Policy Diffusion of Emission Standards: Is there a Race to the Top?*

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POLICY DIFFUSION OF EMISSION STANDARDS
Is There a Race to the Top?

By ERI SAIKAWA*

THE conventional wisdom is that globalization leads to a "race to the bottom" of environmental policies because environmental regulations are costly. Due to economic competition, the thinking goes, equilibrium at the "lowest common denominator" based on the "policies of the most laissez-faire country" should ensue.[1] However, mixed empirical results have raised questions about the validity of the conventional wisdom.[2] The literature on regulatory competition has burgeoned in recent years, and researchers now debate whether there are races to the bottom *or* to the top.[3] Some argue that there is a race to the top among a number of developed countries over domestic environmental regulations. Prakash and Potoski[4] argue that countries adopt ISO 14001—a *voluntary* environmental regulation—when their major export markets have adopted them. As yet, however, no scholars have included developing countries in their analysis, let alone conducted rigorous, quantitative studies to test this hypothesis of *compulsory*—not voluntary—environmental standards.[5] In this article, I fill this gap and find that there is indeed a race to the top of automobile emission regulations, including in developing countries.

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[1] Drezner 2001, 59.

[2] Drezner 2007, 15–16.

[3] For examples, see Scharpf 1997; Janicke and Jacob 2004; and Holzinger and Knill 2004.

[4] Prakash and Potoski 2006.

[5] Greenhill, Mosley, and Prakash 2009 addresses a diffusion of labor-rights standards in developing countries.

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Despite growing discussions about global environmental problems and ways to regulate pollution effectively, few studies have examined the conditions under which national governments adopt environmental regulations. Vogel has demonstrated that the adoption of stringent emission standards in California prompted other states to tighten standards to match them (using the term "California effect"); he then extended his hypothesis to some developed countries.[6] His main argument is that the benefits of adopting the standards to be able to continue selling in California outweighed the costs of being shut out from the market even with incurred costs. As California was a major automobile market, firms needed to invest in the necessary R&D and create new production lines to continue selling cars there. Once they acquired the requisite technologies, they pressureed their own governments to adopt similarly high standards so as not to be disadvantaged in their local markets. That way, they could ensure that standards would limit competition from firms that did not have the technologies. This argument works well for developed countries, and past studies have focused mainly on the first-mover advantage. Developing countries were left out of the picture, but we need a good explanation for the diffusion of domestic environmental regulations in those countries as well.

Since the 1980s, there has been evidence of diffusion from developed to developing countries of compulsory domestic regulation to reduce emissions in new cars. The question is: why would developing countries adopt automobile emission standards? As many as sixty-seven countries, including thirty-six developing countries, have decided to regulate their automobile emissions voluntarily by adopting standards from developed countries without any international requirements to do so.[7] I argue that the motivation for this domestic environmental policy diffusion is to stay *competitive* in the international automobile market. I provide two related but distinct policy diffusion mechanisms: in one adoption by importers creates pressure (*direct export pressure,* that is, "California effect") and in the other adoption by economic competitors creates pressure (*indirect export pressure*) to adopt such standards, following the logic of the policy diffusion literature.[8]

In this article, I focus on explaining the diffusion of the first comprehensive emission standards. In 1970 the United States took the lead and proposed standards that would reduce exhaust emissions by 90

[6] Vogel 1995.

[7] Author's database. I categorize all countries that do not belong under the "high income" category by the World Bank Group (World Bank Group 2007) as developing countries.

[8] For examples, see Simmons and Elkins 2004; and Dobbin, Simmons, and Garrett 2007.

percent from the requirements in place at that time (the actual implementation was postponed until 1983). In the 1970 US Clean Air Act, new cars were required to meet standards for three pollutants: carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxides (NO_x).[9] When the US adopted these standards, countries that were exporting to the US faced an urgent need to meet the new market requirements. Japan tightened its regulations soon after the decision by the US and ended up implementing the regulation earlier, in 1978, with NO_x reductions. Within the United Nations Economic Commission for Europe (UNECE)—the institution in charge of adopting emission standards for Europe at the time—Germany and the UK, the two large automobile exporters in Europe, proposed adopting the US standards. However, this was vetoed by France, which had only minor exports to the US at the time, and Europe created its own, more moderate standards.[10] The adoption of the US standards in 1970 forced technological innovation both at home and abroad and has contributed to the diffusion of both technology and standards.[11] The first three sets of comprehensive emission standards by Japan (Japan 76), the US (US 81), and Europe (Euro 1) required catalytic converters for meeting the demands for emissions reduction (see Figure 1). These standards resulted in similar limits for CO, HC, and NO_x that were unprecedented at the time of initial adoption. In this article, I demonstrate why these domestic environmental regulations diffused internationally over the past three decades.

