Are Regional Trading Arrangements Harmful to the Environment?
An Empirical Investigation

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Abstract

This paper investigates the impact of regional trading arrangements (RTAs) on the environment. We propose an empirical model where RTAs, trade, growth and environmental quality are interrelated. As a result, an RTA in our model can impact the environment either directly or indirectly via trade and income. We find that membership in an RTA reduces the amount of environmental damage by increasing the volume of trade and raising per capita income. We do not, however, find that RTAs directly impact the environment. Taken together, our results suggest that the recent surge of regional trading arrangements will not increase the amount of pollution, but in fact may help the environment.

† This paper has been written for presentation at the Oxford Round Table at the University of Oxford from August 8th - 13th, 2004. The results here are preliminary. Please do not quote without the authors’ permission. We would like to thank Andrew Rose for use of his data. All remaining errors are, of course, our own.
1. Introduction

There has been an ongoing policy debate over the impact of free trade on the environment. This debate has been largely driven by the increasing role of international trade in the world economy as well as increasing environmental damage across the globe. In the past fifty years, world trade has increased nearly five times faster than world output (Santos-Paulino and Thirlwall, 2004). Over the same period, global carbon dioxide emissions have quadrupled; 25,000 people die daily from poor water quality, one-quarter of fish stocks have depleted; and one-fourth of the world’s mammal species are at risk of extinction (United Nations Environment Programme, 2000).

At the same time, there has been rapid growth in the number of regional trading arrangements (RTAs) operating in the world. A regional trading arrangement is the lowering of trade barriers within a group or bloc of member countries. As of July 2002, the World Trade Organization (2004) reported that 170 RTAs are in force, with an additional 70 under negotiation. Moreover, the World Trade Organization (WTO) estimates that by the end of 2005 the number of RTAs could reach 300 (World Trade Organization, 2004).

In this paper, we examine the impact of regional trading arrangements on the environment. We estimate a model where RTAs can impact trade, per capita income and the environment. We find that membership in RTAs decreases the amount of environmental degradation by raising the volume of trade and by increasing the level of real GDP per capita. However, we do not find any evidence that RTAs themselves decrease the quality of the environment.

Our research draws from three established literatures in economics. First, the gravity model literature examines the empirical determinants of bilateral (between two countries) trade flows. In its core, the gravity model predicts that trade is positively related to the size of each country
and negatively related to distance between the two. Over the past 20 years, a consensus has emerged that RTAs create more trade within the bloc than divert trade from outside the bloc (c.f. Frankel, 1997). Second, the growth empirics literature has found a positive empirical link between trade and economic growth. For instance, Frankel and Romer (1999) find that a one percent increase in the trade to GDP ratio increases the per capita income by at least one-half percent. Third, a more recent literature is examining the empirical connection between trade, growth and the environment. Beginning with the work of Grossman and Krueger (1993, 1995), one strand of this literature examines the environmental Kuznets curve (EKC) hypothesis that increased income raises pollution in poor countries but lowers pollution in rich countries. A second strand of this literature looks at whether openness to trade will lead pollution-intensive industries to relocate to countries with lax environmental countries. Recent research by Antweiler et al. (2001) and Frankel and Rose (2002a) find that contrary to the pollution haven hypothesis increased trade actually decreases the level of environmental degradation.

In this paper, we ask if membership in a regional trading agreement leads to higher levels of environmental damage. We propose an empirical model where RTAs, trade, growth and environmental quality are interrelated. Our model is comprised of a gravity model equation where bilateral trade is determined by geographic factors and membership in a common RTA, a growth equation where per capita income is a function of trade, factors of production and RTAs, and an environmental degradation equation where pollution is determined by trade, per capita income, RTAs and other exogenous factors. As a result, an RTA in our model can impact the environment either directly or indirectly via trade and income. We measure environmental

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1 Trade creation within an RTA occurs as low-cost producers in member countries displace high-cost domestic producers. Trade diversion occurs when members of a trading bloc reorient their trade away from low-cost, nonmember countries towards higher-cost, member countries.

2 Earlier papers by Baumol (1971), Markusen (1975), and Seibert (1977), among others, examined the normative issues of gains from trade and optimal policy.
degradation using three indicators of air quality and four indicators of resource utilization. We then estimate our model using least squares and instrumental variables. Instrumental variables allow us to control for the endogeneity of trade and income.

We find that membership in an RTA reduces the amount of environmental damage by increasing the volume of trade and raising per capita income. In the gravity model equation, we estimate that RTAs raise the volume of trade between member countries. Moreover, in the growth equation, we find that membership in a RTA increases the level of real GDP per capita. In the environmental degradation equation, we estimate that trade decreases the level of pollution. We also find evidence of the environmental Kuznets curve in that development will eventually reduce environmental damage. Taken together, our results suggest that the recent surge of regional trading arrangements will not increase the amount of pollution, but in fact may help the environment.

The rest of the paper is as follows. Section II discusses the previous literature. Section III presents the empirical strategy used for the analysis. Section IV describes the data. The results are discussed in section V and section IV concludes.

2. **Trade, Growth and the Environment**

Our research draws from three established literatures in economics. In this section, we discuss each literature in turn to uncover the link between trade, growth and the environment.\(^3\)

*Do RTAs enhance trade?*

The international trade literature recognizes the potential of regional trading arrangements to increase trade among its members. However, concerns about whether regionalism enhances the

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\(^3\) Copeland and Taylor (2004) provide a more comprehensive survey of the literature on trade, growth and the environment.
volume of trade within the bloc or simply diverts bilateral trade away from countries outside the bloc can be attributed back to Viner (1950) and Meade (1955) who first distinguished between trade creation and trade diversion. Specifically, trade creation occurs as low-cost member countries displace high-cost domestic producers. Trade diversion, on the other hand, occurs when members of a trading bloc reorient their trade away from low-cost, nonmember countries towards higher-cost, member countries. Viner and Meade both conclude that regional trading arrangements can either increase or reduce world welfare depending upon the relative magnitudes of the trade-creation and trade-diversion effects.

