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Trade and the Environment: An Application of the WIOD Database

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and Michael Schymura

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Executive Summary

At times, the term structural change has been used largely in debates regarding increasing unemployment in industrial nations because of movements of industries into low-wage countries. Therefore, structural change is often associated with negative connotations, even more in the recent debate on its impact on the environment. Whether these concerns can be justified or not will be discussed later in this paper. But to forecast the major insights from our analysis, structural change is—counter to conventional wisdom—necessary for industrialized countries to maintain economic growth and high wages, and furthermore, it spurs international trade which was identified to have positive influence on the environment for reasons going to be discussed in this paper.

The WIOD database allows for improved empirical analysis on a wide range of important environmental research questions. In this paper we demonstrate the scientific power of the WIOD database and give answers for very urgent policy questions on the impacts of international trade and structural change on the environment. This debate about the impacts of international trade and structural change on the environment has been very heated up to now and it is of very high political importance. This holds in particular true for the European Union. The reasons are the stringent European climate and environmental policy measures and their potentially harmful effects on the competitiveness of the energy-intensive European manufacturing sectors. Structural change has been identified to have a significant impact on environmental issues just because of its potential impact on international trade patterns. Whether concerns can be justified or not will be discussed in this paper application of the WIOD database. It provides insights into the driving forces of structural change and its close relationship to international trade. In a further step, the paper connects these economic forces with environmental issues based on recent econometric approaches in the literature. In addition to this guidelines by the literature, an econometric panel data approach is offered to shed some light on the impact of structural change and international trade on environmental pressure.

By relying on this guideline, we are aware of the problem that some of these variables can not be considered as being strictly exogenous. This is the case for trade and income as was pointed out. To cope with the problem of endogenous regressors, we construct instruments for trade and income. We start our analysis with endogenous cross-section and panel regression. Subsequently we employ our instrumental variables.

In the end, our models, indicate strong support for the evidence, that globalization has no harmful effects on the environment.

Das Wichtigste in Kürze

Das Wort Strukturwandel ist nicht zuletzt seit der Debatte um Standortverlagerungen industrieller Produktion aus Industrieländern und dem damit verbundenen Verlust an Arbeitsplätzen mit negativen Assoziationen besetzt. Auch in der aktuellen Debatte bezüglich des Einflusses von internationalem Handel und Strukturwandel auf die Umwelt werden Befürchtungen geäußert, dass die strenge Regulierung von Emissionen in Industrieländern die Abwanderung emissionsintensiver Industrien in Länder mit weniger strengen Umweltstandards nach sich ziehen kann. Ob diese Bedenken berechtigt sind oder nicht, ist eine wesentliche Forschungsfrage dieser Studie. Dies ist insbesondere für europäische Staaten interessant, da Europas verhältnismäßig strenge Umwelt- und insbesondere Klimapolitik als potentiell schädlich für den Erhalt der europäischen Wettbewerbsfähigkeit in der globalen Weltwirtschaft angesehen wird. Um das zentrale Ergebnis unsere Studie vorwegzunehmen: Strukturwandel und internationaler Handel haben, entgegen der herrschenden Meinung, einen positiven Einfluss auf die Umwelt. Der Grund hierfür ist nicht, dass freier Handel in Industrieländern mit strenger Klimapolitik zu einer Verlagerung schadstoffintensiver Industrien ins Ausland führt, sondern dass Handel einen wohlfahrtssteigernden Einfluss hat, der schlussendlich zu erhöhter Nachfrage nach Umweltqualität und damit einhergehender Entwicklung und Nutzung umweltfreundlicherer Produktionstechnologien führen kann.

Dieses Ergebnis beruht auf einer empirischen Analyse mit Hilfe einer Datenbank, die seit Mai 2012 frei und öffentlich verfügbar ist, der World Input Output Database, kurz WIOD. Die WIOD Datenbank bietet neben einer Reihe sozioökonomischer Variablen, wie etwa Informationen zur Höhe der Produktion, der Beschäftigung, des Kapitaleinsatzes, auch damit kompatible Daten zu Luftemissionen (z.B. für Schwefeldioxid) für insgesamt 40 Länder und einen Zeitraum von 1995-2009 an. Ein weiterer und speziell für den Zweck unserer Analyse bedeutsamer Vorteil der WIOD-Datenbank ist, dass diese kompatible bilaterale Handelsdaten zwischen allen 40 Ländern bereitstellt.

Die empirische Schätzung in unsere Studie greift auf ein gängiges Standardverfahren (die ökonometrische strukturelle Dekompositionsanalyse, kurz SDA) zurück und diskutiert mögliche Endogenitätsprobleme sowie deren Lösung. Die empirische SDA schätzt dabei den Einfluss von Wirtschaftswachstum, technischer Entwicklung der Schadstoffintensität, welche durch Umweltregulierung getrieben und auch hiermit abgebildet wird, sowie natürlich des Strukturwandels und hiermit einhergehender Veränderung des Handelsvolumens auf die Schwefeldioxidemissionen eines Landes.

Mit Hilfe dieses ökonometrischen Verfahrens bieten wir eine Anwendung der WIOD-Daten für politisch aktuelle Fragen im Zusammenhang mit Umweltregulierung und nationaler Wettbewerbsfähigkeit an. Um die Qualität der WIOD Daten bzw. deren Eignung für empirische makroökonomische Studien zu zeigen, vergleichen wir die Ergebnisse unserer Schätzungen mit bestehenden empirischen Arbeiten. Es zeigt sich, dass die Ergebnisse unserer Analyse die vorherigen Studien bestätigen, d.h. einen positiven Effekt von internationalem Handel auf die Umweltqualität identifizieren.

TRADE AND THE ENVIRONMENT: AN APPLICATION OF THE WIOD DATABASE

Andreas Löschel,[*] *Sascha Rexhäuser*,[†] *and Michael Schymura*[‡]

ABSTRACT: The new WIOD database allows for improved empirical analysis on a wide range of important environmental research questions. In this paper we demonstrate the scientific power of the WIOD database and analyze very urgent policy questions on the impacts of international trade and structural change on the environment. We apply recent econometric approaches to show the impact of international trade on the environment via its different channels as for instance to increase welfare and potentially affects environmental regulation as well as countries' sector. This approach has become known as the econometric structural decomposition method. In addition to this guidelines by the literature, an econometric panel data approach is offered to shed some light on the impact of structural change and international trade on environmental pressure, where we especially address and solve several endogeneity issues that add further complexity to the analysis. (Key words: Environmental and Climate Economics, Trade and the Environment, Structural Decomposition)

1 INTRODUCTION

At times, the term structural change has been used largely in debates regarding increasing unemployment in industrial nations because of movements of industries into low-wage countries. Therefore, structural change is often associated with negative connotations, even more in the recent debate on its impact on the environment. Often, it is argued by environmentalists and other opponents of free trade and globalization, that structural change in connection with free trade harms the environment since these forces may lead to an outsourcing of pollution-intensive industries into less developed countries with less stringent environmental protection. Whether these concerns can be justified or not will be discussed later in this paper. But to forecast the major insights from our analysis, structural change is—counter to conventional wisdom—necessary

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for industrialized countries to maintain economic growth and high wages, and furthermore, it spurs international trade which was identified to have positive influence on the environment for reasons going to be discussed in this paper.