My data on the adoption year of the standards that are at least equivalent to Japan 76, US 81, and Euro 1 show a strong trend in which the number of countries adopting emission standards has steadily increased over the past thirty years (see Figure 2).[12] By 1976, only two countries—the US and Japan—had adopted these standards. By 2000, forty-six countries had adopted them, and by 2009, sixty-seven countries had equivalent standards. This includes several upper-middle-income countries, such as Mexico and Brazil, and lower-middle-income countries, such as China and India, as well as low-income countries, such as Bangladesh and Nepal. All the countries adopted one of the three sets of emission standards, and these are still the only standards that currently exist, although the stringency level has been gradually tightening.

[9] The standards required for each pollutant were: 3.4 g/mile for CO, 0.41 g/mile for HC, and 0.4 g/mile for NO_x emissions. CO and HC standards were required to be in place by 1975 and NO_x by 1976.

[10] Wurzel 2002.

[11] Janicke and Jacob 2004.

[12] There are countries that skipped the first comprehensive level and adopted more stringent standards. In such cases, the year that any higher level standard was adopted is included as the adoption year.

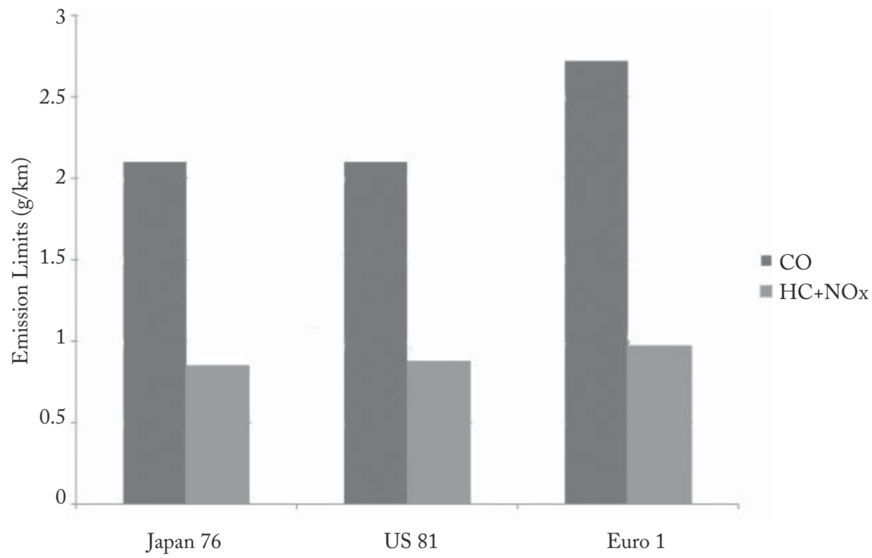


FIGURE 1
COMPARISON OF THE LIMITS (IN G/KM) FOR CARBON MONOXIDE (CO) AND THE SUM OF HYDROCARBONS (HC) AND NITROGEN OXIDES (NO_x) FOR THE THREE FIRST COMPREHENSIVE AUTOMOBILE EMISSION STANDARDS

SOURCES: Taken from CONCAWE 1997; and AEA Technology Environment 2001.

There is also a general trend that shows a rapid increase in automobile exports trade value during the years after adoption. Such an increase is visible not only in rich countries with large automobile industries but also in developing countries such as Brazil and China. Figure 3 clearly demonstrates that higher levels of trade need not come at the cost of lower environmental standards in developing countries. These trends go far to counter the notion that environmental protection creates a competitive disadvantage for industry. I argue that in an open economy firms face competitive pressure from the international market and countries therefore adopt emission standards so as not to disadvantage firms with technologies in their local markets.

ADOPTION OF EMISSION STANDARDS AND THE MECHANISMS OF DIFFUSION

I argue that "competitive pressure" includes the two types of competition—direct export pressure and indirect export pressure—that are the main mechanisms of diffusion for environmental product standards.