The majority of the researchers use the gravity model to test for the trade effects of RTAs. At its core, the gravity model equation predicts that the volume of trade between two economies should increase with their size (proxied by real GDP) and decrease with transaction costs (measured as bilateral distance). Researchers, however, have added other variables to the core model to control for differences in geographic factors, historical ties, exchange rate risk and trade policy. For example, Frankel (1997) talks of real GDP and distance constituting a “basic” gravity model, while the two core factors plus common border, common language, per capita GDP and membership in regional trading arrangements making up a “full” gravity model. Similarly, Rose (2000) speaks of an “augmented” gravity model, which consists of Frankel’s variables plus colonial ties, exchange rate volatility and common currency. Typically, the effects of regional trading arrangements on bilateral trade flows are estimated by including a dummy variable that measures both countries’ membership in an RTA. A positive value for the coefficient on the RTA variable indicates that the two countries trade more with one another than predicted by the gravity model, and is thus taken as evidence of trade creation.
In the gravity model literature, a consensus has emerged among researchers that RTAs are trade creating. For example, studies by Frankel and Wei (1995) and Frankel (1997) find evidence of trade creation in Asian and North American trading blocs from 1970 to 1992, while Soloaga and Winters (2001) find trade creation in Latin America during the 1990s. Recent papers by Rose (2000), Feenstra et al. (2001) and Frankel and Rose (2002b) find that RTAs, in general, are trade creating.

**Does openness increase growth?**

In a seminal paper, Rivera-Batiz and Romer (1991) derived a theoretical model where trade openness promotes economic growth. Rivera-Batiz and Romer began with the premise that innovation in intermediate goods was the engine of economic growth. In their model, trade allowed countries to specialize in the production of a specific intermediate good. As a result, opening up to international trade would lead to less duplication of intermediate goods and thus more innovation world-wide. The increased innovation would in turn raise the level of productivity and thus economic growth.

The first generation of empirical papers (Dollar, 1992; Ben David, 1993; Sachs and Warner, 1995; Edwards, 1998) estimated a positive relationship between measures of openness and economic growth. However, these researchers used ordinary least squares (OLS), which failed to account for the endogeneity of openness or trade. As a result, one was left asking “does trade liberalization result *in*, or *from*, economic growth?” (Winters, 2004, p. F8).

Frankel and Romer (1999) overcame the endogeneity problem by using instrumental variables (IV). Instrumental variables estimation uses the endogenous RHS variable and new independent variables called “instruments” in the estimation procedure. In the case of trade,

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4 Helpman and Krugman (1991) showed that with scale effects the link between trade and growth becomes ambiguous.
Frankel and Rose used geographical characteristics, which are correlated with trade but uncorrelated with income, as instruments. Using a cross-section of countries in 1985, they found that one percentage point increase in the ratio of trade to GDP increases the level of real GDP per capita by at least one-half percent.

In a recent review, Rodriguez and Rodrik (2000) argued that geographical variables can affect growth directly through their effect on health, endowments, and institutions. These direct influences of geography on trade could by itself help explain the significance of these geographically constructed instrumental estimates of trade. This criticism, however, has been addressed by Frankel and Rose (2002b) who duplicate the basis estimation procedure of Frankel and Romer (1999) but incorporate geographical and institutional variables in the income equation such as the distance of a country from the equator, the percentage of land area within the tropics for a country, continental dummies and a measure of institutional quality. Their results show that the basic conclusions of trade openness causing higher growth are still robust after factoring in geography.

**Does increased economic activity harm the environment?**

The policy debate regarding the environmental impact of liberalized trade over the past decade was initiated by the negotiations over the North American Free Trade Agreement (NAFTA) and the Uruguay Round of GATT negotiations. The recent formation of the WTO and the formation of environmental rules for further trade negotiations have further intensified this policy debate. Regional trading arrangements that enhance trade and economic growth will have an impact on the environment through two channels. First, via its’ impact on economic growth and the subsequent environmental Kuznet’s curve effect and, second, through the pollution haven hypothesis.
In the economics literature it is Grossman and Krueger’s (1993, 1995) influential study on NAFTA and a follow-up study examining the reduced-form relationship between per capita income and various environmental indicators that has led to a renewed interest in the empirical relationship between economic growth and environmental quality. In their 1995 study, they find, using a panel data on air quality from 42 countries, that there is an inverted U shaped relationship between some measures of air quality and per-capita incomes. This has come to be known as the environmental Kuznet’s curve which hypothesizes that as per capita incomes rises, pollution will initially rise but will fall subsequently at higher levels of per capita income. While it varies for the different measures of pollutants, the turning point for the decrease in pollution comes before a country reaches a per capita income of $8,000. The rationale being that at the initial stages of industrialization, growth is bad for the environment but as countries get rich they can pay for cleaning up their environment, which reduces pollution.

Grossman and Krueger (1993) further discuss that openness to trade will have both positive and negative impacts on the environment and these impacts are decomposed into three effects: the scale effect, the technique effect and the composition effect. The scale effect explains the negative environmental consequences after the expansion of economic activity given no change in the nature of that activity. The technique effect explains the positive environmental impact of increased trade that call for modern technology and cleaner production methods. The composition effect explains the trade-induced changes in the composition of output produced which affects the pollution level and can have either a positive or negative effect on the environment. For example, increased trade leads a country to specialize in goods in which they have a comparative advantage, and if this advantage stems primarily from differences in environmental regulations then the composition effect of trade liberalization will be negative.
Theoretical models that derive EKC relationship are typically based on the rationale that the technology used in the production of goods will invariably lead to pollution, but with a rise in income the demand for environmental quality will also increase.

There have by now been several empirical studies on the EKC using various measures of environmental quality, time periods and countries. However, it is Antweiler et al. (2001) that developed the theoretical model which divides trade’s impact on pollution into the scale, technique, and composition effects and then conducted a systematic empirical testing of their model. Adding up these three effects for 43 countries over 1971-96 leads them to conclude that “if trade liberalization raises GDP per person by 1 percent, then pollution concentrations fall by about 1 percent” (p. 877) and that “Free trade is good for the environment” (p 878). This result has been reconfirmed in Frankel and Rose’s (2002) study on whether international trade is good or bad for the economy, given the level of per capita GDP. They conclude that they have “found evidence that, for any level of income, trade appears to have a beneficial effect on some measures of environmental quality” (p 26).

