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Do countries with higher institutional quality transition to cleaner trade?

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ABSTRACT

There is growing concern about the shift of trade in more polluting products to countries with less restrictive environmental standards, popularly known as pollution havens. This paper explores whether institutional quality affects trade composition and fosters a transition towards cleaner products. Applying a gravity model to a sample of 140 countries for the period 2002–2018, our results show a negative link between institutional quality and trade in products classified as dirty. In addition, the results show a non-linear pattern, with the effects being stronger for countries with high levels of institutional quality. We also examine which dimensions of institutional quality play a more prominent role. Finally, we find that part of the effect of institutional quality is channelled through higher environmental stringency.

1. Introduction

Trade has an undeniable impact on the environment (OECD, 2021). This is primarily because trade itself produces substantial greenhouse gas emissions. However, there is also growing concern that increased environmental regulation in some regions of the world may be raising the risk of "carbon leakage" in certain industries (OECD, 2020; European Commission, 2018). This concept refers to a situation where firms reallocate their production to countries with laxer environmental regulations, leaving global emissions unchanged or even increasing them. The pollution haven hypothesis[1] posits that lower abatement costs may represent a source of comparative advantage, thus driving a shift in exports of more polluting goods to countries with lower environmental standards, the so-called "pollution havens". Moreover, since the demand for environmental quality increases with income (Dasgupta et al., 1995), developing countries may end up with a greater concentration of trade in more polluting goods, while developed countries could specialise in less polluting goods. Factor endowments are also relevant to account for, as they can heavily condition countries' trade specialisation. It is thus important to understand the determinants of trade composition.

This paper investigates one of these potential drivers; namely, the quality of government institutions. According to North (1991), institutions are the formal rules and informal constraints that shape social, political and economic relations. We specifically focus on the quality of formal institutions, understood as the ability of governments to set appropriate regulations and a framework of guarantees for human interactions. The influence of government institutions reaches virtually all social and economic spheres. However, quantifying their effects is challenging due to the difficulty of measuring institutional quality and the coexistence of multiple transmission channels for said effects, particularly in the context of ecological economics.

Regarding the links between institutional quality, trade, and its environmental impact, a growing body of academic research reports a positive impact of institutional quality on trade (e.g., Nunn, 2007; Francois and Manchin, 2013; Beverelli et al., 2018). More importantly, institutional quality has also been found to play a moderating role in the

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[1] See, for example, Copeland and Taylor (2004) and Levinson and Taylor (2008) for a more thorough description.

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relationship between economic development and environmental impact (Puppim de Oliveira et al., 2013; Mombeuil, 2020). The institutions-environment relationship has been largely analysed in Environmental Kuznets Curve (EKC)[2] frameworks, with the research showing that high-quality institutions shift the turning point of the curve, such that it takes place at an earlier stage of development in countries with high-quality institutions (see, among others, Egbetokun et al., 2020; Laegreid and Povitkina, 2018; Bjørnskov, 2020).

This article contributes to the existing knowledge by linking the literatures on trade, institutional quality and the environment. Previous studies have analysed the link between i) institutions and trade, ii) institutions and the environment, and iii) trade and the environment. Nevertheless, to the best of our knowledge, no attempts have been made thus far to examine these three aspects simultaneously. To do so, this paper explores whether institutional quality affects trade composition, focusing specifically on goods categorised as *dirty* according to their environmental impact.[3] We employ the commonly-used product classification of Low and Yeats (1992), which identifies categories of products whose pollution abatement costs are high and can therefore be considered as pollution intensive. Institutional quality is measured by means of the widely-used World Governance Indicators (WGI) produced by the World Bank. The empirical strategy consists of a gravity equation framework of dirty trade flows, applied to a sample of 140 countries for the period 2002–2018.

Our results show a negative link between institutional quality and dirty trade, also lending support to the pollution haven hypothesis. Moreover, the relationship is non-linear, suggesting that only when institutional quality is sufficiently high does it actually foster a transition towards trade in cleaner goods. Finally, we identify the dimensions of institutional quality that drive the trade in dirty products, as well as some potential transmission mechanisms. Particularly, we find that a substantial part of the effect of institutional quality may be channelled through more stringent environmental regulations and that a sufficiently high level of institutional quality can moderate the specialisation of resource-rich countries in dirty industries.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 details the empirical analysis, including the econometric approach, data, sources and some descriptive statistics. Results are discussed in Section 4 and, finally, Section 5 concludes.

2. Literature review: Institutions, trade and the environment

2.1. Institutions and trade

The literature on the effects of institutional quality on trade has been gaining momentum recently (see Levchenko, 2007; Nunn, 2007; Francois and Manchin, 2013; Beverelli et al., 2018). Generally, these studies report a positive association between institutional quality and trade flows (see also Anderson and Marcouiller, 2002; Dutt and Traca, 2010; Gil-Pareja et al., 2019). However, the impact is found to be highly dependent on the categories of products traded (Méon and Sekkat, 2008). Accordingly, studies on the effect of institutions on trade have disaggregated the impact by manufactured goods and non-manufactured goods (e.g., Méon and Sekkat, 2008; Álvarez et al., 2018) or have adopted a broader approach by distinguishing sectors of economic activity (Barbero et al., 2021). Nevertheless, this sectoral disaggregation does not evaluate whether a product or sector is particularly damaging for the environment.

In fact, evidence on the effects of institutions on trade in products according to their environmental footprint is restricted to specific categories—typically fuels and renewable energy. In this vein, Nuñez-Rocha and Turcu (2019) find that an increase in environmental regulations impacts trade in fossils fuels, although the effects depend on the objective of the regulation. Specifically, international treaties have a notable effect on trade in fuels, whereas national laws have only a slight impact, which is sensitive to political enforcement.

2.2. Institutions and environment

Environmental issues are characterised by uncertainty and cooperation problems (Weisbuch, 2000). Following North (1991), institutions in the form of property rights and social norms tend to constitute common forms of societal responses to environmental problems. Indeed, Paavola and Adger (2005) argue that institutional economics is strongly tied to ecological economics. As noted in the Introduction, most analyses apply EKC frameworks to examine how institutions moderate the impact of economic development on the environment. These studies support the EKC hypothesis and also find that where institutional quality is high, the turning point takes place at an earlier stage of development (see Adams et al., 2016; Adams and Klobodu, 2017).

Some mechanisms for this effect have been proposed by Acemoglu et al. (2003), who suggest that government institutions may not only affect the economic policies chosen but also facilitate their implementation. Institutional quality minimises the effects of policy revisions during their implementation, enhances governments' ability to implement programs and ensures the impartiality of the legal system. In addition, institutional quality and political stability have been associated with more stringent environmental regulations (see, among others, Fredriksson and Svensson, 2003; Damania et al., 2003; Fredriksson et al., 2005; Pellegrini and Gerlagh, 2006; Woods, 2008; Galinato and Chouinard, 2018).

Along the same lines, Goel et al. (2013) conclude that important dimensions of institutional quality such as corruption and the size of the shadow sector reduce the effectiveness of government institutions, in turn undermining the effectiveness of control policies. Ibrahim and Law (2016) find that a strong institutional framework reinforces the relationship of trade openness to both growth and a better environment. Adams et al. (2016) examine the relationship between energy consumption and growth, finding that democracy positively moderates the energy-growth nexus, whereas Adams and Klobodu (2017) report that having healthy institutions reduces environmental degradation in the long run. In the same vein, Salman et al. (2019) conclude that efficient and impartial domestic institutions play an important role in driving growth and reductions in carbon emissions. Finally, Ibrahim et al. (2020) conclude that governance is a key element for the successful implementation and management of a sustainable green infrastructure. Specifically, a well-coordinated and committed government is essential for the adoption of management activities that prioritise the environment.

Another set of mechanisms relates to the influence of institutions on different actors in the economy. Chen et al. (2018) find that firms engage in more green innovations in areas of higher coercive and normative pressure. Yang et al. (2020) identifies a U-shaped relationship between an index of green institutions and the use of renewable energy, indicating that institutions' commitment to the environment needs to be strong enough to secure a positive response from economic actors.

2.3. Trade and environment

The literature on how environmental regulation alters the composition of trade—what is known as the composition effect —is extensive and employs various different approaches. A first strand of the literature explores the composition effect by analysing the impact of trade

[2] The EKC hypothesis indicates that the pressure of economic growth on the environment increases in the early stages of development. However, once a sufficient level of development has been reached, the relationship between growth and environmental pressure becomes negative.

[3] These include metals, petroleum and other chemicals, manufactured fertilisers or pulp and paper products, among others. See Section 3.2 for a more thorough description.

liberalisation on the environment, measuring environmental impact either through air pollutant concentration (Antweiler et al., 2001) or emissions (Cole and Elliott, 2003; Frankel and Rose, 2005; Cherniwchan, 2017).

A second group of studies examines the composition effect by observing changes in trade flows directly, and analysing their relationship with environmental standards and pollution abatement costs. These studies use a wide variety of indicators as the variable of interest: for example, imports (Aichele and Felbermayr, 2015), exports (Aichele and Felbermayr, 2013), net imports/exports (Tobey, 2001; Mani and Wheeler, 1998; Ederington et al., 2005),[4] measures of revealed comparative advantage – RCA (Low and Yeats, 1992; Marconi, 2012), the share of certain products over total exports (Brandi et al., 2020) or the pollution displaced by imports[5] (Levinson, 2009). Some of them further classify products as green or dirty according to several criteria based on pollution abatement costs (Tobey, 2001; Low and Yeats, 1992; Brandi et al., 2020), toxic release or emission intensities (Lucas et al., 1992; Mani and Wheeler, 1998; Marconi, 2012) or lists used in environmental trade negotiations (Brandi et al., 2020). For example, Marconi (2012) explores the pollution haven effect using data on bilateral trade in dirty industries between China and 14 EU countries, finding no evidence of a such an effect. Using a sample of 117 exporters, Aichele and Felbermayr (2013) show that the ratification of the Kyoto protocol affected the competitiveness of certain dirty industries such as iron and steel, non-ferrous metals, chemical and machinery in ratifying countries. Finally, Brandi et al. (2020) conclude that restrictive environmental provisions reduce dirty exports from developing countries while liberal environmental provisions[6] promote green exports.

