The effect of the Kyoto Protocol on international trade flows: Evidence from G20 countries

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Abstract

This study examines the effect of the Kyoto Protocol on trade using a gravity model with a Quandt–Andrews test and data of the G20 countries to detect structural break. The structural break on international trade occurred in 2003, that is, around 1 year after the adoption of the Marrakesh Accords, which provided the detailed implementation rules of the Kyoto Protocol. From the estimation results, this study supports the negative effect of environmental regulations on trade flows.

Keywords: gravity model, Kyoto Protocol, structural breakpoint, trade flows

JEL Classification: F18; Q56

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I. Introduction

The Kyoto Protocol is an international agreement designed to control greenhouse gas (GHG) emissions. During its first and second commitment periods, the developed countries committed to reduce their GHG emissions by 5.2% and by at least 18% below the 1990 levels, respectively.

Policies to improve energy efficiency or directly regulate GHG emission in developed countries could induce an increase in the production costs of energy- or emission-intensive industries and the increased production costs could further lead to deterioration in price competitiveness and a loss of export markets. In other words, the introduction of environmental protection policies may alter the international trade structure. Recently, several studies have empirically found that costly pollution control has a negative impact on international trade (Koo 1974; Walter 1974; Pethig 1976; Asako 1979; Siebert et al. 1980; Kim and Koo 2011; Santis 2012; Aichele and Felbermayr 2013). However, a couple of studies have shown little evidence that stringent environmental regulations worsen the international competitiveness of pollution-intensive industries (Kalt 1988; Xu 2000).

The objective of this study is therefore to answer the question, "Does the Kyoto Protocol have a significant effect on international trade flows?" To answer this question, this research first determines the structural breakpoint of international trade due to the Kyoto Protocol. The Quandt–Andrews breakpoint test (Quandt 1960; Andrews 1993) is used to determine the point of structural break. After determining the structural breakpoint, the study estimates the effect of the Kyoto Protocol on trade flows by using a gravity model of trade. This study specifically focuses on trade flows of the G20 countries because they comprise the world's most advanced and emerging economies and represent 85% of the global gross domestic product and over 75% of global trade.

The gravity model has been used by a bunch of studies to explain the bilateral trade flows between country pairs. Anderson (1979) and Bergstrand (1985, 1989) provided a formal theoretical gravity model. Several studies have used the model to examine the effects of Free Trade Agreement (FTA); Bergstrand (1985), Koo et al. (1994), Frankel et al. (1995), Soloaga and Winters (2001), Carrére (2006), and Baier and Bergstrand (2007) are examples. With regard to the effect of environmental policies on international trade, Kim and Koo (2011) recently examined the impacts of regulating GHG emissions on livestock trade flows for OECD countries. They find that regulating GHG emissions has a negative effect on livestock trade flows.

However, these studies estimate the effects of FTA or environmental regulations using dummy variables, but with no test to detect the structural breakpoint. As far as I know, this study is the first to examine the effect of the Kyoto Protocol on trade using a test to detect structural break.

II. Brief history of the Kyoto Protocol

The international political response to climate change came in 1992 with the signing of the United Nations Framework Convention on Climate Change (UNFCCC).

The convention established a legal framework for stabilizing the GHG concentration in the atmosphere and preventing dangerous anthropogenic interference with the climate system. They also set a voluntary emission reduction target for the industrialized countries, the Annex I parties, to achieve the 1990 levels by 2000, but most countries failed to meet this target.

In December 1997, the member countries adopted the Kyoto Protocol, recognizing the necessity of stronger action for emission reduction. The Protocol set binding targets for the Annex I parties to reduce their GHG emissions by 5.2% to below their 1990 levels by the first commitment period. However, when the United States declared its opposition to the Kyoto Protocol in March 2001, the political development on climate change looked rather uncertain. In November 2001, the 7th Session of the Conference of the Parties (COP7) adopted the Marrakesh Accords, the detailed rules for implementation of the Protocol, and this paved the way for enforcement of the Protocol.

The second commitment period began in 2013. The binding overall target set was to reduce GHG emissions by at least 18% to below the 1990 levels. However, Canada withdrew from the Protocol, and Belarus, Kazakhstan, and Ukraine stated that they may withdraw the Protocol or may not put into legal force the amendment with the second commitment targets. In addition, Japan, New Zealand, and Russia have not taken on new targets in the second commitment period.

III. Empirical model and data

Gravity model and the Quandt–Andrews test

The basic concept of the gravity model is that bilateral trade flows can be predicted from the economic size of countries and the distance between them. Thus, bilateral trade flows have a positive relationship with the exporting and importing countries' income, but a negative relationship with the distance between the countries. The basic gravity model in international trade can be defined as

$$X_{ij} = \beta_0 (Y_i)^{\beta_1} (Y_j)^{\beta_2} (D_{ij})^{\beta_3} \varepsilon_{ij}, \tag{1}$$

where X_{ij} represents the bilateral trade flows from country *i* to country *j*, Y_i (Y_j) is the income of country *i* (*j*), D_{ij} is the distance between country *i* and *j*, and ε_{ij} indicates a log-normally distributed error term with zero mean.

