*, 231–239.

Kasman, A., and Duman, Y. S. 2015. CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: a panel data analysis. *Economic Modelling*, *44*, 97–103.

Kearsley, A., and Riddel, M. 2010. A further inquiry into the Pollution Haven Hypothesis and the environmental Kuznets curve. *Ecological Economics*, *69*(4), 905–919.

Keho, Y. 2016. Trade openness and the environment: A time series study of ECOWAS countries. *Journal of Economics*, *4*(4), 61–69.

Kim, D.-H., Suen, Y.-B., and Lin, S.-C. 2019. Carbon dioxide emissions and trade: Evidence from disaggregate trade data. *Energy Economics*, *78*, 13–28.

Kirkpatrick, C., and Scrieciu, S. S. 2008. Is trade liberalisation bad for the environment? A review of the economic evidence. *Journal of Environmental Planning and Management*, *51*(4), 497–510.

Kleemann, L., and Abdulai, A. 2013. The impact of trade and economic growth on the environment: Revisiting the cross-country evidence. *Journal of International Development*, *25*(2), 180–205.

Kohler, M. 2013. CO2 emissions, energy consumption, income and foreign trade: A South African perspective. *Energy Policy*, *63*, 1042–1050.

Le, T.-H., Chang, Y., and Park, D. 2016. Trade openness and environmental quality: International evidence. *Energy policy*, *92*, 45–55.

Li, T., Wang, Y., and Zhao, D. 2016. Environmental Kuznets curve in China: new evidence from dynamic panel analysis. *Energy Policy*, *91*, 138–147.

Li, Z., Xu, N., and Yuan, J. 2015. New evidence on trade-environment linkage via air visibility. *Economics Letters*, *128*, 72–74.

Lim, S., Menaldo, V., and Prakash, A. 2015. Foreign aid, economic globalization, and pollution. *Policy Sciences*, *48*(2), 181–205.

Lin, F. 2017. Trade openness and air pollution: City-level empirical evidence from China. *China Economic Review*, *45*, 78–88.

Managi, S., Hibiki, A., and Tsurumi, T. 2009. Does trade openness improve environmental quality? *Journal of environmental economics and management*, *58*(3), 346–363.

McCarney, G. R., Adamowicz, W. L., et al. 2005. The effects of trade liberalization on the environment: An empirical study. In *Annual meeting, july 6-8, 2005, san francisco, ca.*

Nasir, M., and Rehman, F. U. 2011. Environmental Kuznets curve for carbon emissions in Pakistan: an empirical investigation. *Energy Policy*, *39*(3), 1857–1864.

Nolen, E. C. J., Cantú, J. d. J. S., Guajardo, R. C. R., and García, H. G. 2017. Free trade and pollution in the manufacturing industry in Mexico: A verification of the inverse Kuznets curve at a state level. *Ensayos Revista de Economía (Ensayos Journal of Economics)*, *29*(2).

Oganesyan, M. 2017. *Carbon emissions, energy consumption and economic growth in the BRICS.*

Ohlan, R. 2015. The impact of population density, energy consumption, economic growth and trade openness on CO2 emissions in India. *Natural Hazards*, *79*(2), 1409–1428.

Olivier, J. G., Schure, K., and Peters, J. 2017. Trends in global CO2 and total greenhouse gas emissions. *PBL Netherlands Environmental Assessment Agency*.

Onoja, A. O., Ajie, E., and Achike, A. 2014. Econometric analysis of influences of trade openness, economic growth and urbanization on greenhouse gas emissions in Africa (1960-2010). *Journal of Economics and Sustainable Development*, *5*(10), 85–93.

Opoku, E., Amoako, S., and Amankwa, I. 2014. Trade openness, economic growth and the environment: The case of Ghana. *International Journal of Economics, Commerce and Management*, *2*(8), 1–13.

Ozatac, N., Gokmenoglu, K. K., and Taspinar, N. 2017. Testing the EKC hypothesis by considering trade openness, urbanization, and financial development: The case of Turkey. *Environmental Science and Pollution Research*, *24*(20), 16690–16701.

Ozturk, I., and Acaravci, A. 2013. The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. *Energy Economics*, *36*, 262–267.

Pazienza, P. 2015. The relationship between CO2 and Foreign Direct Investment in the agriculture and fishing sector of OECD countries: Evidence and policy considerations. *Intellectual Economics*, *9*(1), 55–66.

Phimphanthavong, H., et al. 2013. The impacts of economic growth on environmental conditions in Laos. *International Journal of Business Management and Economic Research*, *4*(5), 766–774.

Poncet, S., Hering, L., de Sousa, J., et al. 2015. *Has trade openness reduced pollution in China?* (Tech. Rep.).

Rafindadi, A. A. 2016a. Does the need for economic growth influence energy consumption and CO2 emissions in Nigeria? Evidence from the innovation accounting test. *Renewable and Sustainable Energy Reviews*, *62*, 1209–1225.