As it can be inferred from the above literature review, the institutions-trade-environment link has been studied only partially. Establishing a causal framework can be seen as a major empirical challenge. Institutional quality boosts trade flows by reducing transaction costs and uncertainty (Francois and Manchin, 2013; Barbero et al., 2021). However, little is known about the influence of the quality of institutions on trade composition, particularly trade in dirty goods, for which a negative relationship is expected. In such a scenario, trade composition might be one of the channels through which institutional quality affects the environment. The empirical analysis conducted in the following sections is aimed at filling that gap in the literature.

3. Empirical framework

3.1. Empirical model and estimation strategy

We estimate a gravity model of trade (see Chaney, 2008; Behar and Nelson, 2014; Baier et al., 2018; Allen et al., 2020; Correia et al., 2020; among others). This equation is augmented in our paper with institutional quality. Our baseline empirical model to be estimated is expressed by Eq. (1):

$$\ln X\_DIRTY_{ijt} = \beta_0 + \beta_1 INSTQ_{it} + \beta_2 INSTQ_{jt} + \beta_3 \ln GDP_{it} + \beta_4 \ln GDP_{jt} + \beta_5 RTA_{ijt} + \rho_{it} + \varphi_{jt} + \gamma_{ij} + \varepsilon_{ijt} \tag{1}$$

where subscripts i, j and t refer to exporter country, importer country and time, respectively, and ln stands for natural logarithm. X_DIRTY_{ijt} denotes aggregate exports of dirty products from i to j in year t. $INSTQ_{it}$ and $INSTQ_{jt}$ refer respectively to institutional quality in i and j during t. GDP_{it} and GDP_{jt} are GDP at origin and destination, respectively, during t. In addition, we consider a set of control variables: RTA_{ijt} takes the value 1 if both countries are engaged in a trade agreement and 0 otherwise; ρ_{it}, φ_{jt} and γ_{ij} are exporter-year, importer-year and exporter-importer controls, respectively. Finally, ε_{ijt} denotes the error term. GDP is used as a measure of country size and has been part of gravity models since the basic specifications that found that countries preferred to trade with larger countries (Tinbergen, 1962). Regional trade agreements are positive for trade, since trade liberalisation contributes to a reduction in transaction costs (Baier and Bergstrand, 2007; Baier et al., 2014).

The traditional specifications of the gravity model (e.g., Frankel et al., 1997) considered additional determinants such as distance between countries. However, we rely on the latest refinements to the gravity model estimation techniques, which include a large set of fixed effects that remove time-invariant features (Baier et al., 2019; Weidner and Zylkin, 2021). The inclusion of exporter-time, importer-time and pair fixed effects is contingent on multilateral resistance terms (MRTs). As defined by Anderson and Van Wincoop (2003), MRTs refer to the unobserved effects produced by third countries that may impact the bilateral trade relationship. Omitting MRTs may potentially bias the estimators in the gravity equation and can therefore be considered a significant problem (Head and Mayer, 2014). To appropriately capture MRTs, we follow recent literature (see Baier et al., 2019; Weidner and Zylkin, 2021) and consider a set of three-way fixed effects represented by exporter-time, importer-time and pair fixed effects.

We include the dependent variable in levels rather than as a share of the total export flow. The reason for doing so is based on theory, since seminal studies using gravity models include trade in levels (see Anderson and Van Wincoop, 2003; Head and Mayer, 2014). To the best of our knowledge, only Eaton et al. (2013) use trade shares, but their analysis is performed at the firm level using a discrete distribution, where trade shares allow them to capture the presence of large firms holding greater shares. However, that framework is not applicable to our case.

In relation to the estimation strategy, Eq. (1) presents several problems that need to be addressed. First, taking logarithms of the dependent variable leads to problems of heteroskedasticity, as pointed out by Santos-Silva and Tenreyro (2006). Second, exporter-time and importer-time controls are perfectly collinear with certain explanatory variables—GDP and institutional quality—and may thus be dropped from the regression. Third, there may be problems related to the potential endogeneity of regressors, which could extend to institutional quality (e.g., Rodrik et al., 2004; Nunn, 2007) and regional trade agreements (e.g., Ornelas, 2005; Baier and Bergstrand, 2007). Accordingly, as an alternative, we define Eq. (2), intended to address the aforementioned problems:

$$X\_DIRTY_{ijt} = \beta_0 + \beta_1 INSTQ_{i,t-1} + \beta_2 INSTQ_{j,t-1} + \beta_3 lnGDP_{i,t-1} + \beta_4 lnGDP_{j,t-1} + \beta_5 RTA_{ij,t-1} + \rho_{it^*} + \varphi_{jt^*} + \gamma_{ij} + \varepsilon_{ijt} \tag{2}$$

Eq. (2) builds on Eq. (1), but it is estimated using Pseudo-Poisson Maximum Likelihood (PPML) following Santos-Silva and Tenreyro (2006) and Correia et al. (2020) to deal with our large set of fixed effects. This allows us to introduce some novel components. First, the dependent variable is expressed in levels and allows us to include zeros, as well as to avoid potential heteroskedasticity problems. The use of the PPML estimator is consistent with roots of the structural gravity model and MRTs proposed by Head and Mayer (2014) in the presence of adequate exporter-time and importer-time fixed effects. As these fixed effects are perfectly collinear with regressors, we follow common practice and define ρ_{it^*} and φ_{jt^*}, which are three-year time-varying fixed effects for exporter-time and importer-time. These control variables take the value 1 for the first three years of the sample, and 0 for the second three years

[4] In some cases, these are scaled by other variables such as total shipments (Ederington et al., 2005) or total domestic production (Grossman and Krueger, 1991).

[5] That is, the amount of pollution that would be emitted if the imports were produced domestically.

[6] By liberal provisions they mean those that reduce trade barriers for environmental goods and services.

of the sample; an analogous procedure is applied across the entire sample.[7] The use of this set of controls prevents perfect correlation and, more importantly, is consistent with the theoretical roots of gravity equations (Martínez-Zarzoso and Márquez-Ramos, 2019; Rodríguez-Crespo and Martínez-Zarzoso, 2019).

Beyond pair fixed effects, some prior specifications of gravity models include distance and certain geographical, institutional and economic bilateral control variables. Distance has been included in gravity models since the early specifications (Tinbergen, 1962), assuming that countries prefer to trade with countries that are geographically closer. The same reasoning applies to the control variable related to adjacency. In addition, controls for past colonial linkages and common language (Head et al., 2010) reflect the existence of colonial legacies contingent on informal institutions. However, these controls are time-invariant and do not capture possible improvements in countries' institutional performance over time.

Finally, it is important to discuss the various sources of endogeneity. The first one is reverse causality. Previous evidence has suggested that local policies can be influenced by external openness via trade liberalisation or foreign direct investment (FDI). Khandelwal et al. (2013) report that trade liberalisation can abolish barriers to trade imposed by specific institutions, while Cole et al. (2006) and Cole and Fredriksson (2009) conclude that FDI can improve environmental policies. However, they only find the abolishment of trade barriers or the improvement of environmental regulations in countries where institutional quality is sufficiently high; the opposite result is found for countries with low institutional quality. Thus, while environmental and trade policies can be affected by country openness (either in the form of trade liberalisation or FDI), the link with the quality of the institutions is weak. According to these arguments, the quality of institutions is exogenous and might indeed moderate the nature of the response to external openness (in the form of specific policies). Furthermore, our aim in this paper is not to study the effects of institutions on trade liberalisation, but on the composition of trade in environmental terms. In principle, we have no reason to suspect that trade composition is affected by reverse causality. That said, in order to minimise the possibility of reverse causality, our models use lagged variables. Another source of endogeneity is the omission of relevant variables, which we deal with by including — in addition to the control variables —origin, destination and, more importantly, country-pair fixed effects. The latter are particularly effective for addressing endogeneity, since they absorb any links existing between regressors and the error term in gravity regressions (see Piermartini and Yotov, 2016, for a thorough discussion).

3.2. Database

Our sample comprises 140 countries from all around the world, covering the years 2002–2018. The list of countries is provided in Appendix A. Regarding the variables measuring institutional quality, we rely on the WGI estimated by the World Bank at the country level (Kauffman et al., 2010). This variable has been collected annually since 1996 for a wide sample of countries. This is an essential feature for our methodological strategy, based on a panel of yearly bilateral flows and a broad set of fixed effects, where annual variability is needed to prevent the impacts being absorbed by the fixed effects of the model. The WGI project is widely used, its construction is transparent, and it ensures comparability both across countries and over time. Finally, the WGI provide information for up to six individual dimensions of institutional quality. Their scores lie in the interval [−2.5, 2.5], which denote the lowest and highest levels of institutional quality, respectively. The six indicators or dimensions available are: (1) voice and accountability, (2) political stability and absence of violence, (3) government effectiveness, (4) regulatory quality, (5) rule of law, and (6) control of corruption. Following Beverelli et al. (2018), as a first step we compute the simple average of the six dimensions of WGI for origin and destination ($INSTQ_{it}$ and $INSTQ_{jt}$). Data on bilateral exports are sourced from the BACI database provided by Centre d'Études Prospectives et d'Informations (CEPII),[8] while GDP is taken from World Bank's World Development Indicators (WDI). Data on Regional Trade Agreements are sourced from CEPII – Gravity database (Head et al., 2010; Head and Mayer, 2014).