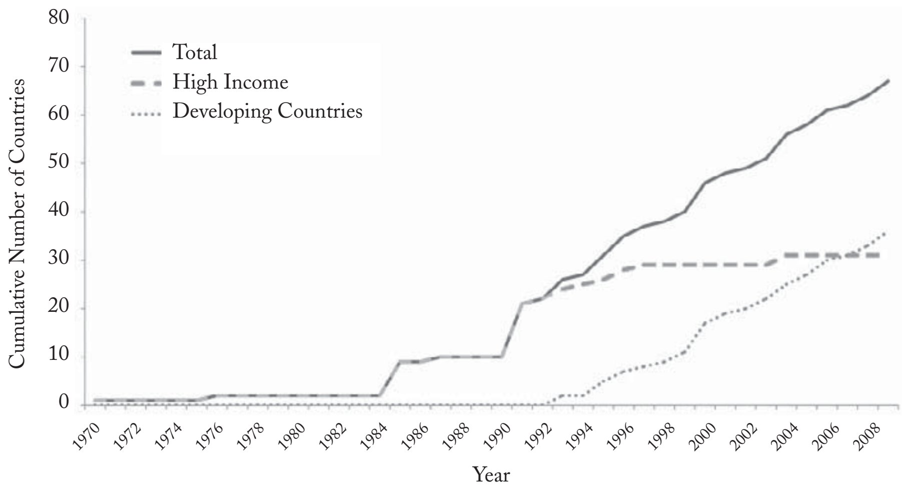


FIGURE 2
CUMULATIVE NUMBER OF COUNTRIES WITH THE FIRST COMPREHENSIVE AUTOMOBILE EMISSIONS STANDARDS

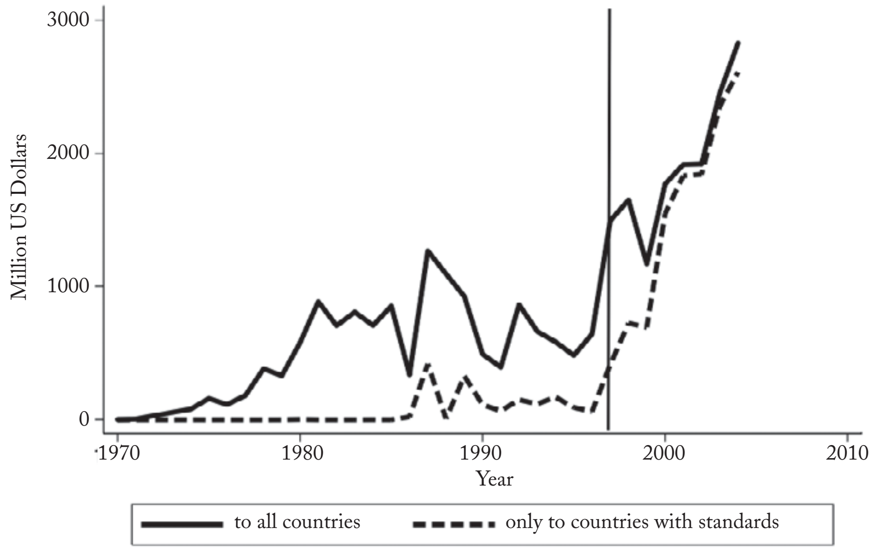
SOURCE: Created based on author's database found at www.mit.edu/~esaikawa/database.html.

In addition to competition, the literature on policy diffusion suggests three other mechanisms: international pressure, normative emulation, and learning.[13] My model also controls for these as possible means of diffusion.