There is, however, an alternate channel through which regional trading arrangements and the subsequent increase in trade can affect the environment. The argument here is that with the reduction in trade barriers and the subsequent increase in trade brought about by the formation of a trading bloc can lead to countries being more reluctant to increase environmental relations due to their fear of becoming internationally uncompetitive. This is known as the pollution haven hypothesis where a reduction in trade barriers can cause a movement of pollution-intensive industries to move from countries with stringent environmental regulations to countries with weaker environmental regulations. This is the issue that lies at the heart of the concern about

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5 Dasgupta et al. (2002) provides a recent review of the EKG.
trade liberalization and the “race to the bottom” in environmental standards as countries weaken their regulations in response to competitive pressures of freer trade.

Whatever the route through which trading blocs affects the environment, it is clear that trading blocs have been making an attempt at addressing the issues of trade and environment. Looking at three different regional trading arrangements: NAFTA (a free trade area), Mercosur (a customs union) and the European Union (a monetary union) we find that NAFTA and the European Union currently have provisions to handle the relationship between increased trade and the environment, while Mercosur is in the process of developing their environmental protocol. For example, NAFTA has separate non-trade agreements on the environment that created the Commission for Environmental Cooperation which, among other things, monitors the environmental effects of NAFTA. It also promotes environmental cooperation between Canada, the United States and Mexico and is the institution through which dispute settlement provisions can be invoked. NAFTA Article 104 lists seven international environmental agreements and confirms that they will over-ride NAFTA in the case of disagreement (United Nations, 2000).\(^6\) Mercosur is still working on its environmental protocol and has created Sub-Grupo No. 6 on the environment, which is one of the recognized technical working bodies of Mercosur. This body has been involved for over two years in negotiating a new environmental protocol, which is being added to the Treaty of Asuncion of Mercosur. A comprehensive stand-alone treaty, this draft agreement provides for upward harmonization of environmental management systems and increased co-operation on shared ecosystems, in addition to mechanisms for social participation.

\(^6\) The seven international environmental agreements are the Montreal Protocol, the Basel Convention, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and four bilateral treaties.
The European Union, on the other hand, has extensive environmental legislation with more than 300 items included that cover practically every aspect of environmental policy.\footnote{EU legislation covers emission standards and quality objectives for water; managing hazardous and domestic waste; packaging; atmospheric emissions from plants and vehicles; air quality standards and stratospheric ozone layer; all aspects of toxic substances control; nature protection, migratory birds and endangered species; wildlife; noise; and climate change. Moreover, EU addresses impact assessment, freedom of information, ecolabelling, eco-management and auditing (United Nations, 2000).}

3. Empirical Strategy

**Empirical Model**

We propose the following empirical model

\[
\ln t_{ij} = a_0 + a_1 R_{ij} + a_2 G_{ij} + e_{ij} \tag{2}
\]

\[
T_i = \sum_{j \neq i} \exp(a_0 + a_1 R_{ij} + a_2 G_{ij} + e_{ij}) \tag{2}'
\]

\[
\ln y_i = b_0 + b_1 T_i + b_2 R_i + b_3 Z_i + u_i \tag{3}
\]

\[
\ln E_i = c_0 + c_1 T_i + c_2 R_i + c_3 \ln y_i + c_4 (\ln y_i)^2 + c_5 X_i + \omega_i \tag{4}
\]

where subscripts \(i\) and \(j\) denote countries; \((a_k, b_k, c_k)\) for \(k = 0, 1, 2, 3, 4, 5\) are coefficients to be estimated; and \((e_{ij}, u_i, \omega_i)\) are independent random error terms.

Equation (2) is the bilateral gravity model equation where \(t_{ij}\) is the bilateral trade flow (exports + imports) between countries \(i\) and \(j\) as a percentage of country \(i\)’s GDP, \(R_{ij}\) is common membership in a regional trading arrangement, and \(G_{ij}\) are geographic factors. Equation (2)’ sums up the level of bilateral trade flows for country \(i\) across all trading partners \(j\) to get \(T_i\) – total trade for country \(i\) as percentage of GDP of country \(i\)’s GDP. We refer to \(T_i\) as trade intensity. Equation (3) is the growth equation where \(y_i\) is real GDP per capita, \(R_i\) is the number of current memberships in regional trading arrangements, and \(Z_i\) are other explanatory variables.
derived from neoclassical growth theory. Equation (4) is the environmental degradation equation where $E_i$ is a measure of environmental damage and $X_i$ is a vector of exogenous variables that impact the environment. The EKC hypothesis predicts a negative value for $c_3$ and a positive value for $c_4$ in equation (4). The turning or inflection point of the EKC can be calculated by $-c_3/2c_4$.

**Econometric Issues**

Our empirical model contains four endogenous variables ($t_{ij}, T_i, y_i, E_i$), two exogenous RTA variables ($R_{ij}, R_i$), and three vectors of exogenous variables ($G_{ij}, X_i, Z_i$). There are a couple of ways to estimate the model. For instance, one could estimate each structural equation (2), (3) and (4) using ordinary least squares (OLS). The benefits of OLS are its ease of application and its relative insensitivity to problems of multicollinearity, errors in variables or misspecification, especially in small samples (Kennedy, 2004). However, OLS suffers from the endogeneity problem where the causal relationship between the LHS variable and an endogenous RHS variable can run in either direction. For example, in the environmental degradation equation (3), a negative OLS estimate for $c_1$ would not necessarily imply that trade $T$ is directly responsible for improved environmental quality $E$. It could be that tighter environmental regulations stimulates technological innovation and, hence, trade via the Porter (1991) hypothesis. In such cases of endogeneity, the OLS estimates would be inconsistent and biased due to the correlation between the endogenous independent variable $T$ and the stochastic error term $\omega$.

An alternative method to estimate each structural equation is to use instrumental variables (IV). IV estimation uses the endogenous RHS variable and new independent variables called
“instruments” in the estimation procedure. To serve as a valid instrument, these new independent variables must be uncorrelated with the error term (exogenous) and correlated (preferably highly correlated) with the endogenous RHS variable. If appropriate instruments can be found, IV provides a consistent estimator for each structural equation (2), (3) and (4). The main drawback of IV estimation is that the precision (variance-covariance matrix) of the IV estimator is larger than that of the OLS estimator, by an amount inversely-related to the correlation between the instruments and the endogenous regressor.