One of the key issues in our analysis is identifying which products are categorised as dirty. For this purpose, dirty industries are usually defined as those associated with high pollution abatement costs. Classifications of dirty goods date back to the studies of Tobey (2001), Mani and Wheeler (1998) and Low and Yeats (1992).[9] Although the criteria vary from one study to another, they mostly coincide in terms of industries and goods. We employ the classification by Low and Yeats (1992), since it is the most commonly used in similar studies for dirty trade (Brandi et al., 2020).[10] The lists of dirty goods are normally expressed using the SITC classification of trade, while data on trade from the BACI database are divided in HS codes. We then use the list of equivalences between classifications provided by international organisations to match them. Due to computational issues derived from working with sectoral disaggregated trade data, we consider aggregate flows of dirty trade.[11] Finally, we replace missing values of trade flows with zeros, which is standard practice in gravity studies, following Santos-Silva and Tenreyro (2006). This replacement procedure is applied when there is no trade of a certain product between country pairs. This rarely occurs in our sample, so the impact on final outcomes is negligible.

3.3. Descriptive statistics

Some descriptive statistics are provided in this section. Table 1 presents a complete description of the variables used and their sources, while Table 2 reports some descriptive statistics of the main variables for the years 2002 and 2018. As can be seen, the average values for the share of dirty trade remain stable over the period, although there is a notable

[7] The exception is the last set of years, where the value 1 is taken for the years from 2014 to 2018.

[8] The CEPII trade databases disaggregated by product only report information for exports. However, while we acknowledge that there may be some mismatch between exports and imports due to the existence of different trade regimes, the context of bilateral trade allows us to interpret the results in terms of imports: assuming a bilateral trade context between countries 1 (origin) and 2 (destination), exporting from 1 to 2 can also be interpreted as importing into 2 from 1.

[9] These lists include all three-digit products in SITC 67 (ferrous metals), 68 (nonferrous metals) and 69 (metal manufactures), as well as pulp and paper products, organic and inorganic chemicals, radioactive materials, mineral tars and petroleum chemicals, manufactured fertilisers, paper and board, paper articles, plywood and improved wood, wood manufactures, refined petroleum, agricultural chemicals and cements. See Low and Yeats (1992) for further details.

[10] The classification of dirty goods has barely changed over time. For example, Aichele and Felbermayr (2013) consider similar industries and products for classifying goods as energy-intensive by employing information from the EU Commission and the US Department of Energy. Also, a similar classification is derived from the classification of industries at risk of carbon leakage by the European Commission, July 2019 (see Annex of the Commission Delegated Decision (EU) 2019/708 of 15 February 2019, supplementing Directive 2003/87/EC of the European Parliament and of the Council concerning the determination of sectors and subsectors deemed at risk of carbon leakage for the period 2021 to 2030).

[11] Disaggregated sectoral trade data contain a high number of missing values.

Table 1
Variables description and sources.

Variable	Description	Source
X_DIRTY_{ijt}	Bilateral exports of dirty goods from *i* to *j* during *t* (Millions USD)	CEPII
$INSTQ_{i,\ t-1}$	Institutional quality in *i* during *t*, 1-year lagged	World Bank - WGI
$INSTQ_{j,\ t-1}$	Institutional quality in *j* during *t*, 1-year lagged	World Bank - WGI
$GDP_{i,\ t-1}$	Gross Domestic Product of *i* during *t*, 1-year lagged (Millions USD)	World Bank - WDI
$GDP_{j,\ t-1}$	Gross Domestic Product of *j* during *t*, 1-year lagged (Millions USD)	World Bank - WDI
$RTA_{ij,\ t-1}$	Control variable that takes the value 1 if *i* and *j* are members of a regional trade agreement and 0 otherwise, 1-year lagged	CEPII
$DIST_{ij}$	Bilateral distance (km) that separates *i* and *j*	CEPII
$CONTIG_{ij}$	Control variable that takes the value 1 if *i* and *j* share a common border and 0 otherwise	CEPII
$COMLANG_{ij}$	Control variable that takes the value 1 if *i* and *j* share a common language and 0 otherwise	CEPII
$COLONY_{ij}$	Control variable that takes value 1 if *i* and *j* share past colonial linkages and 0 otherwise	CEPII
$CCOR_{i,\ t-1}$	Control of corruption in *i* during *t*, 1-year lagged	World Bank - WGI
$CCOR_{j,\ t-1}$	Control of corruption in *j* during *t*, 1-year lagged	World Bank - WGI
$RQ_{i,\ t-1}$	Regulatory Quality in *i* during *t*, 1-year lagged	World Bank - WGI
$RQ_{j,\ t-1}$	Regulatory Quality in *j* during *t*, 1-year lagged	World Bank - WGI
$VAC_{i,\ t-1}$	Voice and Accountability in *i* during *t*, 1-year lagged	World Bank - WGI
$VAC_{j,\ t-1}$	Voice and Accountability in *j* during *t*, 1-year lagged	World Bank - WGI
$PV_{i,\ t-1}$	Political Stability and Absence of Violence in *i* during *t*, 1-year lagged	World Bank - WGI
$PV_{j,\ t-1}$	Political Stability and Absence of Violence in *j* during *t*, 1-year lagged	World Bank - WGI
$GE_{i,\ t-1}$	Government Effectiveness in *i* during *t*, 1-year lagged	World Bank - WGI
$GE_{j,\ t-1}$	Government Effectiveness in *j* during *t*, 1-year lagged	World Bank - WGI
$RL_{i,\ t-1}$	Rule of Law in *i* during *t*, 1-year lagged	World Bank - WGI
$RL_{j,\ t-1}$	Rule of Law in *j* during *t*, 1-year lagged	World Bank - WGI
$(CO_2)_{i,\ t-1}$	CO_2 emissions intensity (kg per 2015 PPP $ of GDP) in *i* during *t*, 1-year lagged	World Bank - WGI
$(CO_2)_{j,\ t-1}$	CO_2 emissions intensity (kg per 2015 PPP $ of GDP) in *j* during *t*, 1-year lagged	World Bank - WGI
$Primary\_exporter_{i,\ t-1}$	Dummy variable that takes the value 1 if *i* can be catalogued as primary exporter and 0 otherwise, 1-year lagged	World Bank - WDI and own elaboration
$Primary\_exporter_{j,\ t-1}$	Dummy variable that takes the value 1 if *j* can be catalogued as primary exporter and 0 otherwise, 1-year lagged	World Bank- WDI and own elaboration
$MpliberalC_{ij,\ t-1}$	Mean overall proportion of liberal clauses over the total number of clauses related to environmental provisions in *i* and *j* during *t*, 1-year lagged	TREND
$MptradeRestC_{ij,\ t-1}$	Mean overall proportion of trade restrictiveness clauses over the total number of clauses related to environmental provisions in *i* and *j*, 1-year lagged	TREND
$Climate\_policies_{i,\ t-1}$	Cumulative sum of climate change-related policies or other executive provisions in *i* during *t*, 1-year lagged	QoG-EI
$Climate\_policies_{j,\ t-1}$	Cumulative sum of climate change-related policies or other executive provisions in *j* during *t*, 1-year lagged	QoG-EI
$IEAs_{i,\ t-1}$	Number of International Environmental Agreements in *i* during *t*, 1-year lagged	QoG-EI
$IEAs_{j\ ,\ t-1}$	Number of International Environmental Agreements in *j* during *t*, 1-year lagged	QoG-EI

increase in the maximum of the share of dirty exports.[12] As for institutional quality scores, they also remain relatively stable, although the data show a slight reduction in disparities.

It is also interesting to analyse the temporal evolution of dirty trade with respect to total trade, in order to study changes in trade composition. Fig. 1 represents the evolution of total trade (in million $) and the share of dirty trade over total trade. The plot shows a rising trend in total trade, with a noticeable decline in 2008 because of the Great Recession, followed by a recovery. In contrast, the share of dirty trade increased until 2007, followed by a sustained decline until 2013. Since then, the share has remained relatively stable with only slight fluctuations, although the changes are moderate and always below two percentage points. Accordingly, it can be argued that trade composition has remained relatively stable in terms of dirty products.

Highlighting specific countries, Table 3 reports the top 10 countries with the largest share of dirty trade, differentiating by exports and imports, and also the 10 countries with the highest institutional quality. Considering dirty trade, the ranking comprises a heterogeneous group of countries, including underdeveloped African and Asian countries and highly developed economies such as Sweden and Finland. In terms of institutional quality, however, the ranking is more homogeneous, including mostly advanced European countries in addition to Canada and Australia. Consequently, the rankings do not clearly point to a link between institutional quality and dirty trade. In fact, some countries with the highest levels of institutional quality, such as Sweden and Finland, are ranked among the countries with the largest share of dirty exports, which indicates that these countries may have a comparative advantage in more pollution-intensive sectors. To paint a more general picture of dirty trade around the world, Fig. 2 shows the shares by country, considering average data for our period of analysis. As can be seen, the pattern is fairly heterogeneous, with dirty traders scattered over the five continents.