The remainder of this paper is organized as follows. The next section briefly reviews the existing literature dealing with the impact of international trade on the environment and especially highlight the different approaches used by previous attempts. Moreover, we will put special emphasis on existing work that used a so called empirical structural decomposition analysis (SDA) as this method is the workhorse model in the present contribution applying the World Input-Output Database (WIOD), a new, consistent and comprehensive dataset that combines intercountry (world) input-output tables with extensive satellite accounts on environmental and socio-economic indicators. In section 3, we discuss this model in detail and focus especially on econometric aspects as potential problems of endogeneity. However, before discussing the model, we will present the WIOD database used in this approach, which is new and freely available data source covering 40 countries, including China, from 1995-2009. As to forecast later insights, the WIOD database is an almost perfect choice for the aimed analysis since it offers data on international trade, economic activity, and environmental pressure in one consistent data set. The empirical findings drawn from this data source will be presented in section 4. Section 5 concludes.

2 Related Literature

A common held opinion is that output in the more regulated country decreases and increases in the countries with less strict regulations, the so called "pollution havens". Using the terminology of Copeland and Taylor (2004), this effect is hereafter denoted as the "Pollution Haven Effect" (PHE), which is subject to several empirical studies like Ederington and Minier (2003), Ederington et al. (2004), Ederington et al. (2005), Levinson and Taylor (2008), Kellenberg (2009), and Tang (2010) among many others. For a detailed review of the literature, see Brunnermeier and Levinson (2004) or Copeland and Taylor (2004). The assumption that tightening environmental regulations forces pollution-intensive production to relocate into countries with less stringent regulation, rather than only to decrease economic activities, needs the so called Pollution Haven Hypothesis (PHH) to be true. The research dedicated to this topic also deals with firms location decistion in response to tightening of environmental regulation; see for instance Henderson (1996), Becker and Henderson (2000), and List et al. (2003) to mention only the most important contributions. But in addition to these two effects with the same direction, dealing with environmental issues in a world of globalization and trade liberalization may need to consider another effect. The direction of this effect is counter to the direction of the the PHE and PHH. Further trade liberalization can also result in more specialization with the effect that countries with comparative advantages in capital intensive dirty good production increase related economic activities regardless of the presence of stringent environmental regulation. Following Antweiler et al. (2001), this effect is called the Factor Endowment Hypothesis (FEH). To include also this last effect requires a more complex econometric approach. The standard approach to investigate the overall effect of trade on the environment is using econometric structural decomposition analysis (SDA).

Antweiler et al. (2001) decompose countries' pollutant emissions into scale, composition, and technique effect. The scale effect asks for the impact of a country's economic size (measured with GDP) on its total pollutant emissions. The composition effect (measured with capital-to labor ratio) accounts for the impact of a nation's weight of pollution intensive sectors in the total economy on emissions while the technique effect deals with the effect of pollutant supply, i.e. environmental regulation (proxied by the environmental Kuznets curve), on emissions. Furthermore, they separate the effect of international trade (the so called trade induced composition effect) with all its channels on emissions from the other effects. As already mentioned, these channels can be seen as the impact of regulation on trade as the PHE predicts. A further channel, asks for the impact of a countries factor endowment on trade flows and pollution which is denoted as the FEH. They find that a 1 % increase in scale forces pollution to increase by around 0.3%. For the composition effect, a 1 % increase in the capital-to-labor ratio causes nearly a 1 % increase in pollution (Antweiler et al., 2001, pp. 893).

The basic methodology of the model offered by Antweiler et al. (2001) has been adopted by several other authors like Cole and Elliott (2003), Frankel and Rose (2005), Cole (2006), and most recently by Managi et al. (2009) and is based on previous work by Grossman and Krueger (1991). Here, the normal composition effect describes the environmental consequences of a change in a country's industry composition holding scale and production technology constant. Antweiler et al. (2001) measure the composition effect using countries' capital-to-labor ratios. The scale effect describes the environmental consequences of an increase in economic activity holding industry composition and production technology fixed. The technique effect describes the environmental consequences of a change in production technology holding scale and composition effect fixed. Please note that the technique effect can be proxied by per capita income and squared per capita income only in a case of pollutants with strong local environmental damage, like for instance SO_2 as an environmental pressure indicator.

Why is SO_2 the most favored choice? A good indicator (or pollutant) should be a by-product of goods production and should be subject to regulation. Furthermore this by-product should vary across industries, have strong local effects and there should be well known abatement technologies for this special pollutant. "An almost perfect choice for this study is sulfur dioxide" (Antweiler et al., 2001, p. 889). Cole and Elliott (2003, p. 370) argue that NO_x and BOD (biochemical oxygen demand) also meet these requirements. CO_2 for instance was formerly no subject to regulation and also does neither have strong local nor transboundary effects (Cole and Elliott (2003), p. 370). Another argument for the use of SO_2 mentioned by Antweiler et al. (2001, p. 889) is that this gas is emitted in energy-intensive industries, which are also capital-intensive. Finally, using the measure of the technique effect described before for approaches on greenhouse gases like CO_2 causes some difficulties since unilateral regulation of greenhouse gases is less likely as a consequence of potential free-riding behavior.