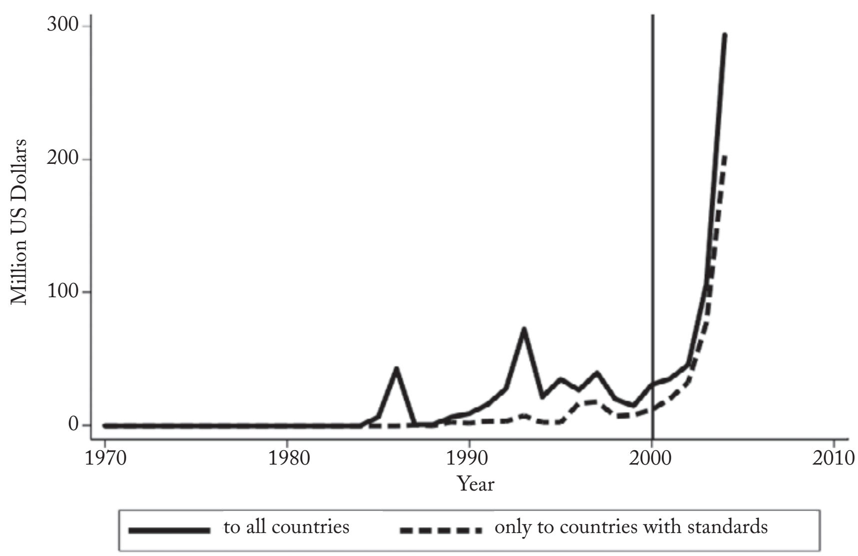
COMPETITIVE PRESSURE

The adoption of emission standards by other countries carries the potential to alter the competitive dynamics for automobile exports in the international market. These standards directly affect trade as nontariff barriers, given that governments restrict imports based on whether the product meets their domestic emission standards for environmental protection. This creates pressure on exporters when it is only the importer, but not the exporter, that has such standards. Emission standards may also be a source of competitive advantage to the extent that capacity to produce automobiles equipped with emission-reduction technologies in markets serves as a signal of technological capacity.

[13] For examples, see Simmons, Dobbin, and Garrett 2006; Dobbin, Simmons, and Garrett 2007; and Shipan and Volden 2008.



(a)
Automobile Exports Trade Value (Brazil)



(b)
Automobile Exports Trade Value (China)

FIGURE 3
AUTOMOBILE EXPORTS TRADE VALUE (IN MILLION US DOLLARS) FROM BRAZIL AND CHINA[a]

SOURCES: Created using data from the UN Comtrade database.

[a] Brazil and China adopted the emissions standards in 1997 and 2000, respectively (shown at black vertical line).

Earlier research highlighted that industries push for environmental policy harmonization when faced with a potential competitive disadvantage. Vogel has argued that developed countries raise their environmental standards to bring them into harmony with the stricter standards of their export markets.[14] Indeed, it might be more efficient for multinational corporations to use their home-country standards (which are higher than the host-country standards) when they have production across a diverse set of regions. DeSombre has used the Baptist and bootlegger dynamic to capture how bootleggers (industry) in the US align with the Baptists (environmentalists) out of fear of competitive disadvantage when foreign firms are not required to follow the same environmental regulations as the ones to which US firms are subject.[15]

Two competitive pressure mechanisms that are related and thus sequential lead to successful adoption of emission standards by countries that were waiting for the right moment to reduce the level of domestic air pollution from automobiles. One is direct export pressure, where firms lobby governments after facing direct pressure from the markets to which products are being exported. Second is indirect export pressure, where firms lobby governments once other countries that also export products to the same markets have adopted emission standards.

Multinational companies export environmentalism and put pressure on the developing country governments to adopt more stringent environmental standards.[16] Firms with technologies lobby governments to adopt emission standards, because without government intervention other firms could continue producing high-polluting vehicles for sale locally at a lower price. Government intervention is required to ensure that all manufacturers meet a certain standard for domestic sales.[17]

Domestic producers without any foreign partner may oppose stringent emission standards, but they are often unable to overcome the pressure of multinational companies. First, the public and the government often favor stringent emission standards for better air quality, as long as the cost increase is not significantly large. Second, governments in developing countries welcome foreign direct investment, and they prefer to increase their technological capabilities. Third, the developing country governments are aware that the adoption of stringent emission standards forces multinational companies to produce auto-

[14] Vogel 1995.

[15] DeSombre 2000.

[16] Garcia-Johnson 2000.

[17] A Vietnamese news article states that local carmakers, especially foreign invested ones, are technically capable of adopting stringent emission standards, "but they won't exert themselves unless the government forces them to" (Van 2007).

mobiles with better technologies. For these reasons, developing countries adopt more stringent standards despite opposition from some of their domestic firms.

China is a good example of a central government adopting emission standards because of both direct and indirect export pressure. Until the early 1990s, China's automobile firms manufactured almost solely for the domestic market (see Figure 3), and its small exports were mainly to other developing countries without any emission standards. China was open to foreign direct investment, but in order to enhance learning and increase its competitiveness in the international market, China did not allow foreign companies to own more than 50 percent of a joint venture for automobile production. Furthermore, for foreign joint venture companies, at least 40 percent of parts and components needed to be from the local firms.[18] However, starting in the mid–1990s, as more countries adopted emission standards, firms came under both direct and indirect export pressure. Interviews conducted in China reveal that firms with technologies lobbied the government to adopt the European emission standards.[19] The central government, interested in improving the air quality and building the automobile industry as its "pillar industry," adopted the European standards in 2000, once it was sure that the stringent emission standards would not negatively impact the automobile industry. Despite strong opposition from domestic firms, China was eager to adopt tight standards and did so in hopes of increasing its technological capacity.