Trade theory and growth theory provide us with a list of possible instruments for $T$ in the growth equation (3) and for $T$ and $y$ in the environmental degradation equation (4). The gravity model literature argues that trade intensity $T$ is determined by geographical variables $G$ and RTA membership $R$. Therefore, if uncorrelated with the error terms $u$ and $\omega$, the predicted value of the gravity model equation (2) will serve as a good instrument for $T$ in equations (3) and (4). Similarly, neoclassical growth theory contends that the level of real GDP per capita $y$ is determined by factors such as initial income, physical and human capital investment, population growth and rule of law included in $Z$. As before, the predicted value of the growth equation (3) will serve as a good instrument for $y$ in equation (4) if uncorrelated with the error term $\omega$.

Frankel and Romer (1999), Irwin and Tervio (2002) and Frankel and Rose (2002a, 2002b) have followed this approach in estimating equations (3) and (4).

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8 To see the difference between the OLS and IV estimator, consider the regression model: $y = Xb + e$ where $y$ is a $T \times 1$ vector of dependent variables, $X$ is a $T \times k$ matrix of independent variables, $b$ is a $k \times 1$ vector of parameters to estimate, and $e$ is a $k \times 1$ vector of errors. The OLS estimator is $\hat{b}_{OLS} = (X'X)^{-1}X'y$. The IV estimator uses a $T \times k$ matrix of independent variables $Z$ that are correlated with $X$ and uncorrelated with $e$. The $Z$ instruments are then regressed on the $X$ variables to get the fitted values $\hat{X} = Z(Z'Z)^{-1}Z'X$. The fitted values are then used instead of the endogenous $X$ variables in the IV estimation to get $\hat{b}_{IV} = (\hat{X}'\hat{X})^{-1}\hat{X}'y$. 

4. Data

We use bilateral and cross-country data to conduct our empirical analysis. The bilateral data set is 4052 observations for 162 countries in 1995. The cross-country data set consists of 151 annual observations for developing and developed countries for 1995. Appendix A lists the countries in our sample, while Appendix B describes each variable and its source. Summary statistics are provided in Table 1.

The variable of interest \(RTA\) is measured in two ways. In the bilateral gravity model equation, \(RTA_{ij}\) is a dummy variable that is one if both countries are members of the same regional trading arrangement and zero otherwise. In the cross-country growth and environmental degradation equations, \(RTA_i\) records the number of current RTA memberships.

We consider 17 regional trading arrangements: European Community (EC), European Free Trade Arrangement (EFTA), European Economic Area (EEA), Association of South-East Asian Nations (ASEAN), Australia-New Zealand Closer Economic Relations Trade Agreement (ANZCERTA), Asian Pacific Economic Cooperation (APEC), Latin America Integration Agreement (LAIA), Central American Common Market (CACM), Andean Pact (Andean), Caribbean Community (Caricom), North America Free Trade Arrangement (NAFTA), Mercado Común del Sur (Mercosur), Central European Free Trade Area (CMEA/CEFTA), Group of Three (G3), Gulf Cooperation Council (GCC), Bangkok Agreement (Bangkok), South African Customs Union Agreement (SACU) and South Pacific Regional Trade and Economic Agreement (Sparteca). Appendix C lists the member countries of each RTA. The RTAs considered range in size from the biggest – APEC – whose member’s produce around half of the
world’s GDP to the smallest – Caricom – whose membership produces less than one percent of the world’s output.  

We measure environmental degradation using three indicators of air quality and four indicators of resource utilization. The first measure of air quality is the mean of suspended particulate concentration (PM) in micrograms per cubic meter for 1995 and is a measure of the mean total suspended particulate concentrations in the air (airborne dust). A higher concentration means more pollution and thus, worse air quality. The next two measures of air quality are mean sulphur dioxide (SO₂) in micrograms per cubic meter and mean nitrogen dioxide (NO₂) in micrograms per cubic meter in 1995. Similarly, higher SO₂ and NO₂ numbers imply worse air pollution.

We measure resource utilization with carbon dioxide (CO₂) emissions per capita, average annual percentage change in deforestation, energy depletion as a percentage of GDP and water pollution per capita. While the emission of CO₂ is usually of great concern to environmentalists, it is important to note that CO₂ is a global externality and is unlikely to be addressed by national regulations because of its lack of local impact.

5. Empirical Results

We use Antweiler et al. (2001) and Frankel and Rose (2002a, 2000b) as a guide for choosing our exogenous variables \((G_j, X_i, Z_j)\). In the bilateral trade equation (2), we include the natural logarithms of bilateral distance, product of land area, and population of country \(j\) in \(G\). The prediction is that both distance and land area increase shipping costs and thus decrease the volume of trade. Population is a measure of market size and is expected to be positively related

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9 Percentages estimated using GDP measured at purchasing power prices in 1998.
to trade. We also include dummies for membership in a common currency, common land border, common language and landlocked in $G$.

The estimation results of the bilateral gravity model equation are shown below

$$\ln t_{ij} = -1.66 -1.03 \ln distance_{ij} + 0.52 rta_{ij} + 0.12 cu_{ij} + 0.98 \ln pop_j - 0.30 \ln area_i area_j$$

$$-0.70 \ln landlock_{ij} + 0.69 comlang_{ij} + 0.55 \ln border_{ij}$$

where the t-statistics are in parentheses. The R-squared is 0.37 in value. We find that the point estimate for common membership in a RTA is positive and significant at the one percent level.

Using the formula $\exp(\text{RTA}) - 1$, the point estimates imply that membership in an RTA increases trade by 53 percent. Using equation (2)', we then sum up the exponent of the fitted values across bilateral trading partners $j$ to obtain the predicted value of trade intensity for a country $i$, $\hat{T}_i$. The $\hat{T}_i$ will be used as an instrument in the income and environmental degradation equations.