3 Econometric Approach

3.1 The WIOD Database

The implementation of the aforementioned approaches using the World Input Output Database (WIOD) is subject to this section. The primary interest lies in the impact of structural change on the environment, i.e. the impact of structural change on trade issues affecting the environment. For this aim, this paper adopts following key approaches by Antweiler et al. (2001) and Cole and Elliott (2003) to the whole country sample of the WIOD data. WIOD (see http://www.wiod.org) is a consistent and very comprehensive dataset that allows us to compare the development of several environmental indicators over the period of time covered by the database (1995 to 2009), where we used the data from February 2012 in this paper. The dataset covers 40 countries (27 EU countries and 13 other major countries, including China) which together account for $\approx 80 - 85\%$ of world's GDP in 2006. The data is disaggregated in 36 industries (agriculture, manufacturing and services). Beside the broad country coverage, the sectoral disaggregation and the time period character of the dataset has another important feature: it contains several consistent satellite accounts with the same sectoral classification as the core dataset. The satellite accounts consist of bilateral trade data, socio-economic data (different skill types of labor, sectoral and total capital stocks, etc.) and, most important for this analysis, it offers a rich set of environmental information. The environmental satellites cover the following data: energy use broke down by several energy carriers (fossil, non-fossil, renewables, etc.), emissions of greenhouse gases (CO_2, N_2O, CH_4), air pollutants relevant for acidification (SO_2, NO_x, CH_4) and tropospheric ozone information (NO_x, NMVOC, CH_4).

3.2 More Data Issues

Environmental Data — Data on environmental pressure by country and year has been taken from the WIOD environmental accounts, where we focus on SO_2 emissions only. SO_2 emissions by country are reported in physical units, or more precisely, in tons.

Socio-Economic Data — Output by country is expressed in monetary units in basic prices (and in local currency) of 1995 and converted to Mio. US-$ (1995) using the supplied exchange rates. The measure of economic activity is gross output (*GO*). We have used hours worked by employees as a measure of labor input. Data on three types of labor quality is also included (low-skilled (*LABLS*), medium-skilled (*LABMS*) and high-skilled (*LABHS*). One major advantage of the WIOD database is the availability of data for physical capital stock and gross fixed capital formation for each country, sector and year. We use this information to construct capital-to-labor ratios (*KL*). Moreover, we have also use the information on bilateral trade flows provided by the WIOD database to capture the effect of structural change.

Other Data — Beside the WIOD database we also use the Penn World Tables (PWT 7.0) to obtain information about real GDP per capita, the population size, openness of a country as defined by the sum of imports and exports divided through GDP , and the share of GDP invested. The information about the geographical country characteristics, like e.g. the area, was obtained from the CIA World Fact Book and the CEPII Gravity Data Set, see http://www.cepii.fr/anglaisgraph/bdd/gravity.asp. Furthermore we have used the Barro and Lee database (Barro and Lee , 2010) on educational attainment and Psacharopoulos and Patrinos (2004) for estimated social Mincearian returns on education to construct our measure for human capital.

The summary statistics for key variables are given in table 6.

3.3 Addressing the endogeneity problems

To cope with potential endogeneity issues, we construct instruments for both trade openess and also income before running an econometric structural decomposition analysis. In what follows, information of how these instruments for the later approach are calculated is presented.

The endogeneity of trade — The trade openess regressors in our model may cause a serious problem as they are not exogenous as Frankel and Rose (2005) firstly notice. Countries which typically have high pollutant emissions are industrialized countries. Clearly, those countries play the most important role in international trade. Treating trade flows as exogenous would mean that these countries emit more pollutants just because they engage more in international trade than others. But it would be more realistic to argue that those countries which engage more in international trade emit more pollutants for other reasons than trade. Put it otherwise: Trade is endogenous. To solve this problem, an instrument for trade openess has to be used. Frankel and Romer (1999) suggest to use instrument variables borrowed from gravity models of international trade. Such instruments are for instance geographical distance and common boarders. Clearly, geographic distance is highly correlated with trade flows but uncorrelated with pollutant emissions. Land area as well as population size have strong impact on a country's foreign trade. This is because "residents of larger countries tend to engage in more trade with their fellow citizens simply because there are more fellow citizens to trade with" (Frankel and Romer , 1999, p. 380). For trade openness this implies that larger countries in terms of land area and population size have higher within country trade flows and a smaller trade openness (foreign trade) compared to smaller countries. Please note that constructing instruments borrowed from the gravity model need to calculate a model of bilateral trade flows for the first stage regression. Clearly, this is because distance, common border, and common language between two countries need a bilateral model. Thus, the measure of trade openness for country i to country j is defined as the sum of export and imports divided through the real Gross Output in 1995 US-$:

$$Openess_{ijt} = \frac{X_{ijt} + M_{ijt}}{GO_{it}}; \qquad i \neq j \tag{31}$$

The gravity equation estimated to obtain the geography-based bilateral trade share of two countries i and j is based on Frankel and Romer (1999); Frankel and Rose (2005):

$$\begin{aligned} \ln Openess_{ijt} = \; & \gamma_0 + \gamma_1 \ln Distance_{ij} + +\gamma_2 \ln Pop_{it} + \gamma_3 \ln Pop_{jt} \\ & +\gamma_4 \ln Area_i + \gamma_5 \ln Area_j + \gamma_6 (LL_i + LL_j) + \gamma_7 CB_{ij} \\ & +\gamma_8 CB_{ij} \ln Distance_{ij} + \gamma_9 CB_{ij} \ln Pop_{it} \\ & +\gamma_{10} CB_{ij} \ln Pop_{jt} + \gamma_{11} CB_{ij} \ln Area_i \\ & +\gamma_{12} CB_{ij} \ln Area_j + \gamma_{13} CB_{ij}(LL_i + LL_j) + \varepsilon_{ijt} \end{aligned} \tag{32}$$

The regressor $Distance_{ij}$ represents the geographic distance between the capitals of the two trade partners i and j. Pop_{it} and Pop_{jt} is a measure of population size (and not economically active population as in Frankel and Romer (1999) due to missing data for 2009 in the Penn World Tables for some countries) of country i and j, respectively.