Rafindadi, A. A. 2016b. Revisiting the concept of environmental Kuznets curve in period of energy disaster and deteriorating income: Empirical evidence from Japan. *Energy Policy*, *94*, 274–284.

Rose, A. K., and Stanley, T. D. 2005. A meta-analysis of the effect of common currencies on international trade. *Journal of economic surveys*, *19*(3), 347–365.

Saidi, K., and Mbarek, M. B. 2017. The impact of income, trade, urbanization, and financial development on CO2 emissions in 19 emerging economies. *Environmental Science and Pollution Research*, *24*(14), 12748–12757.

Salahuddin, M., Alam, K., and Ozturk, I. 2016. The effects of Internet usage and economic growth on CO2 emissions in OECD countries: A panel investigation. *Renewable and Sustainable Energy Reviews*, *62*, 1226–1235.

Sbia, R., Shahbaz, M., and Hamdi, H. 2014. A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. *Economic Modelling*, *36*, 191–197.

Sehrawat, M., Giri, A., and Mohapatra, G. 2015. The impact of financial development, economic growth and energy consumption on environmental degradation: Evidence from India. *Management of Environmental Quality: An International Journal*, *26*(5), 666–682.

Shahbaz, H. Q. M. A. T. A. K., Muhammad, and Leitão, N. C. 2013. Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews*, *25*, 109–121.

Shahbaz, M., Lean, H. H., and Shabbir, M. S. 2012. Environmental Kuznets curve hypothesis in Pakistan: Cointegration and Granger causality. *Renewable and Sustainable Energy Reviews*, *16*(5), 2947–2953.

Shahbaz, M., Nasreen, S., Ahmed, K., and Hammoudeh, S. 2017a. Trade openness–carbon emissions nexus: The importance of turning points of trade openness for country panels. *Energy Economics*, *61*, 221–232.

Shahbaz, M., Tiwari, A. K., and Nasir, M. 2013. The effects of financial development, economic growth, coal consumption and trade openness on CO2 emissions in South Africa. *Energy Policy*, *61*, 1452–1459.

Shahbaz, M., Uddin, G. S., Rehman, I. U., and Imran, K. 2014. Industrialization, electricity consumption and CO2 emissions in Bangladesh. *Renewable and Sustainable Energy Reviews*, *31*, 575–586.

Shahzad, S. J. H., Kumar, R. R., Zakaria, M., and Hurr, M. 2017b. Carbon emission, energy consumption, trade openness and financial development in Pakistan: A revisit. *Renewable and Sustainable Energy Reviews*, *70*, 185–192.

Solarin, S. A., Al-Mulali, U., Musah, I., and Ozturk, I. 2017. Investigating the pollution haven hypothesis in Ghana: an empirical investigation. *Energy*, *124*, 706–719.

Stanley, T. D. 2001. Wheat from chaff: Meta-analysis as quantitative literature review. *Journal of Economic Perspectives*, *15*(3), 131–150.

Stanley, T. D. 2005. Beyond publication bias. *Journal of Economic Surveys*, *19*(3), 309–345.

Stanley, T. D., and Doucouliagos, H. 2012. *Meta-regression analysis in economics and business* (Vol. 5). Routledge.

Stanley, T. D., Doucouliagos, H., Giles, M., Heckemeyer, J. H., Johnston, R. J., Laroche, P., ... others 2013. Meta-analysis of economics research reporting guidelines. *Journal of Economic Surveys*, *27*(2), 390–394.

Sulaiman, J., Azman, A., and Saboori, B. 2013. Evidence of the environmental Kuznets curve: implications of industrial trade data. *American Journal of Environmental Sciences*, *9*(2), 130.

Sun, C., Zhang, F., and Xu, M. 2017. Investigation of pollution haven hypothesis for China: an ARDL approach with breakpoint unit root tests. *Journal of Cleaner Production*, *161*, 153–164.

Torras, M., and Boyce, J. K. 1998. Income, inequality, and pollution: a reassessment of the environmental kuznets curve. *Ecological economics*, *25*(2), 147–160.

ul Haq, I., Zhu, S., and Shafiq, M. 2016. Empirical investigation of environmental Kuznets curve for carbon emission in Morocco. *Ecological indicators*, *67*, 491–496.

van Bergeijk, P. A. 1991. International trade and the environmental challenge. *J. World Trade*, *25*, 105.

Wehkamp, J., Koch, N., Lübbers, S., and Fuss, S. 2018. Governance and deforestation?A meta-analysis in economics. *Ecological Economics*, *144*, 214–227.