Next, we examine the income equation (3). Neoclassical growth theory predicts that the level of real GDP depends upon the factors of production (labor, capital and technology). An alternative line of thought argues that geographical and institutional differences determine variations in real GDP per capita. Rather than deciding upon one, we consider two specifications for $X$. The capital accumulation specification includes initial per capita income, initial population, the population growth rate, and physical and human capital investment rates. The geography and institutions specification includes distance from the equator (latitude), dummy variables for East Asia, Latin America and sub-Saharan Africa, and a rule of law index.
Table 2 presents the estimation results for the income equation. The odd numbered columns are the ordinary least squares (OLS) estimates, while the even numbered columns are the instrumental variable (IV) estimates. The capital accumulation specification explains 90 percent of the variation in real GDP per capita, while the geography and institutions specification explains 75 of the variation. Moreover, with few exceptions, the coefficients are of the correct sign and are significant.

We find that membership in RTAs increase the level of real GDP per capita even when controlling for trade intensity. As with Frankel and Romer (1999) and Frankel and Rose (2000b), we find that greater trade intensity (or openness) increases the level of per capita real GDP. Moreover, the estimated effects of openness are more than doubled once endogeneity of trade is controlled for. In three of the four columns, however, the coefficient for RTA is positive and significant. The point estimates imply that joining an RTA increases the level of real GDP per capita by 5 to 37 percent.

The implication, therefore, is that RTAs raise the income levels of member countries both directly by making domestic industries more efficient as domestic markets are opened and deregulated, and indirectly by increasing trade intensity.

Table 3 presents the results of the environmental degradation equation (4). We consider seven different measure of environmental damage. The first three LHS variables measure air pollution, while the next four LHS variable record other environmental damage. We use the IV estimator where trade intensity, real GDP per capita and real GDP per capita squared are instrumented using the predicted values from the gravity model (5) and from the income equation. The \( F \)-test reports the F-statistic and probability value of the joint significance of the level of real GDP per capita and the square of per capita real GDP. Using the point estimates,
we calculate the turning point or inflection value for $y$. Specifically, if the coefficient for the
level term is positive and the coefficient for the squared term is negative, then the inflection
point represents the turning point on the EKC.

We choose a general specification that combines the variables used by Antweiler et al.
(2001) and Frankel and Rose (2002a) for the $X$ variables on the RHS. *Polity* is a measure of the
political structure of a country ranging from -1 (a “strongly autocratic” government) to +1 (a
“strongly democratic” government). We include land area per capita to capture the impact of
population density. City economic intensity is land area divided by real GDP and measures the
economic intensity in which land is used. We also include dummy variables for the 24 current
and former Communist countries and for the 21 European countries that ratified the Helsinki
Protocol to reduce sulphur emissions.\(^{10}\)

The results for the $X$ variables are mixed. For the most part, the coefficient for *polity* is
negative implying that countries with greater governance have less pollution. Similarly, the
coefficient for population density is mostly negative. However, the coefficients for economic
intensity and economic intensity square change signs depending upon the pollutant considered.
Therefore, unlike Antweiler et al. (2001), we do not find conclusive evidence that economic
intensity harms the environment. Likewise, the coefficient for Communist countries is both
negative and positive, while the coefficient for the Helsinki protocol is insignificant.

We find that RTAs do not have a direct impact on the environment, but do have an indirect
impact via trade intensity and per capita income. Except for water pollution per capita, the
coefficient for $RTAi$ is insignificant, which suggests that membership in a regional trading bloc
does not directly lead to greater environmental damage. However, the coefficients for trade

\(^{10}\) The 1985 Helsinki Protocol to the Convention on Long-range Transboundary Air Pollution on the Reduction of
Sulphur Emissions or their Transboundary Fluxes was entered into force in 1987. It aimed to reduce sulphur
emissions by at least 30 per cent.
intensity, real GDP per capita and real GDP per capita squared are significant. The coefficient signs imply that greater trade intensity lowers air pollution, but increases CO\textsubscript{2} emissions. Therefore, since RTAs increase trade and trade in turn reduces the amount of environmental damage, the implication is that RTAs indirectly improve the environment by increasing trade flows between member countries.

Moreover, we find evidence for the environmental Kuznets curve. For each measure except CO\textsubscript{2} emissions and water pollution, we estimate a positive coefficient for the level of real GDP per capita and a negative coefficient for the square of real GDP per capita. In other words, economic growth initially increases environmental degradation, but eventually growth will decrease the level of environmental damage. The average value for the inflection point is $5008. Therefore, since RTAs increases the level of development and development eventually reduces environmental degradation, our results again suggest that RTAs indirectly improve the environment by increasing the level of per capita income.

6. Conclusion

During the past decade, there have been three major developments in the international world order: the dramatic change in the environment, the high number of regional trading arrangements created and higher growth rates experienced by countries open to trade. In this paper, we examine the impact of regional trading arrangements on the environment. We proposed a model where RTAs, trade, growth and environmental quality are interrelated. As a result, an RTA in our model can impact the environment either directly or indirectly via trade and income. We then estimated our model using cross-country data for 151 countries.

We found that membership in an RTA reduces the amount of environmental damage by increasing the volume of trade and raising per capita income. First, we estimated that RTAs
raise the volume of trade between member countries. Second, we found that membership in a RTA increases the level of real GDP per capita. Third, we estimated that trade decreases the level of pollution and that economic growth will eventually reduce environmental damage via the environmental Kuznets curve.