Table 1: Results for Gravity Model

Dependent Variable:	**OLS Estimates**		
log Openness	**Coef.**	**Std. Err.**	**t-Statistic**
log Distance	-1.025***	(0.02)	-58.03
log Pop i	-0.140***	(0.01)	-9.71
log Area i	0.010	(0.01)	0.84
log Pop j	0.723***	(0.02)	48.31
log Area j	-0.021**	(0.01)	-1.83
Common Landlocked	-0.238***	(0.04)	-6.71
Common Border	1.243*	(0.57)	2.17
CB Dist	-0.322	(0.20)	-1.57
CB Pop i	-0.313***	(0.08)	-4.12
CB Area i	0.247***	(0.08)	2.99
CB Pop j	-0.247**	(0.08)	-3.20
CB Area j	0.305***	(0.08)	3.75
CB LL	0.214**	(0.10)	2.23
Constant	2.62***	(0.15)	17.36
Model Summary:			
Observations			23113
F-Statistic			834.87
Adj. R^2			0.3285
Root-MSE			2.1865
* p<0.05, ** p<0.01, *** p<0.001			

In addition to this, ($Area_i$ and $Area_j$) are controls for the size of two countries, whereas LL_i and LL_j are dummies measuring whether the countries are land locked. ($LL_i + LL_j$) is the common landlocked dummy. This means that the dummies representing the countries' land locked status are summed up. The variable CB_{ij} represents a dummy taking the value of one if trade partners share a common border. The common border dummy is also interacted with other explanatory variables to capture trade between neighboring countries more accurately. The equation is estimated using least squares using the bilateral trade data for all countries included in WIOD and estimation results are presented in table 1. First of all, most of the estimated coefficients in the different models have the expected signs. The distance between the trade partners appears to have a strong negative impact as the gravity model predicts. Furthermore, higher population size of the partner country (Pop_j) is associated with larger trade flows between the two trade partners. The coefficients of a country's own population size have the expected negative sign. Being landlocked also appears to be bad for a country's trade openness as it was expected. Countries sharing a common border (CB) are those ones with higher bilateral trade flows. Finally, the coefficients of the interactions of the common border dummy and all other regressors are of the expected sign except of the coefficient of common border and land area of country i.

From the gravity model regression, the fitted values have to be aggregated across all bilateral trade partners. This is because the second stage regression of the reference model (see equation 39) uses only trade openness for every country but no bilateral trade flows. The aggregation yields trade openness for a respective country adjusted by output-based PPP's. The aggregation method used is:

$$\hat{Openess}_{it} = \sum_{i \neq j} e^{\hat{\gamma}' \boldsymbol{X}_{ijt}} \tag{33}$$

The vector γ represents the coefficients in equation 32 whereas the vector $\boldsymbol{X}_{ijt}$ stands for the right-hand side variables in equation 32. From the first stage regression, fitted values were used to predict trade openness.

The endogeneity of income — Treating income as an exogenous variable would mean to say that those countries that have a higher per capita income emit more pollutants only because of their high income. However, it would be more realistic to say that they emit more pollutants because rich countries produce rather capital-intensive. Thus, per capita income is also endogenous (Frankel and Rose, 2005). To address this insight, we follow Frankel and Rose (2005) and rely on the conditional convergence hypothesis for constructing instruments. The hypothesis states that per capita income converges against one steady state for countries that are similar in their conditions determining the level of the steady state as for instance the share of the GDP invested in new capital

($\frac{I}{GDP}$), population growth, and the technological level or human capital endowment. The income equation reads as follows:

$$\ln\left(\frac{GDP}{Pop}\right)_{it} = \alpha_0 + \alpha_1 \ln\left(\frac{GDP}{Pop}\right)_{it-1} + \alpha_2 \ln\left(\frac{I}{GDP}\right)_{it} + \alpha_3 \ln(n+g+\delta)_{it} + \alpha_4 \ln LABHS_{it} + \alpha_5 \ln K_{it}^{H_c} + \alpha_6 \ln\left(\frac{K}{L}\right) + \alpha_7 \ln Openness_{it} + \varepsilon_{it} \quad (34)$$

This model is borrowed from Mankiw et al. (1992) and augmented in two ways. First, we specify a panel structure as suggested by Islam (1995), and second we model an open economy by including trade openness as an important driver of economic growth as Frankel and Rose (2002) demonstrated.

Table 2: Estimation Results for Income

Dependent Variable:	**FE Estimates**		
log (GDP/Pop)	**Coef.**	**Std. Err.**	**t-Statistic**
lagged log (GDP/Pop)	.850***	(0.02)	36.08
log (I/GDP)	0.132***	(0.02)	7.76
log (n+g+δ)	-0.151***	(0.01)	-3.78
log LABHS	0.05**	(0.02)	2.22
log K^H	0.142*	(0.07)	1.93
log (K/L)	-0.02	(0.02)	-1.12
log Openess	0.05**	(0.02)	-2.61
Constant	0.444**	(0.02)	2.06
Model Summary:			
Observations			570
F-Statistic			1195.71
Adj. R^2			0.99

* p<0.05, ** p<0.01, *** p<0.001

n is the growth rate of population constructed using the PWT and $g + \delta$ is assumed to equal 0.05 as in Mankiw et al. (1992). In the present approach, human capital is modeled twofold. First, we follow Hall and Jones (1999) and Alcalá and Ciccone (2004) and construct average human capital stocks $K_{it}^{H_c}$. Hall and Jones (1999) and Alcalá and Ciccone (2004) used old estimates of returns to schooling and old data on average schooling years. We rely on updated measures of returns to schooling provided by Psacharopoulos and Patrinos (2004) and on the newest version of the Barro and Lee educational attainment data (Barro and Lee , 2010). As Barro and Lee (2010) provide their data in 5-year intervals we have interpolated the values between the intervals. The average human capital stock $K_{it}^{H_c}$ in country i is then defined as: $K_{it}^{H_c} = \exp(\phi(S_c))$, where S_c is average schooling and $\phi(\cdot)$ a piecewise linear function capturing estimated social Mincerian returns (we rely on measures for Mincerian returns provided by Psacharopoulos and Patrinos (2004) with yearly rates of return of for 27 countries, 13 have been obtained by reasoning). We use the share of high-skilled worker compensation in total worker compensation offered in the WIOD socio-economic accounts. Following Managi et al. (2009) we also control for the (logarithmic) capital to labor ratio $\frac{K}{L}$.

Our measures for per capita income are the PWT 7.0 real GDP per capita time series. Since the WIOD data offers only data from 1995, we do not follow Mankiw et al. (1992) and Frankel and Rose (2002) regarding the use of a start point of per capita income (like 1970 in the case of Frankel and Rose (2002)). Instead, the present approach uses one period lagged income per capita and conditions for factors explaining its growth to its value in period t like for instance Managi et al. (2009) have done. Table 2 provides the results form the regression presented in equation 34. In this estimation, all coefficients are of the expected signs and also in terms of the adjusted R^2 the model fit is good. An one percent increase in GDP per capita in $t-1$ is associated with an 0.85 percent increase in period t's per capita GDP. The variables for investment share, population growth and depreciation have the expected signs and are all statistical significant on the one percent level. The control variables for human capital accumulation are both statistical significant as well as economic meaningful.