The exchange rate between two trading partners is another major macroeconomic factor affecting trade flows in international economic theory. Hence, equation (1) can be redefined as

$$X_{ij} = \beta_0 (Y_i)^{\beta_1} (Y_j)^{\beta_2} (D_{ij})^{\beta_3} (R_{ij})^{\beta_4} \varepsilon_{ij} \tag{2}$$

where R_{ij} represents the exchange rate defined as the importing country *j*'s currency per unit of the exporting country *i*'s currency. This study does not consider any other variables used in common gravity models, such as common language, common border, or landlocked dummies, since I focus on changes in effect of economic factors after the structural breakpoint on trade flows. Estimation equation (2) can be rewritten as equation (3) by taking a natural logarithm on both sides of the equation:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln D_{ij} + \beta_4 \ln R_{ij} + \varepsilon_{ij} \tag{3}$$

In equation (3), since the exporting and importing countries' income represents their production capacity and purchasing power, respectively, β_1 and β_2 would have positive signs. The distance between countries should have a negative relationship with trade flows ($\beta_3 < 0$) because a longer distance implies higher transportation costs. The sign of β_4 would be negative because the higher the exchange rate, the more expensive would the products from *i* be for consumers in country *j*.

The study's panel estimation is based on a fixed-effect rather than random-effect model for two reasons. First, as Egger (2000) has shown, a fixed-effect gravity model is more appropriate than a random-effect gravity model in most applications. Second, this study attempts to estimate the trade flows not between randomly drawn samples of countries, but between a predetermined selection of nations. This study conducts fixed-effects *F*-tests to determine the efficiency of the model. The test results show that the null hypothesis of no time and cross-section fixed effects is rejected at the 1% significance level ($F_{290,5145} = 129.72$), implying that both fixed effects should be included in the model. Thus, the study can finally express the time series and cross-sectional form of the model as

$$\ln X_{ijt} = \beta_0 + \sum_{k=1}^{3} \beta_k \ln \Gamma_{kt} + \eta_t + \varphi_{ij} + \varepsilon_{ijt} \tag{4}$$

where X_{ijt} represents the trade flows from *i* to *j* at time *t*, Γ_{kt} is the vector of corresponding trade determinants, η_t is the time fixed effect specific to a particular year, φ_{ij} is the fixed effect associated with the country pair *i* and *j*, and ε_{ijt} is an error term.

The Quandt–Andrews test (Quandt 1960; Andrews 1993) is employed to verify a point of structural breakpoints in a sample for a given gravity model. The basic idea of the test is to carry out the Chow test (Chow, 1960) for all possible breakpoints and choose a point that shows the highest test statistics as the breakpoint. The highest test statistics are shown in 2003 ($F_{295,4850} = 13.19$), meaning that the breakpoint is most likely to have occurred in 2003. This implies that the structural break on international trade took place in 2003, which is around 1 year after the adoption of the Marrakesh Accords, which provides the detailed implementation rules of the Kyoto Protocol.

Data

This study estimates the model with data of the G20 member countries for the period 1994 through 2013. Nominal bilateral trade flows are obtained from the UN COMTRADE database. Because of the limited availability of data, the import and export data of South Africa and the import data of Russia are excluded from the analysis. The EU data are also excluded because the main purpose of this study is to examine the effect of the Kyoto Protocol on individual bilateral trade flows. The trade flows are scaled using the GDP deflators provided by the World Development Indicator (WDI) database to obtain real values. Real GDP values are also mined from the WDI. The real exchange rate is calculated by dividing the import country's per unit local currency in US dollars by the export country's per unit local currency in US dollars. The per unit local currency of either country in US dollars is obtained from the International Financial Statistic. This study uses the product of the distance and the real Western Texas Intermediate price as proxy for the transportation trade costs between countries. The distance between countries is calculated from the longitude and latitude of the countries obtained from the World Factbook of the Central Intelligence Agency. The real Western Texas Intermediate price is collected from the US Energy Information Administration.

IV. Empirical results

Table 1 shows the results of estimating the gravity equation (4) using the real panel data of trade flows of the G20 member countries. All the estimated parameters for both periods except for the exchange rate after the breakpoint have the expected signs and are statistically significant at the 1% level. More specifically, the estimated parameter on the exporting country's income rises from 0.19 to 0.35 after the breakpoint whereas that of the importing country diminishes from 1.05 to 0.70. This could be because an increase in production costs in the exporting country after the point, which leads to an increase in commodity prices, would result in a reduction of consumers' purchasing power in the importing country. The estimated coefficient on the distance variable also decreases after the structural breakpoint. This result implies that trade flows are impaired by an increase in transportation cost after the breakpoint. A 1% increase in exchange rate leads to a decrease in trade flows by 2% before the breakpoint, but after the point, the estimated coefficient of exchange rate is not statistically significant.

V. Conclusions

This study empirically examined the effect of the Kyoto Protocol on trade flows using a gravity model after the detection of the structural breakpoint using the Quandt–Andrews test (Quandt 1960; Andrews 1993). The study found that the structural break on international trade occurred most likely in 2003, which is around 1 year after adoption of the Marrakesh Accords. The adoption of the Marrakesh Accords is a very important event under UNFCCC since the Accords provided detailed rules on the implementation of the Kyoto Protocol and paved the way for the Protocol to have legal force.

The main finding of this study is that the estimated coefficient on the importing country’s income after the breakpoint is smaller than that before the point. This indicates that an increase in the exporting country’s production cost after the structural breakpoint due to environmental regulation policies could lead to a reduction of the consumers’ purchasing power in the importing country. Another empirical finding is that a rise in transportation costs after the structural breakpoint also could lead to a diminishing of trade flows. The empirical findings of this study support the negative effect of environmental regulations such as the Kyoto Protocol on trade flows.

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Table 1. Estimated coefficients of the gravity model.

Variables	1994–2002	2003–2013
Constant	-11.89	-1.63
	(-17.05)*	(-0.96)
Income of exporting country	0.19	0.35
	(5.78)*	(7.35)*
Income of importing country	1.05	0.70
	(69.49)*	(15.69)*
Distance	-0.02	-0.52
	(-6.29)*	(-11.23)*
Exchange rate	-0.02	-0.02
	(-4.35)*	(0.40)

Note: * indicates significance at 1% level. Parentheses are *t*-statistics