We recognize some limitations of our study. First, the data was highly aggregate. Second, the sample size was small in some cases, which lowered the precision of our estimates. Third, there are spillovers in some of our environmental measures. Regardless of these limitations, our results do show that a country’s membership in an RTA does not harm the environment. In fact, our results suggest that membership in an RTA may reduce the amount of pollution by increasing trade and per capita incomes.
### Appendix A – Sample Countries

<table>
<thead>
<tr>
<th>Albania</th>
<th>Dominica</th>
<th>Kenya</th>
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## Appendix B – Description of Data

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<td>$t_{ij}$</td>
<td>Natural log of ratio of country $i$’s overall trade with country $j$ to GDP of country $i$ in 1995 (international prices)</td>
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<tr>
<td>$y_i$</td>
<td>Natural log of real GDP per capita in 1995 (international prices)</td>
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<td>$no2_{i}$</td>
<td>Natural log of mean nitrogen dioxide in micrograms/cubic meter in 1995</td>
</tr>
<tr>
<td>$so2_{i}$</td>
<td>Natural log of mean sulphur dioxide in micrograms/cubic meter in 1995</td>
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<td>$suspended\ matter_{i}$</td>
<td>Natural log of mean total suspended particulates matter in micrograms/cubic meter in 1995</td>
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<tr>
<td>$co2_{i}$</td>
<td>Natural log of industrial carbon dioxide emissions in metric tons per capita in 1995</td>
</tr>
<tr>
<td>$deforestation_{i}$</td>
<td>Average annual deforestation per square km, 1990-1995</td>
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<td>$energy\ depletion_{i}$</td>
<td>Energy depletion as a percentage of GDP in 1995</td>
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<td>$water\ pollution_{i}$</td>
<td>Water pollution per capita in 1995</td>
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<tr>
<td>$distance_{ij}$</td>
<td>Natural log of the bilateral distance between the two capital cities</td>
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<tr>
<td>$rta_{ij}$</td>
<td>Dummy (1 if both countries are members of the RTA in question and 0 otherwise)</td>
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<tr>
<td>$cu_{ij}$</td>
<td>Dummy (1 if the two share a common currency and 0 otherwise)</td>
</tr>
<tr>
<td>$pop_{j}$</td>
<td>Natural log of population of country $j$</td>
</tr>
<tr>
<td>$area_{ij}$</td>
<td>Natural log of the product of the surface area of the two countries</td>
</tr>
<tr>
<td>$landlock_{ij}$</td>
<td>Number of landlocked countries ($0,1,2$)</td>
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<tr>
<td>$comlang_{ij}$</td>
<td>Dummy (1 if the two share a common language and 0 otherwise)</td>
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<tr>
<td>$border_{ij}$</td>
<td>Dummy (1 if the two share a common land border and 0 otherwise)</td>
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<td><strong>Exogenous Variables in Income Equation (3)</strong></td>
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<td>$RTA_{i}$</td>
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</tr>
<tr>
<td>$cu_{i}$</td>
<td>Common currency dummy</td>
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<tr>
<td>$trade\ intensity_{i}$</td>
<td>Natural log of country $i$’s overall trade to GDP of country $i$</td>
</tr>
<tr>
<td>$initial\ GDP\ per\ capita_{i}$</td>
<td>Natural log of initial real GDP per capita (1970)</td>
</tr>
<tr>
<td>$initial\ population_{i}$</td>
<td>Natural log of initial population (1970)</td>
</tr>
<tr>
<td>$investment\ rate_{i}$</td>
<td>Ratio of average gross investment to GDP (1970 to 1995)</td>
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<td>$population\ growth_{i}$</td>
<td>Growth rate of population (1970 to 1995)</td>
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<tr>
<td>$primary\ enrollment_{i}$</td>
<td>Average primary schooling enrollment (1970 to 1995)</td>
</tr>
<tr>
<td>$secondary\ enrollment_{i}$</td>
<td>Average secondary schooling enrollment (1970 to 1995)</td>
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<td>$East\ Asia_{i}$</td>
<td>East Asian dummy</td>
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<tr>
<td>$Sub-Saharan\ Africa_{i}$</td>
<td>Sub Saharaan Africa dummy</td>
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<tr>
<td>$rule\ of\ law_{i}$</td>
<td>Rule of law index (0-6)</td>
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### Exogenous Variables in Environmental Degradation Equation (4)

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<td>$\ln(\text{GDP per capita})$</td>
<td>Natural log of real GDP per capita in 1995</td>
</tr>
<tr>
<td>$\ln(\text{GDP per capita})^2$</td>
<td>Natural log of real GDP per capita in 1995 squared</td>
</tr>
<tr>
<td>$\ln(\text{trade intensity})_i$</td>
<td>Natural log of country $i$’s overall trade to GDP in 1995</td>
</tr>
<tr>
<td>$\text{polity}_i$</td>
<td>Measure of political structure of country $i$</td>
</tr>
<tr>
<td>$\ln(\text{area per capita})$</td>
<td>Natural log of land area per capita</td>
</tr>
<tr>
<td>$\ln(\text{economic intensity})_i$</td>
<td>Natural log of GDP per sq. kilometer (city economic intensity)</td>
</tr>
<tr>
<td>$\ln(\text{economic intensity})_i^2$</td>
<td>City economic intensity squared</td>
</tr>
<tr>
<td>Communist$_i$</td>
<td>Communist country dummy</td>
</tr>
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<td>Helsinki$_i$</td>
<td>Helsinki protocol dummy</td>
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### Notes

1. The endogenous variables are from Frankel and Rose (2000a) at http://faculty.haas.berkeley.edu/arose/Envdata.zip
2. The exogenous variables for the trade equation are from Frankel and Rose (2002b) at http://haas.berkeley.edu/~arose/frbilat.zip
3. The exogenous variables for the income equation are from the following:
   - The real GDP, investment and population data are taken from Penn World Tables, Mark 6.1 at (http://www.pwt.econ.upenn.edu/).
   - The geographic variables are taken from the World Development Indicators (WDI) CD-ROM.
   - The enrollment rate data are from United Nations Educational, Scientific and Cultural Organization (UNESCO) Statistical Yearbook.
4. The exogenous variables for the environmental degradation equation are from Frankel and Rose (2002b) at (http://www.haas.berkeley.edu/~arose/GravData.zip) except Helsinki is from (http://www.unece.org/env/lrtap/sulf_h1.htm).
### Appendix C
Regional Trading Arrangements Considered