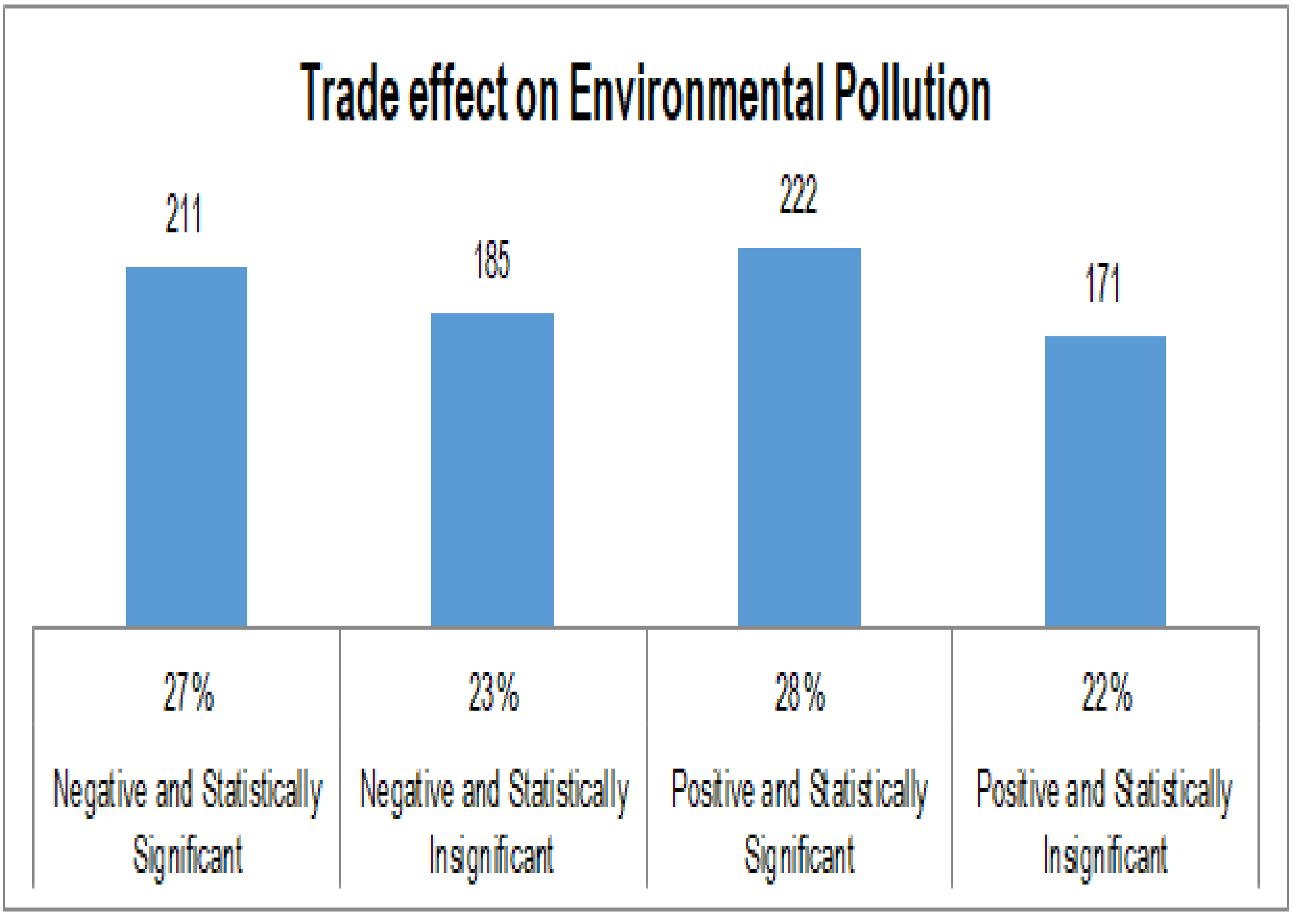
Yazdi, S. K., and Mastorakis, N. 2014. Renewable, CO2 emissions, trade openness, and economic growth in Iran. *Latest Trend in Energy, Enviroment and Development*, *25*, 360–370.

You, W.-H., Zhu, H.-M., Yu, K., and Peng, C. 2015. Democracy, financial openness, and global carbon dioxide emissions: Heterogeneity across existing emission levels. *World Development*, *66*, 189–207.

Zerbo, E. 2015. CO2 emissions, growth, energy consumption and foreign trade in Sub-Sahara African countries.