Finally, in order to better understand the relationship between institutional quality and the share of dirty trade, Fig. 3 displays scatter plots of the two variables, distinguishing between exports (panel a) and imports (panel b) and using average data. The plots also display the total amount of exports and imports of dirty products, indicated by the size of the bubbles. The colour of the bubbles denotes the geographical region to which each country belongs, according to the World Bank regional classification. Interestingly, the figures show a non-linear pattern. Looking at exports, we observe a positive relationship for low levels of institutional quality, while the opposite is found after intermediate levels, describing an inverted U-shaped pattern. For the case of imports,

[12] Note that for the sake of interpretability, the descriptive statistics for the variable of interest are shown using the share of dirty trade, but in the econometric model we use bilateral flows in levels, as explained in Section 3.1. Using shares would not be consistent with the theoretical underpinnings of the gravity model.

Table 2
Descriptive statistics for the variables of interest in the first and final year of the sample.

	Average		Standard deviation		Minimum		Maximum	
	2002	2018	2002	2018	2002	2018	2002	2018
Dirty trade (share share)	0.111	0.116	0.050	0.059	0.011	0.000	0.316	0.537
Dirty exports (share share)	0.094	0.096	0.089	0.109	0.000	0.000	0.438	0.751
Dirty imports (share share)	0.124	0.129	0.035	0.035	0.009	0.000	0.247	0.254
Institutional quality	−0.018	−0.041	0.948	0.937	−1.752	−2.110	1.950	1.815

Note: Institutional quality scores lie in the interval [−2.5, 2,5] where higher values correspond to better institutions. Trade figures are expressed as a share of total trade, ranging from 0 to 1.

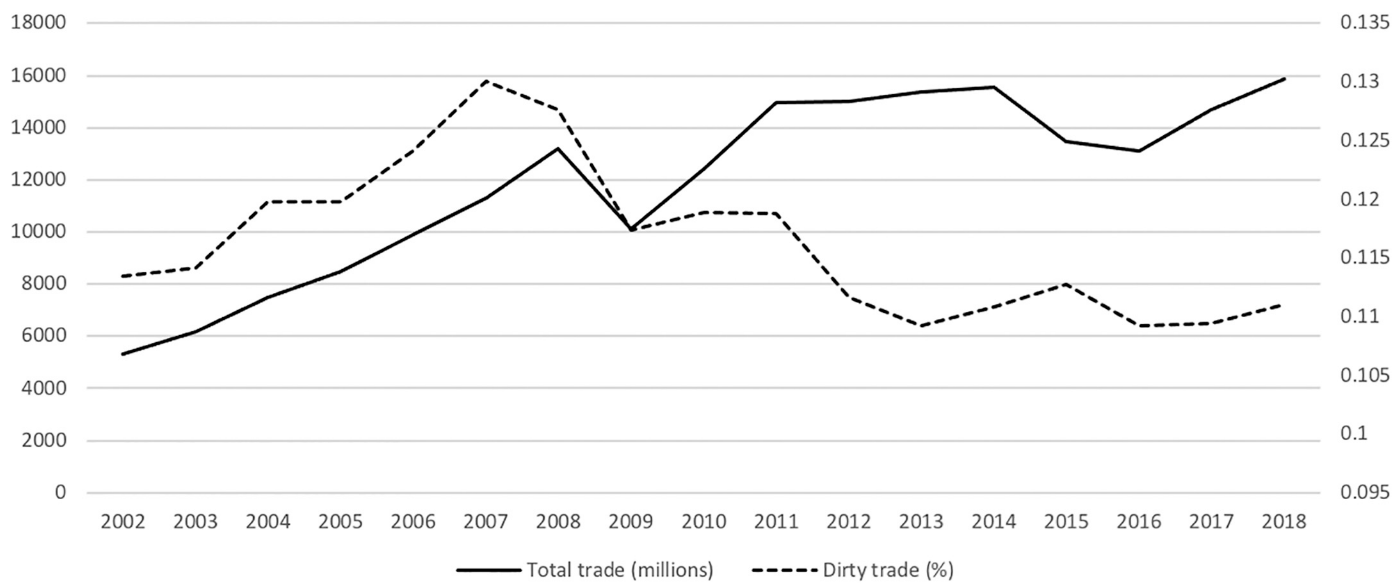


Fig. 1. Total trade (left axis, millions of €) and dirty trade (right axis, share- ranging from 0 to 1 - of aggregate trade).

Table 3
Ranking of countries (top 10) for the period 2002–2018.

Ranking	Dirty trade (share)	Dirty exports (share)	Dirty imports (share)	Institutional quality
1	Zambia	Zambia	Angola	Finland
2	Bhutan	Bhutan	Albania	Denmark
3	Mozambique	Mozambique	United Arab Emirates	New Zealand
4	Chile	Iceland	Argentina	Sweden
5	Iceland	Chile	Armenia	Switzerland
6	Macedonia	Macedonia	Australia	Norway
7	Finland	Finland	Austria	Netherlands
8	Niger	Niger	Burundi	Canada
9	Kazakhstan	Armenia	Benin	Iceland
10	Sweden	Sweden	Burkina Faso	Australia

Note: Rankings produced based on average data for the period 2002–2018. Trade figures are expressed as a share of total trade - ranging from 0 to 1.

the relationship seems unclear for low institutional quality levels, after which point a negative link can be detected. Such patterns would suggest that the transition to cleaner trade due to improvements in institutional quality takes place only after a sufficiently high level of institutional quality has been reached. We test this pattern in the econometric analysis, providing results for different levels of institutional quality disaggregated by quintiles, in line with Rodríguez-Pose and Zhang (2019).

4. Results and discussion

4.1. Selection of the econometric model and baseline results

Despite advances in gravity model estimation in the last two decades, many empirical challenges persist, spawning a wide variety of estimators (Head and Mayer, 2014). In response to these challenges, we first check the robustness of the estimators to assess the consistency of estimation coefficients.

We establish four different specifications: (1) PPML with exporter-time and importer-time fixed effects, in line with structural gravity theory (Head and Mayer, 2014; Piermartini and Yotov, 2016); (2) PPML with three-year time-varying exporter-time and importer-time fixed effects as well as pair effects; (3) specification (2) suppressing exporter-time fixed effects; and (4) specification (2) suppressing importer-time fixed effects. Since column (1) does not incorporate pair effects, we introduce a new set of bilateral variables typical in gravity equations (Frankel et al., 1997) with the aim of capturing the impact of country-pair determinants: $DIST_{ij}$ is the bilateral distance that separates i and j; $CONTIG_{ij}$ takes value the 1 if the two countries are adjacent, and 0 otherwise; $COMLANG_{ij}$ takes the value 1 if the two countries share a common language, and 0 otherwise; and $COLONY_{ij}$ takes the value 1 if countries share historical colonial ties, and 0 otherwise.

The results are provided in Table 4. As we can see in column (1), institutional quality has a negative coefficient even in the presence of

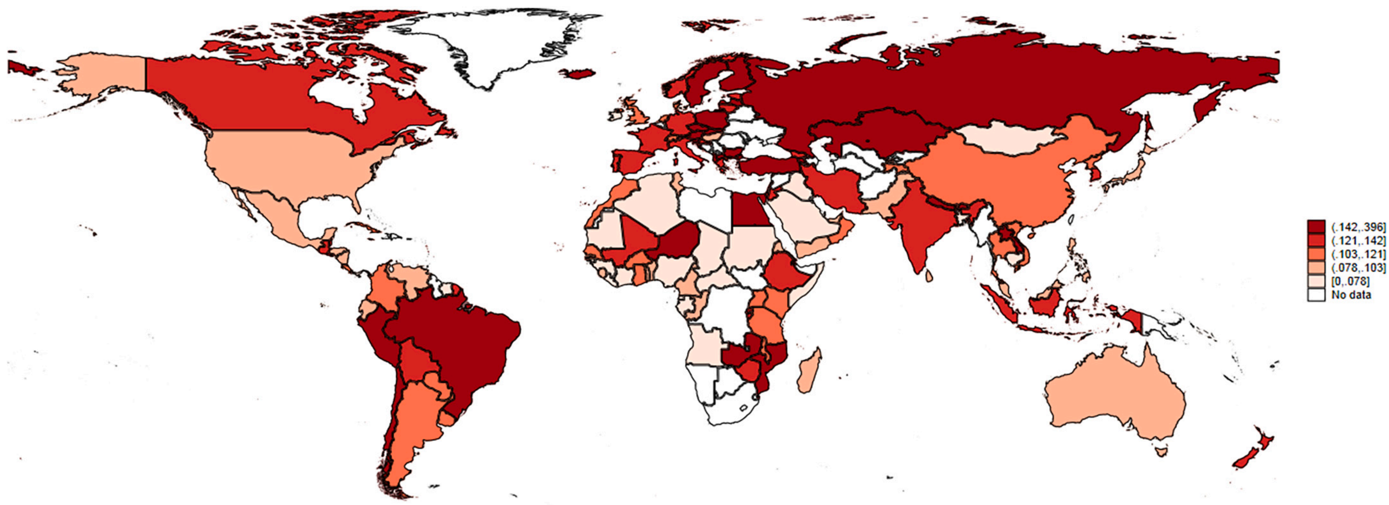


Fig. 2. Dirty trade (share of total trade-from 0 to 1). Average 2002–2018.

structural gravity with MRTs. However, this structural estimation makes it totally impossible to differentiate between impacts for origin and destination, since they are perfectly collinear with fixed effects. For this reason, only the interaction coefficient between institutional quality variables at origin and destination can be shown. This problem is solved in models (2)–(4), by incorporating time-varying exporter-time and importer-time fixed effects. In these models, institutional quality is negative and significant for origin and destination (the only exception is column (3), where the variable is non-significant for origin). As mentioned above, a PPML encompassing a set of three-way fixed effects offers notable advantages for our research objectives. Thus, model (2) is considered as the baseline for our subsequent analyses. According to our results, higher levels of institutional quality are related to a reduction in both dirty exports and dirty imports.