3.4 Estimation strategy

Having calculated the instruments for trade openness and income, these instruments can be used in the second stage regression. The second stage regression investigates the impact of structural change and international trade on the environment. A useful approach to shed light on this question is to run an econometric structural decomposition like for instance Grossman and Krueger (1991), Antweiler et al. (2001), or Cole and Elliott (2003) have done. A very simple decomposition looks as follows:

$$P_{it} = \alpha_0 + \alpha_1 INC_{it} + \alpha_2 (INC_{it})^2 + \alpha_3 KL_{it} + \varepsilon_{it} \quad (35)$$

P_{it} is environmental pressure of country i at time t, i.e. SO_2 emissions. Our measure of scale, INC_{it}, is a per capita GDP at time t which is a proxy for a country's income. By relying on the EKC relationship, we include also $(INC_{it})^2$ to allow for an inverted U-shaped relationship, where α_2 is expected to be negative and α_1 is expected to be positive for the EKC relationship, which is our measure for the technique effect, to hold. However, this approach implies that our measure for scale and technique effect are the same, or in other words: we can not distinguish between the two effects, like in the approaches by Cole and Elliott (2003) and Managi et al. (2009). Finally, the capital-to-labor ratio KL_{it} for the respective country represents our proxy of the composition effect.

The simple estimation equation for a decomposition of P_{it} suits obviously just for a closed economy since there are no trade relations included. As Copeland and Taylor (1994, p. 774) argue, "there is no composition effect in autarky since tastes are homothetic". This means the only source of structural change affecting the environment in a closed economy is that increasing income shifts demand to commodities produced in less pollution intensive industries (non-homothetic preferences). But the aim of the paper is to investigate the impact of structural change in general on environmental issues. Therefore it is necessary to introduce international trade since it is a crucial driver of structural change. To do so, trade openess (or intensity) is introduced into the model which is defined as:

$$TI_{it} = \frac{X_{it} + M_{it}}{GO_{it}} \tag{36}$$

where X_{it} represents a country's exports and M_{it} measures it's imports.

First of all, international trade leads to international specialization. This means that an increase in trade openness has some impact on capital-to-labor ratio. Relatively capital-abundant countries may specialize in the more capital-intensive production due to an increase in trade openness. This effect can be modelled by the interaction of TI_{it} with capital-to-labor ratio relative to the world's average ($REL.KL_{it}$) like it is done by Antweiler et al. (2001). An increase in TI_{it} for capital-abundant countries is expected to rise environmental pressure P_{it} because these countries will specialize in more capital-intensive and thus pollution-intensive production, and vice versa for the relatively labor abundant country. Antweiler et al. (2001) refers to this effect as the Factor Endowment Hypothesis (FEH) which obviously is based on the standard Heckscher-Ohlin Model of international trade. To allow for non-linear relationships, squared interaction term of $REL.KL_{it}$ and TI_{it} are added to the model which leads to:

$$\begin{aligned} P_{it} &= \alpha_0 + \alpha_1 INC_{it} + \alpha_2 (INC_{it})^2 + \alpha_3 KL_{it} \\ &\quad + \beta_1 TI_{it} REL.KL_{it} + \beta_2 TI_{it} (REL.KL_{it})^2 + \varepsilon_{it} \end{aligned} \tag{37}$$

The increased specialization due to an increase in trade openness causes welfare gains in the respective countries. These welfare gains increase citizens' desire for more environmental quality as the EKC relationship predicts. But this is only the case in relatively rich countries. In relatively poor countries, where relative income ($REL.INC$) is below the world's average, trade-induced income gains increases pollution. Thus, the effect of income gains brought by free trade differ by countries with regard to their income relative to the world's average. Including this effect following Antweiler et al. (2001) leads to:

$$\begin{aligned} P_{it} &= \alpha_0 + \alpha_1 INC_{it} + \alpha_2 (INC_{it})^2 + \alpha_3 KL_{it} + \beta_1 TI_{it} REL.KL_{it} \\ &\quad + \beta_2 TI_{it} (REL.KL_{it})^2 + \beta_3 TI_{it} REL.INC_{it} \\ &\quad + \beta_4 TI_{it} (REL.INC_{it})^2 + \varepsilon_{it} \end{aligned} \tag{38}$$

Finally, income gains caused by an increase in trade openness may affect the relative capital-to-labor ratio. This is because higher income increases the demand for a higher environmental quality which can be achieved by implementing a more stringent regulation which in turn forces pollution-intensive production to relocate into countries with less stringent regulation. In the end, relative capital-to-labor ratio could decrease for this reason. This effect of international trade on the environment is known as the PHH. Clearly, pollution havens are countries with lower income than the world's average and also low capital-to-labor ratio. Thus, an increase in trade openness is expected to increase environmental pressure in these countries. For countries with both, capital-to-labor ratio and income above the world's average, the effect of the PHH is expected to decrease environmental pressure. As first shown by Antweiler et al. (2001), this third effect of an change in trade openness can be modeled by using an interaction term of trade openness, relative capital-to-labor ratio and relative income, see equation 39 below.

$$
\begin{aligned}
P_{it} = {} & \alpha_0 + \alpha_1 INC_{it} + \alpha_2 (INC_{it})^2 + \alpha_3 KL_{it} + \beta_1 TI_{it} REL.KL_{it} \\
& + \beta_2 TI_{it} (REL.KL_{it})^2 + \beta_3 TI_{it} REL.INC_{it} \\
& + \beta_4 TI_{it} (REL.INC_{it})^2 + \beta_5 TI_{it} REL.KL_{it} REL.INC_{it} \\
& + \gamma_6 Helsinki_{it} + \gamma_7 Oslo_{it} + \varepsilon_{it} \qquad (39)
\end{aligned}
$$

Please note that this estimation equation is a simplified version of Antweiler et al. (2001). These authors use SO_2 concentrations as the dependent variable (P_{it}). The similar version of Cole and Elliott (2003) provides estimation results also for SO_2 emissions. This model, however, additionally includes a squared term of the capital-to-labor ratio (KL_{it}^2) and an interaction term of capital-to-labor ratio and income ($KL_{it}INC_{it}$). Cole and Elliott (2003, p.367) argue that squared capital-to-labor ratio is included "to allow capital accumulation to have a diminishing effect at the margin [...]"; the interaction term of capital-to-labor ratio and income "captures the fact that the effect of income on pollution is likely to depend on the existing level of KL, and vice versa". In this paper, however, we do not take these effects into account and estimate equation 39 as the reference model taken from the literature.