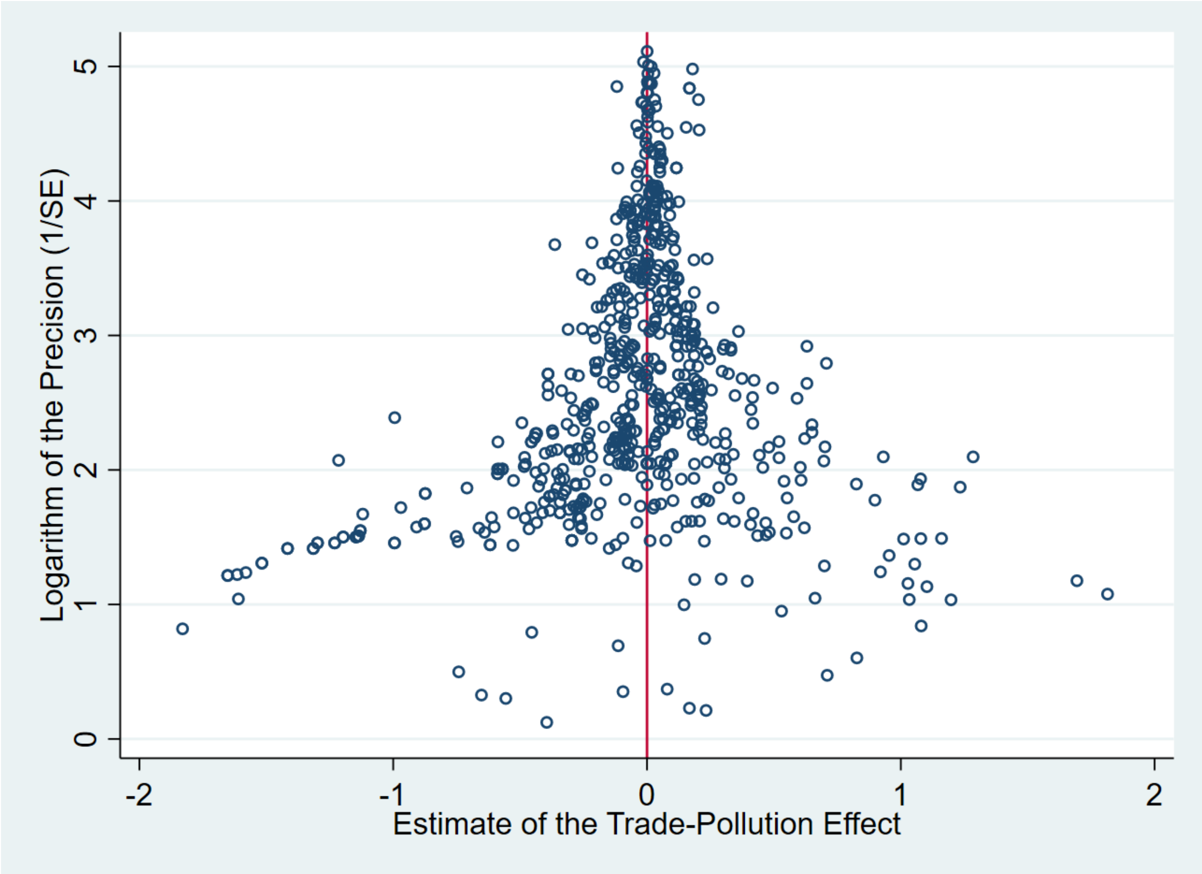
Zhang, B., Wang, Z., Wang, B., et al. 2018. Energy production, economic growth and CO2 emission: evidence from Pakistan. *Natural Hazards*, *90*(1), 27–50.

Zhu, H., Duan, L., Guo, Y., and Yu, K. 2016. The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: Evidence from panel quantile regression. *Economic Modelling*, *58*, 237–248.



Data Source: Based on studies for the meta-analysis

Figure 1: The trade-emission elasticity reported in the studies published in 2001-2018 (N=1296)



Data Source: Based on studies for the meta-analysis

Figure 2: The Funnel Plot: Relationship between precision and effect sizes)

Table 1: Simple and weighted means of the trade-emission elasticity

	(1)	(2)	(3)	(4)
Method	Effect size	S.E	95% confidence interval	
Simple average effect[a]	-0.020	0.019	-0.0506	0.017
Weighted average effect[b]	0.011	0.008	-0.04	0.027

Notes: a represents the arithmetic mean of the trade-emission elasticity, and b uses inverse variance as weight.
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Definition and descriptive statistics of collected variables