<table>
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<th>Name of RTA</th>
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<th>Member Countries</th>
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<tr>
<td>European Free Trade Arrangement</td>
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<td>Iceland (1970), Liechtenstein (1991), Norway, Switzerland</td>
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<td>Former: Denmark (1960-72), United Kingdom (1960-1972), Portugal (1960-85), Austria (1960-94), Sweden (1960-94), Finland (1986-94),</td>
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<td>EEA</td>
<td>1994</td>
<td>Austria, Belgium, Denmark, Finland, France, Greece, Luxembourg, Iceland, Italy, Ireland, Liechtenstein, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom</td>
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<td>Australia-New Zealand Closer Economic Relations Trade Agreement</td>
<td>ANZCERTA</td>
<td>1983</td>
<td>Australia, New Zealand</td>
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<td>Latin America Free Trade Association / Latin America Integration Agreement</td>
<td>LAIA</td>
<td>1960</td>
<td>Argentina, Bolivia (1967), Brazil, Chile, Colombia (1961), Ecuador (1961), Mexico, Paraguay, Peru, Uruguay, Venezuela (1966)</td>
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<td>Central American Common Market</td>
<td>CACM</td>
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<td>Andean Pact / Andean Community</td>
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<td>1969</td>
<td>Bolivia, Colombia, Ecuador, Peru, Venezuela (1973)</td>
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<td></td>
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<td>Former: Chile (1969-76)</td>
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### Appendix C
Regional Trading Arrangements Considered (continued)

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<tr>
<td>Mercado Común del Sur</td>
<td>Mercosur</td>
<td>1991</td>
<td>Argentina, Brazil, Paraguay, Uruguay</td>
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<td>Group of Three</td>
<td>G3</td>
<td>1995</td>
<td>Colombia, Mexico, Venezuela</td>
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<td>Gulf Cooperation Council</td>
<td>GCC</td>
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<td>Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates</td>
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<td>Bangkok Agreement</td>
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<td>Bangladesh, India, South Korea, Laos, Papua New Guinea, Sri Lanka</td>
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<td>South African Customs Union Agreement</td>
<td>SACU</td>
<td>1969</td>
<td>South Africa, Botswana, Lesotho, Swaziland</td>
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**Sources:** Frankel (1997), Mattli (1999) and Soalaga and Winters (2001).
References


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Table 1  
Summary Statistics (continued)

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</tr>
<tr>
<td>$\ln(\text{area per capita}_i)$</td>
<td>0.056</td>
<td>0.114</td>
<td>0.000047</td>
<td>0.771</td>
</tr>
<tr>
<td>$\ln(\text{economic intensity}_i)$</td>
<td>6.99e+07</td>
<td>3.85e+08</td>
<td>0.00055</td>
<td>3.86e+09</td>
</tr>
<tr>
<td>$\text{Communist}_i$</td>
<td>0.148</td>
<td>0.356</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>$\text{Helsinki}_i$</td>
<td>0.113</td>
<td>0.318</td>
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### Table 2
Estimates for Income Equation

<table>
<thead>
<tr>
<th></th>
<th>OLS (1)</th>
<th>IV (2)</th>
<th>OLS (3)</th>
<th>IV (4)</th>
</tr>
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<tbody>
<tr>
<td><strong>RTA</strong></td>
<td>0.071*</td>
<td>0.057</td>
<td>0.32***</td>
<td>0.32***</td>
</tr>
<tr>
<td></td>
<td>(1.64)</td>
<td>(1.23)</td>
<td>(4.80)</td>
<td>(4.51)</td>
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<tr>
<td>currency union</td>
<td>-0.082</td>
<td>0.018</td>
<td>0.63***</td>
<td>0.67***</td>
</tr>
<tr>
<td></td>
<td>(-0.79)</td>
<td>(0.15)</td>
<td>(2.93)</td>
<td>(2.62)</td>
</tr>
<tr>
<td>trade intensity</td>
<td>0.20*</td>
<td>0.48***</td>
<td>0.13</td>
<td>0.38***</td>
</tr>
<tr>
<td></td>
<td>(1.92)</td>
<td>(4.53)</td>
<td>(1.38)</td>
<td>(3.08)</td>
</tr>
<tr>
<td>ln(initial population)</td>
<td>-0.0024</td>
<td>0.058*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-0.10)</td>
<td>(1.65)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln(initial GDP per capita)</td>
<td>0.58***</td>
<td>0.62***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8.40)</td>
<td>(7.66)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>investment rate</td>
<td>3.32***</td>
<td>2.39***</td>
<td></td>
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<tr>
<td></td>
<td>(4.19)</td>
<td>(2.81)</td>
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<td></td>
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<td>population growth</td>
<td>-0.14**</td>
<td>-0.14**</td>
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<td></td>
<td>(-2.43)</td>
<td>(-2.36)</td>
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<tr>
<td>primary enrollment</td>
<td>0.15</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.74)</td>
<td>(0.20)</td>
<td></td>
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</tr>
<tr>
<td>secondary enrollment</td>
<td>0.64**</td>
<td>0.74**</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(2.11)</td>
<td>(2.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>latitude</td>
<td>0.0068**</td>
<td>0.0072**</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>(2.39)</td>
<td>(2.22)</td>
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<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>0.24</td>
<td>0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.15)</td>
<td>(1.49)</td>
<td></td>
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</tr>
<tr>
<td>East Asia</td>
<td>0.069</td>
<td>0.026</td>
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<tr>
<td></td>
<td>(0.20)</td>
<td>(0.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>-0.72***</td>
<td>-0.69***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-2.94)</td>
<td>(-2.66)</td>
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<td></td>
</tr>
<tr>
<td>rule of law</td>
<td>0.47***</td>
<td>0.47***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8.53)</td>
<td>(7.62)</td>
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</tr>
<tr>
<td>R- squared</td>
<td>0.90</td>
<td>0.90</td>
<td>0.75</td>
<td>0.74</td>
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<tr>
<td>Observations</td>
<td>115</td>
<td>110</td>
<td>110</td>
<td>105</td>
</tr>
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</table>

Note: The dependent variable is the natural log of real per capita GDP in 1995. The first two columns are the ordinary least square (OLS) estimates. The last two columns are the instrumental variables estimates where trade intensity is instrumented with the predicted value from the gravity model equation and the other RHS variables. T-statistics are in parentheses. The standard errors used to compute the t-statistics have been corrected for heteroscedasticity. ‘***’, ‘**’ and ‘*’ indicate significance at the 1, 5 and 10 percent level of confidence, respectively.
Table 3
Estimates for Environmental Degradation Equation