We finally add two control variables for the effect of environmental regulation: the Helsinki-Protocol and the Oslo-Protocol dummies (a dummy is 1 in year t if country i has ratified the particular agreement and 0 otherwise). This dummy is eliminated in the Fixed-Effects estimations. The Oslo-Protocol entered into force in 1998 and so this dummy remains in the Fixed-Effects estimations. A negative sign for both coefficients is expected, with a larger magnitude for the Oslo-Dummy since this is the more actual and more stringent regulatory framework. We develop our final equation 39 in three steps: First, we estimate a strictly linear linear relationship without any quadratic terms (Model 1). Then we add the KL_{it}^2 in Model 2. Finally we estimate equation 39 and refer to it as Model 3.

4 Empirical results

Endogenous cross-section regressions — Before we use our constructed instruments for trade-intensity and income, we first employ our approach with simple cross-section ordinary least squares (OLS) for the sake of completeness and for reasons of comparability with previous research. Table 3 summarizes the estimation results for Model 1 (without non-linearities), Model 2 (with KL_{it}^2 and interaction terms) and Model 3 (based on our equation 39).

Because our models are nested, we can compare them using a likelihood ratio (LR) test. The results indicate that the gain from using Model 2 instead of Model 1 is quite imposing and that using Model 3 instead of Model 2 is still beneficial. Thus, the non-linearity restrictions within Model 1 are too tight. In the following, we will limit the interpretation on Model 3 only. The results are in line with previous studies.

Our control for environmental regulation manifests the expected results. Both, the Helsinki as well as the Oslo dummy tend to have a negative and significant impact on SO_X-emissions. The negative sign on the coefficient on Income offers evidence that the technique effect dominates the scale effect, although the relationship is not significant. The composition effect captured by $REL.KL$ indicates an increase in emissions per capita as capital-to-labor ratio increases (p-value <0.001). Since the quadratic term on $REL.KL$ is negative and highly significant, the relationship is inverted u-shaped with an estimated turning point at a capital-to-labor ratio of 5.504, which is a value out of the sample. The significantly positive coefficient of an increase in trade openness on emissions per capita reveals negative consequences of an increase in trade. However, trade affects the relative capital-to-labor ratio and leads to a decline of it. Additionally, it lowers the estimated turning point to 5.027. Furthermore an additional opening affects income positively.

Table 3: Estimation results for the endogenous OLS-regression

Log of SO_X-Emissions	**Model 1**	**Model 2**	**Model 3**
Income (PWT)	0.531***	-0.186	-0.450
	(0.09)	(0.12)	(0.30)
REL.KL	-0.086	3.432***	3.674***
	(0.14)	(0.48)	(0.54)
TI (PWT)	0.009***	0.008**	0.006*
	(0.00)	(0.00)	(0.00)
TI.REL.KL (PWT)	-0.003	-0.034***	-0.037***
	(0.00)	(0.00)	(0.01)
TI.REL.INC (PWT)	-0.005	0.016***	0.022**
	(0.00)	(0.00)	(0.01)
TI.REL.INC.REL.KL (PWT)	0.000	-0.006*	-0.005*
	(0.00)	(0.00)	(0.00)
Oslo	-0.275*	-0.278*	-0.273*
	(0.13)	(0.12)	(0.12)
Helsinki	-0.300*	-0.297*	-0.309*
	(0.14)	(0.13)	(0.13)
REL.KL.SQR		-1.023***	-1.077***
		(0.14)	(0.15)
TI.REL.KL.SQR (PWT)		0.011***	0.011***
		(0.00)	(0.00)
TI.REL.INC.SQR (PWT)		-0.000	-0.002
		(0.00)	(0.00)
Income.SQR (PWT)			0.044
			(0.05)
constant	2.091***	1.894***	2.032***
	(0.16)	(0.16)	(0.21)
Observations	570	570	570
R squared	0.206	0.257	0.266
Adjusted R squared	0.194	0.243	0.250
Root MSE	0.882	0.855	0.851
F-Statistic	18.148	17.580	16.796
LR-Test		69.31***	0.95
Scale + Technique Elasticity	.377	-.131	-.227
Composition Elasticity	.212	.722	.732
Trade Intensity Elasticity	-.239	-.175	-.136
* p<0.05, ** p<0.01, *** p<0.001			

To quantify the effects of trade on the environment, we estimate the relevant elasticities at the sample means using the standard Delta method for three different effects: First, the combined scale and technique-effect measured by INC_{it} and INC_{it}^2. Model 1, taking only the linear INC_{it} into account, suggests a positive Scale-and-Technique elasticity (0.377), an indicator for the hypothesis that the scale effect, an increase in economic activity measured by an increase in output, rules out the technique effect. It also shows a positive composition elasticity represented by a nations capital-to-labor ratio. In all models we find a positive composition effect due to an increasing capital-to-labor ratio and a negative trade intensity elasticity. Model 2, which takes non-linearities in the capital-to-labor ratios into account, finds a negative scale and technique elasticity, but a higher composition elasticity than Model 1. The impact of trade intensity is negative. Model 3, also accounting for the potentially non-linear relationship of emissions and income, shows a stronger technique than scale-effect (-0.227). Finally, we provide estimates for the impact of a changing trade-intensity on the SO_X-emissions. Our results indicate a strong negative impact ranging from -0.136 (Model 3) up to -0.239 (Model 1). The results are significant for all Models since we could reject the hypothesis that the relevant terms reflecting our trade-intensity elasticity are jointly equal to zero. Put it otherwise, for an average country the trade-induced composition effect is negative. Thus, free trade tends to have positive impacts on the environment, at least in the endogenous cross-section regressions.

Endogenous panel estimates — The next estimations we carry out are using panel econometrics. In table 4, the estimation results for Fixed- (labeled in the tables as FE) and Random-Effects (RE) estimations are presented.