Moderator Variables	Definition	Mean	St. Dev.
Outcome Characteristics			
E	Trade-emission elasticity	-0.02	0.490
SE	Standard error of elasticity	0.174	0.428
Data Characteristics			
LOG DURATION OF DATA	Logarithm of the number of years of the data used	3.17	.662
LOG OBSERVATIONS	Logarithm of number of observations	5.45	1.714
LOG NUMBER OF COUNTRIES	Logarithm of number of countries	1.855	1.603
PANEL	=1 if data set type is panel	.51	.5
TIME SERIES	=1 if data set type is time series	.467	.499
DATA SOURCE	=1 if data come from international sources	.821	.383
Estimation Characteristics			
SHORT_RUN	=1 if estimated elasticity is short-run	.747	.435
LONG RUN	=1 if estimated elasticity is long-run	.253	.435
OLS	=1 if estimation method is OLS	.185	.388
FE	=1 if estimation method is fixed effects	.124	.329
ENDOGENEITY	=1 if endogeneity is controlled for	.516	.5
DOUBLE LOG	=1 if the coefficient is taken from a log-log form	.59	.492
YEAR FE	=1 if year fixed effects are included	.359	.48
COUNTRY FE	=1 if country fixed effects are included	.432	.496
LAG	=1 if effect size represents lagged trade variable	.07	.255
Macroeconomic conditions			
GDP	=1 if GDP is included	0.822	0.268
INSTITUTION	=1 if institutional variable is included	0.292	0.453
ENEGY CONSUMPTION	=1 if energy consumption is controlled for	0.574	0.495
URBANIZATION	=1 if urbanization variable is controlled for	0.535	0.495
Emission Variables			
CARBON DIOXIDE	=1 if dependent is measured with carbon dioxide emission	.658	.475
SULFUR DIOXIDE	=1 if dependent is measured with sulfur dioxide emission	.189	.392
OTHER POLLUTANTS	=1 if dependent is measured with other pollution measures	.172	.377
Trade Variables			
TRADE OPENNES (VALUES)	=1 if trade measured with values of export and import	.125	.331
TRADE OPENNESS (RATIO)	=1 if trade measured at per capita level	.642	.48
TRADE OPENESS(PERCENTAGE)	=1 if trade measured as percentage of GDP	.233	.423
Publication Characteristics			
LOG YEAR	Logarithm of the publication year of the study	2.198	.494
PUBLISHED	=1 if published in a peer-reviewed journal	.872	.334
LOG CITATIONS	Logarithm of citations in Google Scholar per age of the stud	1.97	1.157
JOURNAL IMPACT	Recursive journal impact factor from RePEc	.081	.203

Note: The list of variables used to account for heterogeneity.

Table 3: Bivariate MRA for FAT-PET: publication bias and true effect

	(1)	(2)	(3)
	OLS	Fixed	MEM
Genuine effect (PET/Precision)	0.0302*	0.0236	0.0207***
	(0.0165)	(0.0161)	(0.00480)
Bias (FAT/Constant)	-0.518	-0.370	-0.394
	(0.425)	(0.361)	(0.300)
Observations	688	688	688
R squared	0.056	0.034	
Number of ID	84	84	84

Notes: The dependent variable is t-values of the associated reported elasticity. Robust standard errors are reported in the parenthesis and all estimates use the inverse variance as weights. We apply the Hausman test that indicates that the MEM model is appropriate (a chi-squared with one degree of freedom is 0.03 with a p-value of 0.87). p<0.01***, ** p<0.05, * p<0.1

Table 4: Bivariate MRA for FAT-PET: publication bias and true effect for different group of countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Developing Countries			Developed Countries			Both Countries		
	OLS	FE	MEM	OLS	FE	MEM	OLS	FE	MEM
Genuine effect (PET/Precision)	0.0253	0.0162	0.0136***	0.0107	0.0332***	0.0305***	0.0761	0.0644	0.0619***
	(0.0166)	(0.0168)	(0.00526)	(0.0239)	(0.00527)	(0.00930)	(0.0491)	(0.0463)	(0.0152)
Bias (FAT/Constant)	-0.712	-0.499	-0.248	-0.0104	-0.389***	-0.752	-0.170	0.0832	-0.127
	(0.507)	(0.393)	(0.349)	(0.723)	(0.0888)	(0.833)	(0.583)	(1.005)	(0.715)
Observations	501	501	501	83	83	83	104	104	104
R squared	0.047	0.018		0.006	0.152		0.202	0.150	
Number of Studies	60	60	60	15	15	15	15	15	15

Notes: The dependent variable is t-values of the associated reported elasticity. Robust standard errors are reported in the parenthesis and all estimates use the inverse variance as weights. * *** p<0.01, ** p<0.05, * p<0.1***¡0.1. We apply the Hausman test that indicates that the MEM model is appropriate for all the three group of countries (for developing country is 0.09 with a p-value of 0.76; for developed country is 0.14 with a p-value of 0.71; and for mixed country is 0.06 with a p-value of 0.80). Both represents when regression specification includes both developing and developed countries.

Table 5: Explaining Heterogeneity in the Trade-Emission Elasticity for All Countries

	(1)	(2)	(3)
VARIABLES	OLS	FE	MEM
Genuine effect (PET/Precision)	0.157***	0.139	0.160***
	(0.0467)	(0.119)	(0.0453)
Bias (FAT/Constant)	-0.285	0.0845	0.252
	(0.396)	(0.155)	(0.261)
Countries	0.000293**	3.95e-05	0.000116
	(0.000141)	(0.000210)	(0.000129)
OLS	-0.0324**	-0.0368*	-0.0361***
	(0.0124)	(0.0221)	(0.0108)
Fixed Effect	-0.0234	-0.0738***	-0.0419**
	(0.0149)	(0.0257)	(0.0170)
Double Log	-0.0713***	-0.0665***	-0.0726***
	(0.0166)	(0.0217)	(0.0136)
Country FE	0.0355**	0.0581***	0.0484***
	(0.0160)	(0.0215)	(0.0137)
Lag	0.0231**	0.0103	0.0135
	(0.00945)	(0.0121)	(0.0139)
Trade percentage	0.0278**	0.0204	0.0256**
	(0.0135)	(0.0208)	(0.0113)
Carbon dioxide	0.0171	0.0137	0.0180*
	(0.0117)	(0.0205)	(0.00932)
Sulfur dioxide	-0.0854***	-0.0643**	-0.0647***
	(0.0241)	(0.0278)	(0.0129)
Urbanization	-0.0466***	-0.0214	-0.0270***
	(0.0103)	(0.0192)	(0.00923)
Year	-0.0511***	-0.0466	-0.0520***
	(0.0179)	(0.0451)	(0.0174)
Reviewed	0.0765***	0.0679*	0.0688***
	(0.0165)	(0.0382)	(0.0175)
Citations	-0.0245***	-0.0274*	-0.0309***
	(0.00745)	(0.0151)	(0.00609)
Observations	685	685	685
R squared	0.346	0.260	
Number of Studies	83	83	83