These results lend support to the pollution haven hypothesis. Institutional quality has been associated with more stringent environmental regulations (see, among others, Fredriksson and Svensson, 2003; Pellegrini and Gerlagh, 2006; Woods, 2008; Galinato and Chouinard, 2018). Therefore, it can potentially act as a transmission channel for the reduction of dirty trade, a proposal which is tested in Section 4.4. The coefficients for the rest of the explanatory variables are in line with gravity theory.

4.2. Results for different levels of institutional quality

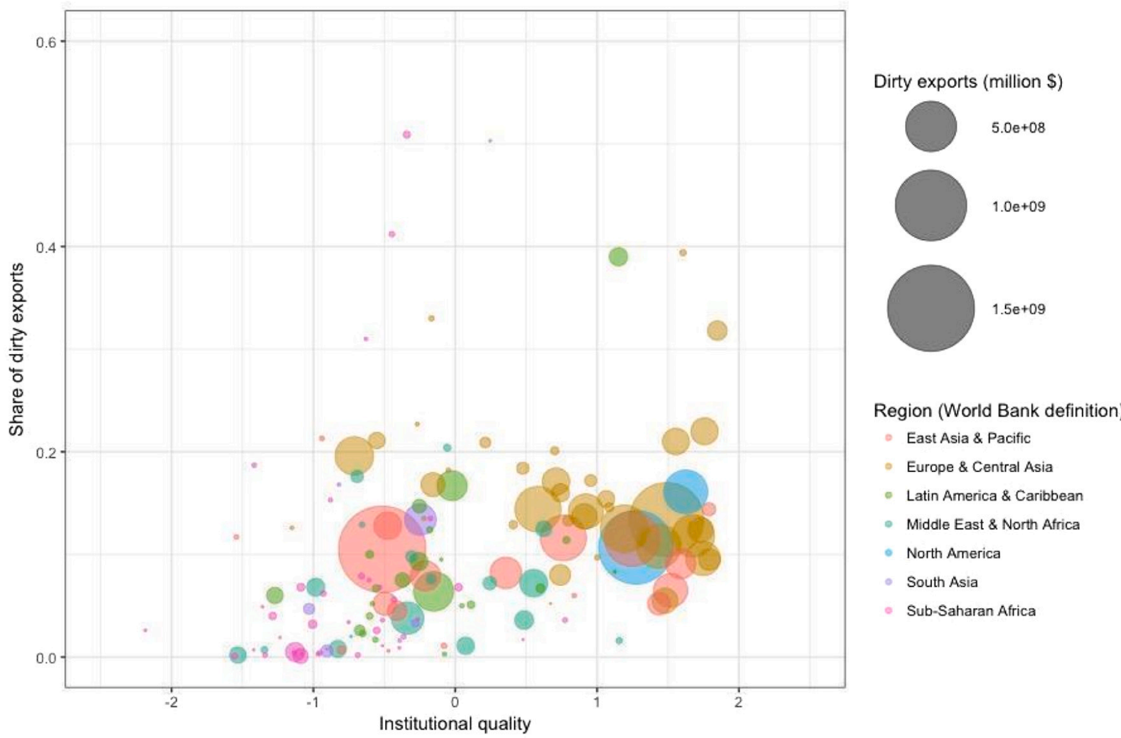
Departing from our baseline specification (model 2 in Table 4), in this section we analyse the non-linear patterns identified in our descriptive analysis. We follow Rodríguez-Pose and Zhang (2019) and provide results for different levels of institutional quality by quintiles. The results, displayed in Table 5, show that the effects do indeed differ depending on the level of institutional quality. In columns (4, 5) — the fourth and fifth quintiles — the coefficients for both exporter and importer are negative and significant. For the first to third quintiles, results reveal a positive impact of institutional quality on dirty exports, while effects in the case of dirty imports tend to be non-significant or only weakly significant.

Therefore, for the exporters, an inverted U-shaped relationship is confirmed: dirty trade seems to increase until a certain level of institutional quality is reached, after which point the link becomes negative, a result compatible with a sort of EKC for institutions and trade. For the case of the importers, the benefits of institutional quality are only apparent in countries with high-quality institutions. Although previous studies support the EKC-type relationship between institutional quality and growth (e.g., Bhattarai and Hammig, 2001; Culas, 2007), this issue has not been studied for trade composition.

Our findings are aligned to those reported in recent related studies. Yang et al. (2020) find a U-shaped relationship between a green institutional environment index and renewable energy investment, showing that when the green institutional environment is in the initial stage of development it cannot promote renewable energy investment, but rather produces an inhibitory effect. However, when the green institutional environment develops to a certain level, it significantly promotes renewable energy investment. Some studies on the EKC hypothesis have also found that the turning point of the curve tends to take place at an earlier level of development when institutional quality is high (Adams et al., 2016; Adams and Klobodu, 2017). Moreover, institutions are a fundamental driver of economic development (Rodríguez-Pose, 2020); as such, we expect less developed economies to have lower levels of institutional quality. These countries tend to increase their levels of industrialisation as they grow. Since dirty industries are strongly linked to manufacturing and tend to be capital-intensive (Antweiler et al., 2001), this process can trigger trade in dirty products. In addition, as argued by Dasgupta (2002), these countries are not usually particularly concerned about environmental issues, since they face more pressing problems such as ensuring their citizens have a minimum level of economic welfare. However, over the course of the development process, institutions start to become an effective driver, playing a stronger role in enforcing environmental regulations (Dasgupta, 2002). Our results show that a minimum level of institutional quality is required for these benefits to emerge.

Other arguments on the part played by institutions can be found in Acemoglu and Robinson (2012). In particular, the different impact of institutions on dirty trade depends on the characteristics of the institutional framework. In that regard, higher levels of institutional quality are inclusive by nature, which means that they allow and encourage people's participation in economic activities that make the best use of their talents and skills. In contrast, low-quality institutions tend to be extractive, excluding the majority of the population from participating in political or economic affairs. This is an important point, as progress towards a greener economy needs the participation of the different

a) Dirty exports and institutional quality



b) Dirty imports and institutional quality

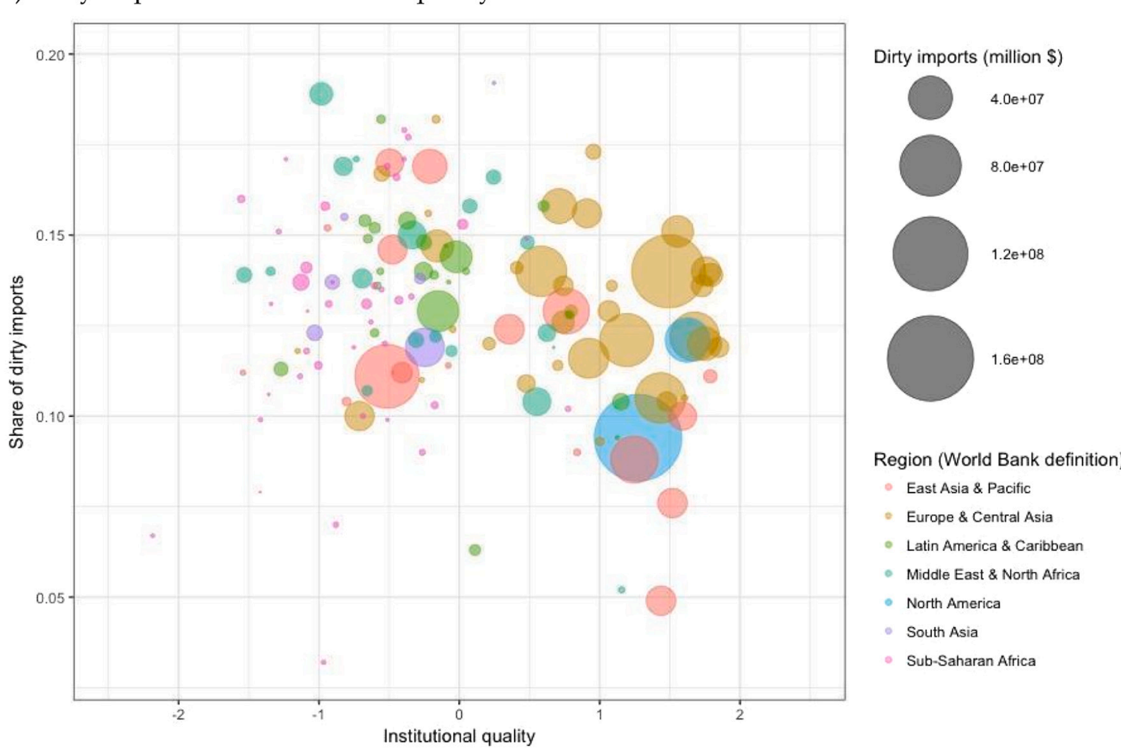


Fig. 3. Institutional quality and dirty trade. Average 2002–2018. Dirty exports and imports are expressed as a share of total trade - ranging from 0 to 1.
a) Dirty exports and institutional quality
b) Dirty imports and institutional quality.

Table 4
Model selection of gravity estimators and baseline results, 2002–2018.