Table 4: Estimation results for endogenous Panel-regressions

Log of SO_X-Emissions	M1(FE)	M1(RE)	M2(FE)	M2(RE)	M3(FE)	M3(RE)
Income (PWT)	-0.270***	-0.267***	-0.171*	-0.221**	-0.870***	-0.714***
	(-3.35)	(-3.52)	(-2.04)	(-2.78)	(-4.68)	(-3.85)
$REL.KL$	-0.371**	-0.116	-0.955*	-0.0531	-0.312	0.373
	(-2.67)	(-0.89)	(-2.53)	(-0.15)	(-0.78)	(0.97)
TI (PWT)	-0.00286	-0.00418*	-0.00604*	-0.00951***	-0.00595*	-0.0103***
	(-1.66)	(-2.45)	(-2.50)	(-4.18)	(-2.50)	(-4.51)
TI.REL.KL (PWT)	-0.00430**	-0.00393**	-0.00871**	-0.0128***	-0.0152***	-0.0170***
	(-3.09)	(-2.86)	(-3.00)	(-4.56)	(-4.68)	(-5.38)
TI.REL.INC (PWT)	-0.00532***	-0.00335*	0.00174	0.00994**	0.0117**	0.0180***
	(-3.72)	(-2.44)	(0.45)	(2.78)	(2.61)	(3.95)
TI.REL.INC.REL.KL (PWT)	0.00260***	0.00210***	0.00183	0.00126	0.00210*	0.00162
	(5.72)	(4.64)	(1.81)	(1.24)	(2.12)	(1.60)
Oslo	-0.106	-0.111	-0.125	-0.131	-0.123	-0.133
	(-1.55)	(-1.57)	(-1.81)	(-1.85)	(-1.81)	(-1.90)
Helsinki		0.174		0.232		0.225
		(0.48)		(0.63)		(0.60)
REL.KL.SQR			0.152		0.0103	-0.127
			(1.54)		(0.10)	(-1.27)
TI.REL.KL.SQR (PWT)			0.00103	0.00226*	0.00219*	0.00294**
			(1.13)	(2.52)	(2.33)	(3.18)
TI.REL.INC.SQR (PWT)			-0.000991	-0.00218*	-0.00510***	-0.00526***
			(-1.08)	(-2.47)	(-3.83)	(-3.83)
Income.SQR (PWT)					0.126***	0.0852**
					(4.20)	(2.95)
constant	4.749***	4.430***	4.936***	4.394***	5.271***	4.628***
	(34.02)	(22.61)	(26.66)	(20.21)	(26.50)	(20.02)
Observations	570	570	570	570	570	570
R squared (within)	0.41	0.41	0.43	0.42	0.45	0.44
F-Statistic	52.85		39.76		38.91	
χ^2		303.89		335.43		352.77
Hausman-Test	51.53***		47.24***		54.39***	
Scale + Technique Elasticity	-.191	-.189	-.122	-.157	-.351	-.326
Composition Elasticity	-.200	-.152	-.388	-.301	-.259	-.236
Trade Intensity Elasticity	-.162	-.115	-.105	.01	-.113	.03

* p<0.05, ** p<0.01, *** p<0.001; t-values in par.

A Hausman-test suggests strong evidence for the fixed effects estimation for all three models. Just like in the cross section IV estimations of model 3 in the previous section, the scale-and-technique elasticity is negative (from -0.122 to -0.351). The composition elasticity is, not like in previous results, negative. The trade-intensity elasticity remains negative in most cases (-0.105 to -0.162), beside the fixed effects estimations of Model 2 and Model 3. There the respective elasticity is almost zero, and we conclude that trade has almost no impact on the environment when employing the workhorse-model on panel-data. But since our variables of income and trade are endogenous, we will employ our instruments in the following subsection in order to investigate the impact of the endogeneity.

Panel estimates using Instruments — Finally, we employ the fitted values of our instruments and include them in our panel estimations (see Table 5). The obtained estimates for the elasticities of interest are now more in line with the results from the previous section. In most cases we find a positive scale-and-technique elasticity, despite in Model 2 (RE). The composition elasticity is heterogenous and lies between -2.15 and 0.83. And finally the trade-intensity elasticity is again negative in all estimations (ranging from -0.51 to -0.36). Again we have to warn the reader to draw conclusion from the panel-estimations.

Overall, in our preferred model specification—Model 3 where trade intensity and per capita income have been instrumented—the RE estimates are in line with the findings by Antweiler et al. (2001) and Cole and Elliott (2003). Antweiler et al. (2001) find a composition elasticity of approximately 1.0 while Cole and Elliott (2003) estimated this effect to be more than two times as high. Our estimate of approximately 0.71 is thus close to the one in Antweiler et al. (2001). Regarding our estimates of the trade elasticity in model 3 (RE), our estimate of -0.36 almost perfectly fits to the estimate in Antweiler et al. (2001) who reported a value of -0.35. Regarding the scale and technique elasticity, we performed as mention before an approach similar to Cole and Elliott (2003) where the scale effect cannot be separated from the technique effect. Therefore, we can only compare our results to Cole and Elliott (2003) who reported a value of -1.7. In terms of sign, our estimate of -0.48 fits well to the reference from the literature, although we find a considerable smaller effect.

To sum up, our estimates drawn from the WIOD database strongly support previous literature's findings, namely that the negative trade and technique effects more than compensate the positive composition effect. However, these results vary—at times considerably—across different model specifications and for different estimation techniques.

Table 5: Estimation results for instrumented Panel-regressions

Log of SO_X-Emissions	M1(FE)	M1(RE)	M2(FE)	M2(RE)	M3(FE)	M3(RE))
Income (2SLS)	-0.375***	-0.532***	-0.120	-0.510***	-0.193	-0.925***
	(-5.23)	(-8.84)	(-1.48)	(-7.87)	(-0.84)	(-4.99)
$REL.KL$	-0.0366	0.337	1.365*	2.172***	1.353*	2.205***
	(-0.19)	(1.93)	(2.52)	(4.70)	(2.50)	(4.77)
TI (2SLS)	-0.0364*	0.0105**	-0.0734***	0.0121***	-0.0714***	0.00862*
	(-2.45)	(2.97)	(-4.72)	(3.36)	(-4.30)	(2.22)
TI.REL.KL (2SLS)	-0.00515*	-0.00843***	-0.0293***	-0.0285***	-0.0295***	-0.0308***
	(-2.45)	(-5.08)	-6.70)	(-7.64)	(-6.67)	(-8.01)
TI.REL.INC (2SLS)	-0.0109***	-0.00774***	0.00783*	0.00406	0.00913	0.0137**
	(-5.60)	(-4.24)	(2.43)	(1.26)	(1.83)	(2.66)
TI.REL.INC.REL.KL (2SLS)	0.00334***	0.00372***	0.00693***	0.00400*	0.00724***	0.00614**
	(5.57)	(7.32)	(4.03)	(2.22)	(3.73)	(3.08)
Oslo	-0.180**	-0.164*	-0.244***	-0.190**	-0.242***	-0.182**
	(-2.70)	(-2.35)	(-3.78)	(-2.76)	(-3.73)	(-2.66)
Helsinki		0.377		0.506		0.503
		(1.02)		(1.41)		(1.38)
REL.KL.SQR			-0.308*	-0.471***	-0.307*	-0.489***
			(-2.35)	(-3.90)	(-2.34)	(-4.05)
TI.REL.KL.SQR (2SLS)			0.00356**	0.00436***	0.00350**	0.00422***
			(2.96)	(3.86)	(2.89)	(3.74)
TI.REL.INC.SQR (2SLS)			0.00713***	-0.00279	0.00774**	-0.00745**
			(-4.78)	(-1.89)	(-3.29)	(-3.07)
Income.SQR (2SLS)					0.0124	0.0812*
					(0.34)	(2.40)
constant	8.736***	3.881***	11.45***	3.057***	11.27***	3.387***
	(6.47)	(11.85)	(8.19)	(8.64)	((7.58)	(8.91)
Observations	570	570	570	570	570	570
R squared (Within)	0.43	0.41	0.49	0.44	0.49	0.45
F-Statistic	57.08		49.56		44.98	
χ^2		308.77		360.07		371.00
Hausman-Test	64.08***		83.61***		79.48***	
Scale + Technique Elasticity	-.252	-.357	-.08	-.342	-.108	-.477
Composition Elasticity	-1.21	.454	-2.15	.827	-2.09	.713
Trade Intensity Elasticity	-.395	-.381	-.509	-.505	-.488	-.364