Notes: The dependent variable is t-values of the associated reported elasticity of Eqn (5): Robust standard errors are reported in the parenthesis and all estimates use the inverse variance as weights. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All the covariates have been divided by the standard errors.

Table 6: Explaining Heterogeneity in the Trade-Emission Elasticity for Different Group of Countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Developing Countries			Developed Countries			Both Countries		
	OLS	FE	MEM	OLS	FE	MEM	OLS	FE	MEM
Genuine effect (PET/Precision)	0.151***	0.169	0.157***	1.576	1.242***	0.844*	0.769***	-0.782**	0.455
	(0.0545)	(0.170)	(0.0561)	(1.316)	(0.179)	(0.470)	(0.165)	(0.342)	(0.506)
Bias (FAT/Constant)	-0.491	-0.103	0.292	-0.0749	0.147	-0.637	0.298	0.689	0.609
	(0.533)	(0.214)	(0.319)	(0.605)	(0.110)	(1.088)	(509)	(0.671)	(596)
Countries	0.000544**	0.000189	0.000312	0.000363	-0.000365	-0.000532	-0.000625	-0.00106	-0.000650
	(0.000244)	(0.000364)	(0.000279)	(0.00141)	(0.000227)	(0.000932)	(0.000631)	(0.00103)	(0.000445)
OLS	-0.0303**	-0.0365	-0.0333***	-0.172	0.0677*	0.0527	-0.0425	0.0712	-0.0364
	(0.0138)	(0.0251)	(0.0121)	(0.133)	(0.0333)	(0.0494)	(0.131)	(0.188)	(0.0636)
Fixed Effect	-0.0205	-0.0770**	-0.0370*	0.0448	0.0139	0.0359	0.0466	-0.00126	0.0178
	(0.0144)	(0.0332)	(0.0210)	(0.272)	(0.0181)	(0.0854)	(0.0487)	(0.0443)	(0.0585)
Double Log	-0.0698***	-0.0708**	-0.0751***	0.325	-0.0602	0.148	-0.111	0.0421	-0.0695
	(0.0200)	(0.0272)	(0.0154)	(0.349)	(0.0980)	(0.139)	(0.0999)	(0.251)	(0.0632)
Country FE	0.0322	0.0501	0.0430**	0.269	0.519***	0.371***	0.0329	0.198	0.0801
	(0.0250)	(0.0326)	(0.0195)	(0.268)	(0.0583)	(0.118)	(0.124)	(0.192)	(0.0696)
Lag	0.0188**	0.00844	0.0104	0.0313	0.0383***	0.0222			
	(0.00933)	(0.0136)	(0.0148)	(0.0239)	(0.00347)	(0.0257)			
Trade percentage	0.0235	0.0189	0.0239*	0.00588	-0.170***	-0.0422	-0.0712	-0.237	-0.100
	(0.0158)	(0.0225)	(0.0130)	(0.139)	(0.0475)	(0.0832)	(0.104)	(0.196)	(0.0713)
Carbon dioxide	0.0128	0.00413	0.0110	0.0918**	0.0190***	0.0211	0.0959***	0.123***	0.105***
	(0.0105)	(0.0115)	(0.0118)	(0.0306)	(0.000355)	(0.0369)	(0.0173)	(0.0405)	(0.0247)
Sulfur dioxide	-0.107***	-0.0746***	-0.0777***	0.119	-0.680***	-0.153	0.0494***	0.0583*	0.0464
	(0.0108)	(0.0253)	(0.0146)	(0.296)	(0.171)	(0.227)	(0.0152)	(0.0316)	(0.0309)
Urbanization	-0.0503***	-0.0262	-0.0304***	0.110	0.0827	-0.0313	-0.0472	0.0724	-0.0196
	(0.0114)	(0.0195)	(0.0102)	(0.165)	(0.0575)	(0.0874)	(0.0471)	(0.0845)	(0.0386)
Year	-0.0462**	-0.0552	-0.0480**	-0.783	-0.332***	-0.340	0.0170	0.349	0.000704
	(0.0203)	(0.0680)	(0.0217)	(0.665)	(0.107)	(0.232)	(0.0972)	(0.299)	(0.0873)
Reviewed	0.0772***	0.0692	0.0698***				-0.594*	-0.340	-0.289
	(0.0173)	(0.0467)	(0.0189)				(0.322)	(1.038)	(0.511)
Citations	-0.0226**	-0.0255	-0.0298***	-0.0665	-0.189***	-0.0665*	-0.0382	0.144	-0.0494
	(0.0111)	(0.0189)	(0.00734)	(0.0449)	(0.0335)	(0.0354)	(0.0639)	(0.267)	(0.0476)
Observations	501	501	501	80	80	80	104	104	104
R squared	0.316	0.248		0.378	0.618		0.626	0.559	
Number of Studies	60	60	60	14	14	14	15	15	15