	(1)	(2)	(3)	(4)
Variables	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}
$INSTQ_{i,\ t-1}$		−0.0597*	−0.0298	−0.0552*
		(0.0326)	(0.0311)	(0.0330)
$INSTQ_{j,\ t-1}$		−0.0685**	−0.0694**	−0.0760**
		(0.0330)	(0.0330)	(0.0309)
$lnGDP_{i,\ t-1}$		0.341***	0.344***	0.336***
		(0.0142)	(0.0137)	(0.0140)
$lnGDP_{j,\ t-1}$		0.408***	0.408***	0.418***
		(0.0137)	(0.0135)	(0.0133)
$RTA_{ij,\ t-1}$	1.051***	0.180***	0.172***	0.177***
	(0.0230)	(0.0171)	(0.0170)	(0.0169)
$INSTQ_{i,\ t-1}*INSTQ_{j,\ t-1}$	−0.0940***			
	(0.0114)			
$lnDIST_{ij}$	−0.351***			
	(0.0147)			
$CONTIG_{ij}$	0.850***			
	(0.0286)			
$COMLANG_{ij}$	0.248***			
	(0.0261)			
$COLONY_{ij}$	0.500***			
	(0.0283)			
Constant	16.12***	−6.409***	−6.473***	−6.509***
	(0.132)	(0.309)	(0.305)	(0.309)
Exporter-time	X			
Importer-time	X			
Pair		X	X	X
Exporter-time each 3 years		X		X
Importer-time each 3 years		X	X	
Pseudo R-squared	0.912	0.984	0.984	0.984
Observations	311,369	207,632	207,632	207,632

Note: X_DIRTY_{ijt} exports of dirty products from i to j in t. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. For the specification that does not contain pair fixed effects, we include the remaining traditional gravity equation variables as in Tinbergen (1962) and Frankel et al. (1997): distance, adjacency and controls for former colonial linkages.

Table 5
PPML estimation by quintiles of institutional quality, 2002–2018.

	(1)	(2)	(3)	(4)	(5)
Variables	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}
Quintiles *INSTQ*	1st	2nd	3rd	4th	5th
$INSTQ_{i,\ t-1}$	1.417***	0.334**	0.249***	−0.116*	−0.405***
	(0.257)	(0.145)	(0.0879)	(0.0652)	(0.0611)
$INSTQ_{j,\ t-1}$	−0.161	−0.163*	0.0757	−0.248***	−0.103**
	(0.296)	(0.0982)	(0.0802)	(0.0780)	(0.0453)
$lnGDP_{i,\ t-1}$	−0.0889	0.209***	0.275***	0.550***	0.0992***
	(0.0862)	(0.0280)	(0.0335)	(0.0396)	(0.0279)
$lnGDP_{j,\ t-1}$	0.828***	0.736***	0.502***	0.313***	0.443***
	(0.113)	(0.0540)	(0.0387)	(0.0448)	(0.0175)
$RTA_{ij,\ t-1}$	−0.306*	0.291***	0.0879**	0.263***	0.135***
	(0.177)	(0.0547)	(0.0446)	(0.0306)	(0.0249)
Constant	−7.089***	−11.41***	−7.647***	−9.662***	0.267
	(2.140)	(1.002)	(0.651)	(0.763)	(0.554)
Pseudo R-squared	0.900	0.982	0.976	0.980	0.991
Observations	23,738	34,196	39,605	45,201	56,361

Note: X_DIRTY_{ijt} denotes exports of dirty products from i to j in t. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All estimations have been conducted using the PPML approach described in Eq. (2). All columns include three-year time-varying exporter-time and importer-time fixed effects, as well as pair effects.

stakeholders in the economy (Mombeuil, 2020). Institutions should thus mobilise to promote action by all economic actors; failure to do so may adversely affect the outcomes of political decisions aimed at environmental protection.

4.3. Results for different dimensions of institutional quality

Institutional quality is a multidimensional concept (Méon and Sekkat, 2008). Accordingly, in this section we investigate which dimensions of institutional quality actually play a relevant role in the reduction of dirty trade flows. The six dimensions considered have already been introduced in the data section and are now defined at origin and destination as follows[13]: Control of Corruption ($CCOR_{i,\ t-1}$ and $CCOR_{j,\ t-1}$), Regulatory Quality ($RQ_{i,\ t-1}$ and $RQ_{j,\ t-1}$), Voice and Accountability ($VAC_{i,\ t-1}$ and $VAC_{j,\ t-1}$), Political stability and absence of Violence ($PV_{i,\ t-1}$ and $PV_{j,\ t-1}$), Government Effectiveness ($GE_{i,\ t-1}$ and $GE_{j,\ t-1}$) and Rule of Law ($RL_{i,\ t-1}$ and $RL_{j,\ t-1}$).

The results, provided in Table 6, show that the negative impact of institutional quality on dirty trade is driven by three dimensions: voice

[13] Recall that, as in previous specifications, they are lagged by one year.

Table 6
PPML estimation by indicators of institutional quality, 2002–2018.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}
$CCOR_{i,\ t-1}$	−0.0321					
	(0.0207)					
$CCOR_{j,\ t-1}$	0.00941					
	(0.0230)					
$RQ_{i,\ t-1}$		−0.0273				
		(0.0225)				
$RQ_{j,\ t-1}$		0.0840***				
		(0.0220)				
$VAC_{i,\ t-1}$			−0.220***			
			(0.0299)			
$VAC_{j,\ t-1}$			−0.161***			
			(0.0255)			
$PV_{i,\ t-1}$				−0.0325**		
				(0.0133)		
$PV_{j,\ t-1}$				−0.0467***		
				(0.0144)		
$GE_{i,\ t-1}$					0.180***	
					(0.0228)	
$GE_{j,\ t-1}$					0.0274	
					(0.0203)	
$RL_{i,\ t-1}$						−0.103***
						(0.0283)
$RL_{j,\ t-1}$						−0.0935***
						(0.0260)
$lnGDP_{i,\ t-1}$	0.345***	0.346***	0.327***	0.343***	0.330***	0.349***
	(0.0140)	(0.0140)	(0.0141)	(0.0139)	(0.0142)	(0.0141)
$lnGDP_{j,\ t-1}$	0.404***	0.401***	0.391***	0.407***	0.411***	0.415***
	(0.0137)	(0.0136)	(0.0135)	(0.0135)	(0.0142)	(0.0136)
$RTA_{ij,\ t-1}$	0.179***	0.176***	0.182***	0.176***	0.169***	0.178***
	(0.0172)	(0.0173)	(0.0169)	(0.0171)	(0.0172)	(0.0171)
Constant	−6.451***	−6.488***	−5.414***	−6.501***	−6.451***	−6.724***
	(0.311)	(0.305)	(0.318)	(0.305)	(0.306)	(0.307)
Pseudo R squared	0.984	0.985	0.984	0.985	0.985	0.985
Observations	207,632	207,632	207,632	207,632	207,632	207,632

Note: X_DIRTY_{ijt} exports of dirty products from *i* to *j* in *t*. Robust standard errors in parentheses.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All estimations have been conducted using the PPML approach described in Eq. (2). All columns include three-year time-varying exporter-time and importer-time fixed effects, as well as pair effects.

Table 7
PPML estimation with environmental standards by quintiles of institutional quality, 2002–2018.

	(1)	(2)	(3)	(4)	(5)
Variables	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}
Quintiles *INSTQ*	1st	2nd	3rd	4th	5th
$INSTQ_{i,\ t-1}$	1.015***	0.431**	0.047	0.066	−0.448***
	(0.000)	(0.017)	(0.685)	(0.357)	(0.000)
$INSTQ_{j,\ t-1}$	−0.172	0.027	0.035	−0.100	0.016
	(0.610)	(0.799)	(0.699)	(0.265)	(0.726)
$lnGDP_{i,\ t-1}$	0.085	0.299***	0.197***	0.492***	0.120***
	(0.404)	(0.000)	(0.000)	(0.000)	(0.000)
$lnGDP_{j,\ t-1}$	0.727***	0.752***	0.548***	0.359***	0.490***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$RTA_{ij,\ t-1}$	−0.385**	0.249***	0.071	0.242***	0.183***
	(0.045)	(0.000)	(0.122)	(0.000)	(0.000)
$ln(CO_2)_{i,\ t-1}$	0.958***	0.571***	−0.045	−0.159**	0.053
	(0.000)	(0.005)	(0.790)	(0.041)	(0.259)
$ln(CO_2)_{j,\ t-1}$	0.874***	0.267***	0.024	0.199**	0.190***
	(0.001)	(0.008)	(0.797)	(0.014)	(0.000)
Constant	−6.751***	−13.724***	−7.204***	−9.459***	−1.365**
	(0.002)	(0.000)	(0.000)	(0.000)	(0.030)
Pseudo R-squared	0.907	0.983	0.965	0.982	0.991
Observations	18,943	25,164	29,999	35,187	45,100

Note: X_DIRTY_{ijt} denotes exports of dirty products from *i* to *j* in *t*. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All estimations have been conducted using the PPML approach described in Eq. (2). All columns include three-year time-varying exporter-time and importer-time fixed effects, as well as pair effects.

and accountability, rule of law, and political stability and absence of violence. Therefore, the involvement of economic actors is needed to enable a transition towards cleaner trade. Political stability and absence of violence can also be important for the implementation and monitoring of green policies. Finally, strong rule of law may give economic actors confidence by setting a framework of guarantees and the appropriate incentives to comply with regulations. In contrast, the estimates for control of corruption and regulatory quality are non-significant. The other variables in the model show positive and significant coefficients, in line with theoretical insights from gravity models.