Direct Export Pressure

I argue that the adoption of automobile emission standards by importing countries creates a nontariff barrier in the international automobile market, thereby affecting the policy choice of exporting countries. By adopting emission standards, countries are able to limit the imports of automobiles that do not meet the requirements.[20] Firms that are located in countries without standards and that export to those that have adopted standards need to make a decision as to whether to modify their cars to meet the foreign market requirements in order to continue exporting or to abandon exports to this specific market. If they

[18] Gallagher 2006.

[19] I conducted interviews in July–August 2008 and February and July 2009. Interviewees include eighteen managers in the automobile industry, ten researchers at the national research institutions, eight local government officials, and five professors.

[20] Under the General Agreement on Tariffs and Trade (GATT), which later became the World Trade Organization (WTO), automobile emission standards fall under the category of the Technical Barriers to Trade (TBT) agreement, as they are product standards that act as nontariff barriers. For more information on standards under the GATT/WTO framework, see World Trade Organization 2012b.

choose to continue exporting, they must either create another production line on top of their domestic production or overhaul all production to match the foreign standards.

Facing this direct export pressure, firms start producing vehicles with catalytic converters, as it is cost inefficient to maintain two production lines. After exporting firms make the switch to producing vehicles with advanced technologies, they then lobby governments to adopt emission standards, in order not to be disadvantaged in local production. I examine this mechanism (that is, Vogel's "California effect") whereby countries adopt tighter standards in response to lobbying from firms being pressured by their importers. The effect would be even higher if a large proportion of automobile exports are directed toward countries with emission standards.

In this model, firms in countries without standards react to pressures from their current export markets. Governments adopt emission standards when costs of regulating vehicle emissions become low after at least some automobile companies adopt the necessary technologies. In a global economy with increasing interdependence, governments (including those in developing countries) are able to adopt environmental standards because of the profit-maximizing behavior of some firms with advanced technologies. I make the following hypothesis based on this model:

> —H1.1. Direct Export Pressure: Share of automobile exports to countries with standards: the greater the exports to countries with emission standards, the more likely it is that a country will adopt such standards.

Indirect Export Pressure

Pressure also comes from exporting firms' competitors for automobile exports. The parallel trends of liberalization and industrialization have brought more countries into the automobile market both as exporters and as importers, thus increasing competition. I argue that firms start installing vehicle emissions-reduction technologies to create competitive advantage by differentiating themselves from other competitors in the international market. Such firms will lobby the government to adopt emission standards nationally, to avoid being disadvantaged in the local market.

Firms are more vulnerable and sensitive to competitors when they do not have diverse exporting markets. Two properties of diversity are relevant: variety and balance.[21] Variety refers to the number of export markets, and balance refers to a country's share within each export market. When a firm has many trade partners to which it exports

[21] Stirling 1998.

automobiles, variety makes it less sensitive to its economic competitors. In contrast, firms that export to only a limited number of countries will work harder to hold on to their current export markets. These firms with limited export markets (that is, less variety) will also try harder to expand their markets.

When a country's exports constitute a significant share of an importing country's automobile exports, this exporting country is considered a dominant market for this specific importing country for automobiles. I argue that when a country has one or more of these dominant markets, firms in the country become less sensitive to their competitors in these countries. When a country is so dominant in a specific market, there is not much reason for the exporter to differentiate its products. If, however, a country does not have such markets, the firms are more vulnerable and therefore are more likely to differentiate themselves from others, because product differentiation can result in competitive advantage.[22] Producing cars with catalytic converters signals that a firm has technological competence to produce better-quality cars, and low labor costs can allow the firm to position itself as the low-cost exporter of good-quality automobiles.

In summary, the less diverse a firm's export markets, the more likely it is to use emission-reduction technologies to differentiate itself from its economic competitors. Firms then lobby governments to adopt national emission standards. The logic behind this builds on the competitiveness mechanism for the diffusion of economic policies: countries adopt certain policies so as not to be disadvantaged by their economic competitors in the global economy.[23] I argue that firms use emission-reduction technologies as a means to gain competitive advantage in the international market. They then lobby governments to adopt these standards. I offer the following hypothesis:

> —H1.2. Indirect Export Pressure: Automobile exports status in the global market: the more market diversity (that is, a greater number of exporting markets and/or a larger share of importers' imports), the more likely it is that a country will adopt emission standards.