Notes: The dependent variable is t-values of the associated reported elasticities. Robust standard errors are reported in the parenthesis and all estimates use the inverse variance as weights. *** p<0.01, ** p<0.05, * p<0.1. We lose the coefficients for some variables as results of lack of variation within sub-sample. All the covariates have been

Table 7: Robustness: Effect of Trade on Different Pollutants

	(1)	(2)	(3)	(4)	(5)	(6)
	Carbon dioxide			Sulfur dioxide		
	OLS	FE	MEM	OLS	FE	MEM
Genuine effect (PET/Precision)	0.215***	0.471***	0.262***	0.511	0.542	0.392
	(0.0770)	(0.175)	(0.0683)	(0.497)	(0.588)	(0.435)
Bias (FAT/Constant)	0.276	0.935***	0.886***	-2.396***	-2.220***	-1.363*
	(0.318)	(0.179)	(0.297)	(0.558)	(0.121)	(0.731)
Countries	4.63e-07	-0.000487**	-0.000183	0.00544***	0.00235**	0.00274*
	(0.000139)	(0.000197)	(0.000173)	(0.00123)	(0.000979)	(0.00154)
OLS	-0.0511**	-0.0595**	-0.0393**	0.126**	0.0839***	0.0927***
	(0.0201)	(0.0292)	(0.0187)	(0.0472)	(0.0137)	(0.0234)
Fixed Effect	-0.0249	-0.0725***	-0.0203	0.286**	0.0148	0.0642
	(0.0218)	(0.0246)	(0.0221)	(0.111)	(0.174)	(0.0753)
Double Log	-0.0884***	-0.0875***	-0.0874***	0.211**	2.300***	0.545
	(0.0171)	(0.0235)	(0.0164)	(0.0811)	(0.0486)	(0.433)
Country FE	0.0686**	0.0348	0.0722***			
	(0.0306)	(0.0333)	(0.0226)			
Lag	0.0189	0.00387	0.00751			
	(0.0130)	(0.00894)	(0.0155)			
Trade percentage	0.0444***	0.0661***	0.0518***			
	(0.0160)	(0.0217)	(0.0145)			
Urbanization	-0.0340*	0.0453	-0.00455	-0.111*	-0.0540	-0.0596**
	(0.0176)	(0.0331)	(0.0158)	(0.0500)	(0.0314)	(0.0296)
Year	-0.0641**	-0.193***	-0.0976***	-0.149	-0.182	-0.124
	(0.0287)	(0.0720)	(0.0280)	(0.173)	(0.214)	(0.158)
Reviewed	0.113***	0.169***	0.122***	-0.0237	-0.0315	-0.0312
	(0.0230)	(0.0390)	(0.0224)	(0.0490)	(0.0265)	(0.0281)
Citations	-0.0456***	-0.0734***	-0.0492***	-0.178*	-0.114	-0.0988
	(0.00985)	(0.0218)	(0.00930)	(0.0917)	(0.102)	(0.0874)
Observations	452	452	452	129	129	129
R squared	0.336	0.184		0.631	0.267	
Number of groups	75	75	75	8	8	8

Notes: The dependent variable is t-values of the associated reported elasticities. Robust standard errors are reported in the parenthesis and all estimates use the inverse variance as weights. *** p<0.01, ** p<0.05, * p<0.1. We lose the coefficients for some variables as results of lack of variation within sub-sample. All the covariates have been divided by the standard errors.