Our results corroborate the importance of disaggregating by dimensions of governance to address their impacts on trade separately. Francois and Manchin (2013) find that government effectiveness, political stability, regulatory quality, and rule of law may be behind the largest increases in bilateral trade. Álvarez et al. (2018) report similar findings. Yu et al. (2015) provide support for the importance of rule of law, as do Méon and Sekkat (2008) for voice and accountability. For the case of political stability and absence of violence, Rotunno (2016) reports that governments are more likely to implement trade reforms when they are about to lose power. The focus of our study is different, as it only considers trade in dirty products. Our results, however, add interesting nuances to these previous findings. These dimensions of institutional quality not only have a positive influence on trade flows, as suggested by previous literature, but also have the capacity to modify trade composition, reducing the trade in dirty products.

4.4. Potential mechanisms and robustness checks

This section explores some of the potential mechanisms through which institutional quality might affect trade in dirty products. These further tests can also be considered robustness checks for the sensitivity of our variable of interest after including in the model additional regressors that can potentially capture the effect of institutional quality.

First, we include an indicator of the stringency of environmental regulation. Less stringent environmental regulation implies lower abatement costs, meaning countries with looser environmental standards enjoy a comparative advantage in the trade of more polluting goods. To account for this possibility, we employ an indicator of emissions intensity; namely, CO_2 emissions per unit of output.[14] Low levels of this indicator should be interpreted as more stringent environmental standards. Under the pollution haven hypothesis, increased abatement costs in countries with stricter environmental standards are expected to reduce exports of dirty goods. Table 7 replicates the results for the different quintiles of institutional quality, including CO_2 emissions. The results are in line with those reported in Table 5, although coefficients for the third and fourth quantiles are now non-significant. Regarding dirty imports, the negative effect for the fourth and fifth quantiles found in previous results is weakened after controlling for environmental standards. The results also suggest a pollution haven effect, given that higher CO_2 intensity— indicating laxer environmental regulation—is associated with an increase in both dirty imports and dirty exports for most of the models.

As a second test, we employ additional measures of the stringency of environmental regulation. Environmental standards could also be embedded in the trade agreements in the form of environmental provisions. We replicate our results reconsidering our treatment of trade agreements, and accounting for the existence of environmental provisions. For this purpose, we employ the TREND (Trade & Environment Database) jointly produced by the Deutsches Institut für Entwicklungspolitik (Germany) and the Canada Research Chair in International Political Economy at Laval University. This is a unique dataset that collects information on different environmental provisions by analysing texts of about 630 preferential trade agreements (PTAs) signed worldwide since 1945. Goods included in the provisions reflect the lists of clean goods provided by international organisations.

Following Brandi et al. (2020), we consider two different categories of environmental provisions: i) trade-restrictive provisions, which are related to specific restrictions on environmentally harmful trade ($MptradeRestC_{ij,\ t-1}$), measured as the share of this type of provisions over the total number of provisions in TREND; and ii) liberal provisions, aimed at the reduction of trade barriers for environmentally-friendly goods ($MpliberalC_{ij,\ t-1}$), measured as the ratio of this type of provisions over the total number of provisions in TREND.

Our results, reported in Table 8, are broadly in line with those in Table 7. The effect of institutions on dirty exports is found to be positive for the first quintile, negative for the fifth, and not significant for the quintiles in between. With respect to dirty imports, however, the effect of institutions remains negative for the highest quintiles (fourth and fifth). Environmental provisions in trade agreements, however, do not seem to directly affect either dirty exports or dirty imports, as coefficients are mostly non-significant. Overall, in both Tables 7 and 8 the coefficients of institutional quality either become smaller or become non-significant for several quintiles. This suggests that part of the effect of institutional quality on dirty trade may be channelled through more stringent regulations, and therefore higher abatement costs. Moreover, the non-linear pattern found in our baseline scenario remains largely unchanged.

In our third test, we check whether countries with higher institutional quality make use of specific environmental institutions to protect the environment. To capture such institutions, we rely on the Quality of Government Environmental Indicators Dataset (QoG-EI) from the Quality of Government Institute (QoG) of the University of Gothenburg. This database provides an exhaustive compilation of environmental indicators. Unfortunately, most of them have low coverage in terms of both the number of countries and years, and only some match our sample. Of those that do, we selected two indicators to reflect the existence of both domestic and international environmental institutions. Domestic institutions are accounted for by considering whether the country has climate change policies and executive provisions in place ("climate_policies"), while international institutions are accounted for by the country's adhesion to International Environmental Agreements ("IEAs"). As reported in Table 9, the inclusion of specific environmental institutions does not lead to substantial differences with respect to the results in Table 5, suggesting that environmental institutions in themselves do not play a significant role in reducing trade in dirty products.

Finally, our results could also be driven by different natural endowments. Since our definition of dirty products involves natural resources such as metals or oil, we would expect resource-rich countries to have a comparative advantage in those polluting industries, thus exporting more dirty goods. To control for this, we include a variable that takes into account whether an exporting/importing country is a

[14] One common strategy for measuring the stringency of environmental standards is the use of indicators of emissions intensity. Indeed, such indicators prevent several problems associated with other measures, such as the lack of multidimensionality or limited availability in terms of both geographical and time coverage, which mean the panel data dimension cannot be exploited and endogeneity issues are not accounted for (see, for example, Brunel and Levinson, 2013a, 2013b). This becomes particularly relevant in our context, given that our analysis includes global trade flows. Another common option is the Environmental Performance Index (EPI) produced by the Yale Centre for Environmental Law and Policy, but it is only provided on a biannual basis. Also, since the methodology changes from one edition of the index to another, the index is not comparable across years (Wendling et al., 2020), meaning the panel data dimension cannot be exploited. A similar problem applies to the OECD Environmental Policy Stringency Index (EPSI), since it only provides information for OECD and BRICS countries, making it unsuitable for our analysis. However, previous studies have shown substantial correlation among different alternative indicators of environmental stringency and performance. For example, Botta and Kozluk (2014) provide evidence of a significant correlation between the OECD EPSI index and several commonly employed measures of environmental policy and stringency, and particularly the measure of CO_2 emissions intensity used in this paper.

Table 8
PPML estimation with environmental provisions in trade agreements, by quintiles of institutional quality, 2002–2018.

	(1)	(2)	(3)	(4)	(5)
Variables	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}
Quintiles *INSTQ*	1st	2nd	3rd	4th	5th
$INSTQ_{i,\ t-1}$	0.543*	−0.334	−0.142	−0.0511	−0.317***
	(0.313)	(0.222)	(0.112)	(0.0760)	(0.106)
$INSTQ_{j,\ t-1}$	0.171	0.0585	0.180	−0.336***	−0.127**
	(0.374)	(0.114)	(0.117)	(0.0790)	(0.0599)
$lnGDP_{i,\ t-1}$	0.599***	0.287***	0.125**	0.724***	0.256***
	(0.144)	(0.0404)	(0.0521)	(0.0502)	(0.0437)
$lnGDP_{j,\ t-1}$	0.520***	0.957***	0.530***	0.187***	0.401***
	(0.146)	(0.0629)	(0.0592)	(0.0584)	(0.0286)
$MpliberalC_{ij,\ t-1}$	0.148	0.212	0.328	−0.149	0.169*
	(0.551)	(0.333)	(0.258)	(0.150)	(0.0991)
$MptradeRestC_{ij,\ t-1}$	−1.331	0.0365	−0.228	−0.0621	0.121
	(0.980)	(0.572)	(0.297)	(0.107)	(0.0866)
Constant	−16.85***	−19.86***	−4.364***	−10.52***	−3.041***
	(2.837)	(0.920)	(0.868)	(0.827)	(0.847)
Pseudo R-squared	0.907	0.983	0.965	0.982	0.991
Observations	13,972	16,789	19,422	24,188	26,102

Note: X_DIRTY_{ijt} denotes exports of dirty products from *i* to *j* in *t*. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All estimations have been conducted using the PPML approach described in Eq. (2). All columns include three-year time-varying exporter-time and importer-time fixed effects, as well as pair effects.

Table 9
PPML estimation with domestic and international environmental institutions by quintiles of institutional quality, 2002–2018.

	(1)	(2)	(3)	(4)	(5)
Variables	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}	X_DIRTY_{ijt}
Quintiles *INSTQ*	1st	2nd	3rd	4th	5th
$INSTQ_{i,\ t-1}$	0.659**	0.291*	0.161*	−0.200***	−0.367***
	(0.040)	(0.073)	(0.090)	(0.003)	(0.000)
$INSTQ_{j,\ t-1}$	−1.135***	−0.160	0.028	−0.262***	−0.132***
	(0.003)	(0.132)	(0.762)	(0.002)	(0.008)
$lnGDP_{i,\ t-1}$	−0.070	0.206***	0.296***	0.523***	0.107***
	(0.592)	(0.000)	(0.000)	(0.000)	(0.001)
$lnGDP_{j,\ t-1}$	0.680***	0.655***	0.478***	0.250***	0.430***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$RTA_{ij,\ t-1}$	−0.308*	0.238***	0.066	0.298***	0.146***
	(0.086)	(0.000)	(0.153)	(0.000)	(0.000)
$ln(climate\_policies)_{i,\ t-1}$	0.059	0.049***	−0.011	0.022***	0.000
	(0.223)	(0.000)	(0.132)	(0.001)	(0.952)
$ln(climate\_policies)_{j,\ t-1}$	0.034	0.006	−0.005	0.007	0.001
	(0.239)	(0.588)	(0.421)	(0.353)	(0.857)
$ln(IEAs)_{i,\ t-1}$	0.050	0.013	−0.023*	0.007	−0.023**
	(0.226)	(0.375)	(0.053)	(0.505)	(0.029)
$ln(IEAs)_{i,\ t-1}$	−0.055	−0.001	0.041***	−0.005	0.020**
	(0.244)	(0.963)	(0.000)	(0.646)	(0.026)
Constant	−4.118	−9.160***	−7.574***	−7.123***	0.418
	(0.164)	(0.000)	(0.000)	(0.000)	(0.523)
Pseudo R-squared	0.910	0.984	0.978	0.983	0.991
Observations	14,390	25,847	31,227	32,905	41,726

Note: X_DIRTY_{ijt} denotes exports of dirty products from *i* to *j* in *t*. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All estimations have been conducted using the PPML approach described in Eq. (2). All columns include three-year time-varying exporter-time and importer-time fixed effects, as well as pair effects.

primary exporter. Following the criteria of the World Commodity Exporters Database (WCED) from the International Monetary Fund, we define a country as a primary exporter based on the usual threshold of 20% of exports coming from metals and mineral or oil products. The results, presented in Table 10, show that being a primary exporter is indeed positively associated with dirty exports, but does not affect or even reduce dirty imports. Nevertheless, our baseline results are robust to the inclusion of this additional control.