* p<0.05, ** p<0.01, *** p<0.001; t-values in par.

5 Concluding remarks

The conventional wisdom about structural change and its simultaneous relations to international trade draws a dark picture on these forces, especially with respect to their impacts on the environment. There is a widely held opinion by the opponents of free trade, that international trade due to structural change relocates dirty production into countries with less stringent environmental protection. In the absence of trade protection, especially environmental regulation in the industrialized nations is supposed to cause such a development, which is well known as the Pollution Haven Effect.

Despite all these concerns, recent empirical research identified trade liberalization to be potentially good for the environment. Also our approach using the WIOD database for a sample of 40 countries confirms these prior findings. The empirical results point out that trade has a beneficial effect on the emission of SO_x pollutants. As it was argued in the very beginning of this paper, structural change and trade cannot be treated isolated from each other. By relying on the literature, the connection of these forces was discussed using very simple considerations. In the econometric analysis, these interrelated influences of structural change and trade were modeled by following the pioneering work of Antweiler et al. (2001), who interacted the respective measures for trade, structural change, and also income in an econometric structural decomposition approach.

By relying on this guideline, we are aware of the problem that some of these variables can not be considered as being strictly exogenous. This is the case for trade and income as is was pointed out. To cope with the problem of endogenous regressors, we have constructed instruments for trade and income. The importance of using instrumental variables has been emphasized in our panel regressions. Using the endogenous measures for income and in particular trade results in a positive trade elasticity. Put it otherwise, in our endogenous panel estimations, trade seems to have harmful effects on the environment. By employing our instruments, we could show, that this would be a premature conclusion. Our core model, taking non-linearities and endogeneity into account, shows that an increase in trade by 1 % leads to a decrease of per-capita SO_x-pollution of 0.364 %, a result of similar magnitude as in Antweiler et al. (2001). So we can conclude, that the conventional wisdom of negative effects of globalization on the environment holds not true in our case.

A Descriptive Statistics

Variable	Source	Mean	SD	Min	Max
Gravity Variables					
Distance	CEEPI	5232.9	4395.6	160.9	18260.4
Population Country i	CEEPI	100	249.5	0.4	1311.8
Area Country i	CEEPI	1879075.8	3822376.4	316	17075400
Population Country j	CEEPI	100	249.5	0.4	1311.8
Area Country i	CEEPI	1879075.8	3822376.4	316	17075400
Common Border	CEEPI	0.1	0.2	0	1
Landlocked i	CIA	0.1	0.3	0	1
Landlocked j	CIA	0.1	0.3	0	1
Common Landlocked	CIA	0.3	0.5	0	2
Income Instrument Variables					
Real GDP per Capita	PWT 7.0	21981.4	13135.8	1566.5	89832.9
Investment Share in GDP	PWT 7.0	23.1	5.7	5.3	47.8
Real Openness	PWT 7.0	84.2	49.8	19	324.3
Population Growth	PWT 7.0	0.005	0.007	-0.014	0.026
Years Primary Schooling	Barro and Lee (2010)	5.6	1.2	2.5	8.8
Years Secondary Schooling	Barro and Lee (2010)	3.5	1.2	1.1	7.5
Years Tertiary Schooling	Barro and Lee (2010)	0.6	0.3	0.1	1.6
Mincerian Return	Psacharopoulos (2004)	0.073	0.027	0.027	0.147
logarithmic Human Capital	Own Calculation	0.693	0.271	0.223	1.589
Other Regressors					
Employees Hours	WIOD	96175.2	261579.2	244.5	1555748.5
Gross Output (in 1995 US-$)	WIOD	1557368.7	3147111.8	6810.3	19669172
Real Capital Stock	WIOD	2541598.5	5295651.2	10387.6	31372992
Capital-to-Labor Ratio	WIOD	6.9	6.3	0.1	21.3
logarithmic SO_X per Capita	WIOD	3.001	0.989	0.05	4.974
Helsinki Dummy	Helsinki Protocoll	0.2	0.4	0	1 0
Oslo Dummy	Oslo Protocoll	0.3	0.4	0	1
Former Communist Country	CIA	0.2	0.4	0	1
EU15	CIA	0.3	0.5	0	1

Table 6: Descriptive Statistics of used Variables

B List of countries included in the regression

Countrycode	Country	Countrycode	Country
AUS	Australia	JPN	Japan
AUT	Austria	KOR	Korea
BEL	Belgium	LVA	Latvia
BRA	Brazil	LTU	Lithuania
BGR	Bulgaria	LUX	Luxembourg
CAN	Canada	MLT	Malta
CHN	China	MEX	Mexico
CYP	Cyprus	NLD	Netherlands
CZE	Czech Republic	POL	Poland
DNK	Denmark	PRT	Portugal
EST	Estonia	ROM	Romania
FIN	Finland	RUS	Russia
FRA	France	SVK	Slovakia
GER	Germany	SVN	Slovenia
GRC	Greece	ESP	Spain
HUN	Hungary	SWE	Sweden
IND	India	TWN	Taiwan
IDN	Indonesia	TUR	Turkey
IRL	Ireland	GBR	United Kingdom
ITA	Italy	USA	United States

Table 7: Country coverage of the WIOD database

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