<table>
<thead>
<tr>
<th></th>
<th>no2</th>
<th>so2</th>
<th>suspended matter</th>
<th>co2</th>
<th>deforestation</th>
<th>energy depletion</th>
<th>water pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td><strong>RTA</strong></td>
<td>4.53</td>
<td>-2.42</td>
<td>13.02</td>
<td>0.33</td>
<td>0.07</td>
<td>-0.61</td>
<td>-0.0007*</td>
</tr>
<tr>
<td></td>
<td>(0.46)</td>
<td>(-0.48)</td>
<td>(0.95)</td>
<td>(1.00)</td>
<td>(0.57)</td>
<td>(-0.62)</td>
<td>(-1.78)</td>
</tr>
<tr>
<td><strong>ln(GDP per capita)</strong></td>
<td>627.24**</td>
<td>507.20*</td>
<td>867.97**</td>
<td>-22.45***</td>
<td>8.52***</td>
<td>32.27**</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td>(2.04)</td>
<td>(1.75)</td>
<td>(2.69)</td>
<td>(-4.67)</td>
<td>(3.59)</td>
<td>(2.81)</td>
<td>(-1.42)</td>
</tr>
<tr>
<td><strong>[ln(GDP per capita)]²</strong></td>
<td>-34.29**</td>
<td>-27.77**</td>
<td>-51.07**</td>
<td>1.53***</td>
<td>-0.54***</td>
<td>-1.83**</td>
<td>0.0009*</td>
</tr>
<tr>
<td></td>
<td>(-2.01)</td>
<td>(-1.78)</td>
<td>(-2.77)</td>
<td>(5.13)</td>
<td>(-3.76)</td>
<td>(-2.85)</td>
<td>(1.78)</td>
</tr>
<tr>
<td><strong>trade intensity</strong></td>
<td>-40.61*</td>
<td>-33.00***</td>
<td>-37.23</td>
<td>2.39**</td>
<td>-0.05</td>
<td>0.97</td>
<td>0.0019</td>
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<tr>
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<td>(-1.90)</td>
<td>(-3.34)</td>
<td>(-0.63)</td>
<td>(2.52)</td>
<td>(-0.16)</td>
<td>(0.54)</td>
<td>(1.21)</td>
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<tr>
<td><strong>polity</strong></td>
<td>-3.70**</td>
<td>-7.66***</td>
<td>-7.35**</td>
<td>0.015</td>
<td>0.004</td>
<td>-0.22***</td>
<td>-0.0002**</td>
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<tr>
<td></td>
<td>(-2.18)</td>
<td>(-3.90)</td>
<td>(-2.11)</td>
<td>(1.33)</td>
<td>(0.50)</td>
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<td>(-1.99)</td>
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<tr>
<td><strong>ln(area per capita)</strong></td>
<td>-4.73</td>
<td>-3.11</td>
<td>-24.29*</td>
<td>-0.17</td>
<td>-0.29**</td>
<td>0.77</td>
<td>0.0004</td>
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<tr>
<td></td>
<td>(-0.92)</td>
<td>(-1.02)</td>
<td>(-1.66)</td>
<td>(-0.76)</td>
<td>(-2.19)</td>
<td>(1.08)</td>
<td>(0.49)</td>
</tr>
<tr>
<td><strong>ln(economic intensity)</strong></td>
<td>-2.53</td>
<td>-2.05**</td>
<td>3.51</td>
<td>0.14*</td>
<td>0.041</td>
<td>0.45**</td>
<td>0.0002</td>
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<tr>
<td></td>
<td>(-1.02)</td>
<td>(-2.35)</td>
<td>(0.89)</td>
<td>(1.83)</td>
<td>(0.95)</td>
<td>(2.18)</td>
<td>(0.24)</td>
</tr>
<tr>
<td><strong>[ln(economic intensity)]²</strong></td>
<td>0.19</td>
<td>0.09</td>
<td>-0.28</td>
<td>-0.009*</td>
<td>-0.003</td>
<td>-0.014</td>
<td>-0.0000</td>
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<tr>
<td></td>
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<td>(1.44)</td>
<td>(-0.90)</td>
<td>(-1.74)</td>
<td>(-1.53)</td>
<td>(-1.01)</td>
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<tr>
<td><strong>Communist</strong></td>
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<td>-32.53</td>
<td>2.95***</td>
<td>-1.85***</td>
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<td>(-4.76)</td>
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<td>(3.17)</td>
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<tr>
<td><strong>Helsinki</strong></td>
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<td>5.44</td>
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<td>-1.09</td>
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<td>(0.73)</td>
<td>(0.69)</td>
<td>(-1.01)</td>
<td>(1.64)</td>
<td>(-0.85)</td>
<td>(0.16)</td>
</tr>
<tr>
<td><strong>F-test</strong></td>
<td>2.20</td>
<td>2.26</td>
<td>4.38</td>
<td>31.60</td>
<td>10.62</td>
<td>4.20</td>
<td>24.05</td>
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<tr>
<td></td>
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<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.02)</td>
<td>(0.00)</td>
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<tr>
<td>inflection value for <strong>y</strong></td>
<td>9364</td>
<td>9246</td>
<td>4906</td>
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<td>2712</td>
<td>6475</td>
<td>834</td>
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<tr>
<td>R- squared</td>
<td>0.28</td>
<td>0.76</td>
<td>0.65</td>
<td>0.77</td>
<td>0.38</td>
<td>0.20</td>
<td>0.72</td>
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<td>37</td>
<td>92</td>
<td>88</td>
<td>90</td>
<td>56</td>
</tr>
</tbody>
</table>

Note: The dependent variable is listed on the top. Each equation is estimated using instrumental variables (IV) where real GDP per capita, real GDP per capita squared and trade intensity are instrumented with the predicted values from the gravity model equation, trade equation and the other RHS variables. T-statistics are in parentheses. The standard errors used to compute the t-statistics have been corrected for heteroscedasticity. ‘***’, ‘**’ and ‘*’ indicate significance at the 1, 5 and 10 percent level of confidence, respectively. The F-test is the F-statistic and probability value of the joint significance of the GDP per capita terms. The inflection value for **y** is the maximum (or minimum) level of real GDP per capita.