When comparing the coefficients obtained in the sensitivity analyses with those in the main analysis, we can generally conclude that the results are robust. In all four robustness tests, we observe positive coefficients of institutional quality for low quantiles of institutional quality and the expected negative ones for high quantiles, confirming the inverted U-shaped link. However, there are logical differences in their size, which tend to be smaller in the sensitivity analyses. The explanation lies in the correlations between institutional quality and the new variables included, which act as transmission mechanisms and capture part of the effect attributed to institutional quality in the baseline model. Despite having smaller coefficients, though, the main results hold, indicating that the effect of institutional quality remains important to modify trade composition and reduce trade of dirty products.

5. Conclusions

Trade brings meaningful gains in terms of economic progress, but it has an undeniable impact on the environment. In this article, we highlight the role of institutions as a factor that can moderate the composition of trade. In particular, we focus on the ability of institutions to

Table 10
PPML estimation with controls for primary exporter by quintiles of institutional quality, 2002–2018.

Variables	(1) X_DIRTY_{ijt}	(2) X_DIRTY_{ijt}	(3) X_DIRTY_{ijt}	(4) X_DIRTY_{ijt}	(5) X_DIRTY_{ijt}
Quintiles *INSTQ*	1st	2nd	3rd	4th	5th
$INSTQ_{i,\ t-1}$	1.216***	0.318**	0.203**	−0.115*	−0.366***
	(0.000)	(0.032)	(0.017)	(0.077)	(0.000)
$INSTQ_{j,\ t-1}$	−0.070	−0.158	0.100	−0.257***	−0.097**
	(0.802)	(0.107)	(0.207)	(0.001)	(0.035)
$lnGDP_{i,\ t-1}$	0.031	0.204***	0.315***	0.569***	0.096***
	(0.699)	(0.000)	(0.000)	(0.000)	(0.001)
$lnGDP_{j,\ t-1}$	0.649***	0.741***	0.465***	0.295***	0.431***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$RTA_{ij,\ t-1}$	−0.350**	0.294***	0.081*	0.255***	0.139***
	(0.041)	(0.000)	(0.065)	(0.000)	(0.000)
$Primary\_exporter_{i,\ t-1}$	0.392***	−0.047	0.101***	0.115***	0.041***
	(0.000)	(0.189)	(0.000)	(0.000)	(0.000)
$Primary\_exporter_{j,\ t-1}$	0.057	0.025	−0.063**	−0.020	0.002
	(0.486)	(0.442)	(0.018)	(0.379)	(0.827)
Constant	−5.656***	−11.411***	−7.765***	−9.699***	0.591
	(0.006)	(0.000)	(0.000)	(0.000)	(0.288)
Pseudo R-squared	0.902	0.982	0.976	0.980	0.991
Observations	23,738	34,196	39,605	45,201	56,361

Note: X_DIRTY_{ijt} denotes exports of dirty products from *i* to *j* in *t*. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All estimations have been conducted using the PPML approach described in Eq. (2). All columns include three-year time-varying exporter-time and importer-time fixed effects, as well as pair effects.

reduce the amount of trade in products categorised as dirty or polluting. Studies suggest that institutional quality is not only capable of promoting economic development, but can also decouple economic growth and environmental degradation. Nevertheless, there is no evidence on whether institutional quality can influence countries' trade specialisation. This article fills this gap in the literature, by linking the literatures on trade, institutions and the environment.

The analysis has been carried out using state-of-the-art techniques for the estimation of gravity models. The results show an overall negative impact of institutional quality on bilateral flows of dirty trade. Institutional quality thus moderates the role played by trade in environmental degradation, by altering the composition of trade. In addition, countries with low institutional quality specialise in more polluting products as they have less stringent environmental regulations, a finding that supports the pollution haven hypothesis. Our results also suggest that the relationship between institutions and dirty trade is non-linear. For the case of the exporters, a positive link is found for low levels of institutional quality, whereas the opposite relationship emerges after a certain level of institutional quality is reached, suggesting a pattern compatible with an EKC-type scenario. For the case of the importers, however, a negative impact is found only for countries with high-quality institutions, whereas the impact is non-significant for low institutional quality economies. All in all, these results imply that the benefits of having better institutions are only apparent in countries with sufficiently high levels of institutional quality. The analysis identifies voice and accountability, political stability and absence of violence, and rule of law as the key institutional quality dimensions responsible for reducing dirty trade. Finally, we identify more stringent environmental regulations as a potential transmission channel for the effects of institutional quality on trade composition.

Our results have important policy implications, as the influence of institutions on the progress towards a more sustainable economy has proved critical. According to our results, institutional quality is likely to be related to a progressive shift in trade specialisation towards cleaner, less pollution-intensive sectors. That result holds even after controlling for the endowment of natural resources. Despite the fact that countries rich in natural resources such as oil or metals might have comparative advantage in more polluting goods—in fact we find a positive link-, a sufficiently high level of institutional quality can moderate such effect and reduce, to some extent, exports of dirty products. As argued by Puppim de Oliveira et al. (2013), government institutions are in charge of building the political and social mechanisms needed to usher in green socio-ecological and economic systems. This process requires a deeper understanding of the economy as a whole and an appropriate coordination of actors and policies to work towards the objective. In the same vein, to achieve the United Nations Sustainable Development Goals we need high institutional quality and effective government intervention that encourages the engagement of institutional stakeholders, including NGOs, civil society organisations and the business sector (Mombeuil, 2020). Strong institutions are thus an effective tool to reduce the impact of trade on the environment and boost the effectiveness of environmental policies, reducing the risk of carbon leakage. These initiatives, however, can only succeed in a context of political stability and strong rule of law, providing a framework of guarantees and incentives for all the actors involved.

Our research also has some limitations, some of which are related to the imprecise nature of measurements of institutions. The available measures are imperfect, as they are based on surveys and thus reflect citizen's perceptions, which can be influenced by particular events. Second, according to North (1991), institutions not only encompass political structures, but also social interactions. For this reason, it could be interesting to extend this analysis to the impact of informal institutions, especially those related to cultural ties (Forte et al., 2015; Peiró-Palomino and Picazo-Tadeo, 2019; Li et al., 2021). Finally, going beyond the arguments provided in our paper, a deeper understanding is needed of the mechanisms through which institutional quality affects trade composition. According to our analysis in Section 4.4., environmental stringency could be one such mechanism. However, the fact that institutional quality remains significant in many models —albeit with smaller coefficients —suggests that there are other channels through which the effect operates. While these topics deserve more attention in the near future, our article provides a fresh look at the issue and opens the door to a challenging research agenda in the years to come.

Declaration of Competing Interest

None of the authors have any conflict of interest.

Data availability

Data will be made available on request.

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Appendix A. List of countries in the sample

Albania	Canada	Equatorial Guinea	Indonesia	Madagascar	Pakistan	Sudan
Algeria	Central African Republic	Eritrea	Iran, Islamic Rep.	Malawi	Panama	Suriname
Angola	Chad	Estonia	Iraq	Malaysia	Paraguay	Sweden
Argentina	Chile	Ethiopia	Ireland	Mali	Peru	Switzerland
Armenia	China	Finland	Israel	Malta	Philippines	Tajikistan
Australia	Colombia	France	Italy	Mauritania	Poland	Tanzania
Austria	Comoros	Gabon	Jamaica	Mauritius	Portugal	Thailand
Bangladesh	Congo, Rep.	Gambia, The	Japan	Mexico	Qatar	Togo
Barbados	Costa Rica	Georgia	Jordan	Mongolia	Russian Federation	Tunisia
Belize	Cote d'Ivoire	Germany	Kazakhstan	Morocco	Rwanda	Turkey
Benin	Croatia	Ghana	Kenya	Mozambique	Saudi Arabia	Uganda
Bhutan	Cuba	Greece	Korea, Dem. People's Rep.	Nepal	Senegal	United Arab Emirates
Bolivia	Cyprus	Guatemala	Korea, Rep.	Netherlands	Sierra Leone	United Kingdom
Brazil	Czech Republic	Guinea	Kuwait	New Zealand	Singapore	United States
Bulgaria	Denmark	Guinea-Bissau	Lao PDR	Nicaragua	Slovak Republic	Uruguay
Burkina Faso	Djibouti	Honduras	Latvia	Niger	Slovenia	Venezuela, RB
Burundi	Dominica	Hong Kong SAR, China	Lebanon	Nigeria	Solomon Islands	Vietnam
Cabo Verde	Ecuador	Hungary	Liberia	North Macedonia	Somalia	Yemen, Rep.
Cambodia	Egypt, Arab Rep.	Iceland	Lithuania	Norway	Spain	Zambia
Cameroon	El Salvador	India	Macao SAR, China	Oman	Sri Lanka	Zimbabwe

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