Table 1A: List of Studies

Count	study	Freq.	Percent	Cum.
1	Akin (2014)	6	0.76	0.76
2	Aklin (2016)	6	0.76	1.52
3	Al-mulali (2012)	13	1.65	3.17
4	Al-Mulali et al. (2015)	5	0.63	3.8
5	Al-Mulali and Lean (2015)	8	1.01	4.82
6	Al-Mulali et al. (2016)	8	1.01	5.83
7	Ali et al. (2016)	2	0.25	6.08
8	Aller et al. (2015)	20	2.53	8.62
9	Atici (2009)	2	0.25	8.87
10	Atici (2012)	8	1.01	9.89
11	Aung et al. (2017)	6	0.76	10.65
12	Ayeche et al. (2016)	1	0.13	10.77
13	Baghdadi et al. (2013)	10	1.27	12.04
14	Bernard and Mandal (2016)	10	1.27	13.31
15	Boutabba (2014)	2	0.25	13.56
16	Bouznit and Pablo-Romero (2016)	16	2.03	15.59
17	Charfeddine and Khediri (2016)	1	0.13	15.72
18	Choi et al. (2010)	12	1.52	17.24
19	Dogan and Seker (2016)	1	0.13	17.36
20	Dogan and Turkekul (2016)	2	0.25	17.62
21	Dogan et al. (2017)	1	0.13	17.74
22	Farhani and Ozturk (2015)	2	0.25	18
23	Farhani et al. (2014)	2	0.25	18.25
24	Fotros and Maaboudi (2011)	6	0.76	19.01
25	Farzanegan and Markwardt (2012)	26	3.3	22.31
26	Frankel and Rose (2005)	14	1.77	24.08
27	Gani (2012)	12	1.52	25.6
28	Gu and Li (2014)	6	0.76	26.36
29	Hakimi and Hamdi (2016)	9	1.14	27.5
30	He and Richard (2010)	21	2.66	30.16
31	Hossain and Hasanuzzaman (2012)	4	0.51	30.67
32	Hossain (2011)	20	2.53	33.21
33	Hossain (2012)	2	0.25	33.46
34	Islam and Shahbaz (2012)	2	0.25	33.71
35	Jalil and Feridun (2011)	32	4.06	37.77
36	Jalil and Mahmud (2009)	2	0.25	38.02
37	Jamel and Maktouf (2017)	6	0.76	38.78
38	Jayanthakumaran et al. (2012)	9	1.14	39.92
39	Jebli and Youssef (2015)	4	0.51	40.43
40	Jorgenson (2007)	4	0.51	40.94
41	Jorgenson (2009)	8	1.01	41.95
42	Kang et al. (2016)	8	1.01	42.97
43	Kasman and Duman (2015)	1	0.13	43.09
44	Kearsley and Riddel (2010)	35	4.44	47.53

Table 1A(continuation): List of Studies

Studies	Freq.	Percent	Cum.	
45	Keho (2016)	10	1.27	48.8
46	Kleemann and Abdulai (2013)	28	3.55	52.34
47	Kohler (2013)	2	0.25	52.6
48	Le et al. (2016)	24	3.04	55.64
49	Li et al. (2015)	10	1.27	56.91
50	Li et al. (2016)	43	5.45	62.36
51	Lim et al. (2015)	23	2.92	65.27
52	Lin (2017)	24	3.04	68.31
53	Managi et al. (2009)	17	2.15	70.47
54	McCarney et al. (2005)	8	1.01	71.48
55	Nasir and Rehman (2011)	3	0.38	71.86
56	Nolen et al. (2017)	3	0.38	72.24
57	Oganesyan (2017)	2	0.25	72.5
58	Ohlan (2015)	2	0.25	72.75
59	Onoja et al. (2014)	2	0.25	73
60	Opoku et al. (2014)	2	0.25	73.26
61	Ozatac et al. (2017)	1	0.13	73.38
62	Ozturk and Acaravci (2013)	3	0.38	73.76
63	Pazienza (2015)	3	0.38	74.14
64	Phimphanthavong et al. (2013)	2	0.25	74.40
65	Poncet et al. (2015)	49	6.21	80.61
66	Rafindadi (2016a)	2	0.25	80.86
67	Rafindadi (2016b)	4	0.51	81.37
68	Saidi and Mbarek (2017)	3	0.38	81.75
69	Salahuddin et al. (2016)	4	0.51	82.26
70	Sbia et al. (2014)	2	0.25	82.51
71	Sehrawat et al. (2015)	4	0.51	83.02
72	Shahbaz et al. (2012)	2	0.25	83.27
73	Shahbaz and Leitão (2013)	4	0.51	83.78
74	Shahbaz et al. (2013)	3	0.38	84.16
75	Shahbaz et al. (2014)	2	0.25	84.41
76	Shahzad et al. (2017b)	2	0.25	84.66
77	Solarin et al. (2017)	4	0.51	85.17
78	Sulaiman et al. (2013)	18	2.279	87.45
79	Sun et al. (2017)	4	0.51	87.96
80	van Bergeijk (1991)	3	0.38	88.34
81	Yazdi and Mastorakis (2014)	2	0.25	88.59
82	You et al. (2015)	6	0.76	89.35
83	Zerbo (2015)	10	1.27	90.62
84	Zhang et al. (2018)	2	0.25	90.87
85	Zhu et al. (2016)Zhu et al. (2016)	37	4.690	95.56
86	de Sousa et al. (2015)	25	3.17	98.73
87	ul Haq et al. (2016)	2	0.25	98.99
88	Çetin and Ecevit (2017)	8	1.01	100
	Total	789	100	100