To Adopt or Not to Adopt: Why Adopt Emission Standards?

For the analysis of the adoption of emission standards, my dependent variable of interest captures whether a country adopts the first com-

[22] Spence 1976.

[23] Simmons and Elkins 2004; Simmons, Dobbin, and Garrett 2006.

prehensive automobile emission standards, or higher, in the given year (with standards adoption = 1). I collected the data on the year a country adopted the first comprehensive emission standards equivalent to Japan 76 / US 81 / Euro 1 regulations, or higher, for 129 countries.[24] For all years following adoption, the country's observations are removed from the data analysis, as my focus in this study is the initial adoption of the comprehensive emission standards and not the level of stringency. There is no country that has ever rescinded its automobile emission standards; therefore, it is safe to remove observations in order to find the probability that a country adopts standards. Since the adoption of emission standards is a rare event with a 1 percent incidence rate, a standard logistic regression could significantly underestimate the probability of adoption.[25] I therefore use a rare events logistic regression to predict the probability of a country's adoption of emission standards.[26]

Although the US was the first to adopt the stringent set of emission standards in 1970, the implementation was delayed because the technology was unavailable. Most countries started to adopt these standards only in the mid–1980s, after advanced technologies to meet the reduction requirement were readily available. Since my interest lies in the diffusion of emission standards rather than in technological innovation, I focus on 129 countries during the period between 1980 and 2000, after the technology was available and because of the data accessibility.

Independent Variables

In order to assess the competitive pressure mechanism, I construct two variables: *Emission Standards Share* and *Automobile Exports Status*. The first variable, *Emission Standards Share,* takes into account the proportion of a country's automobile exports trade value to the countries with emission standards as a share of all automobile exports trade values. The automobile exports value is taken from the United Nations Commodity Trade Statistics Database. As this value becomes higher, it indicates that exporting firms experience stronger pressure from their im-

[24] Sources include Asian Development Bank 2008; CONCAWE 1997; CONCAWE 2006a; CONCAWE 2006b; and DELPHI 2008.

[25] King and Zeng 2001a; King and Zeng 2001b.

[26] I use a rare events logistic regression, because the data I have are limited to the year in which a country adopts standards, not the specific date. Furthermore, it is difficult to set the starting point for all countries, as there was no definitive beginning at which a country was required to adopt standards due to delays in implementation of the standards. Therefore I treat time as discrete and use logistic regression to estimate the annual probability of adoption when a country has yet to adopt the standards. The results hold with those of a normal logistic regression.

porters to introduce emission-reduction technologies. Without these technologies, firms are no longer able to continue exporting to the same market, and as such markets increase, it becomes cost effective for the firms to switch their production lines to produce cars with technologies. As firms produce vehicles with catalytic converters, they move to lobby the government to adopt emission standards. This variable measures the impact of the direct export pressure from importers.

The second variable, *Automobile Exports Status*, captures the status of a country in terms of automobile exports in the global economy. Using the concept of the Herfindahl-Hirschman concentration index, I create a variable that sums the square of the share of a country's automobile exports as a share of each market's imports. This index increases both as the number of export markets increases (and thus an exporter has a larger number of trade partners) and as disparity in terms of exports share increases (and thus an exporter becomes a major exporter). And the index allows me to measure whether an exporter has diverse exporting markets defined by a large number of trade partners (variety) and/or whether an exporter has a large share in its exporting markets (balance). If, for example, a country has diverse trade partners, the country receives a high value for this variable. At the same time, a large share in a country's automobile imports also leads to a high value for this index. By contrast, when an exporter has limited trade partners and when it does not have major influence within markets, this value is reduced. The higher value indicates higher status in global automobile exports due to greater diversity and shows that a country faces less pressure from its economic competitors. And the lower value indicates lower status due to less diversity and higher indirect export pressure. This measures the level of competition a country faces for global automobile exports, and I expect a negative correlation between this variable and the probability of adoption.

For each of these mechanisms, I use the previous year's data as my independent variables. I use these lagged values to analyze the impact of these mechanisms on adoption in the following year.[27] And by using them, I can also reduce the possibility for endogeneity between mechanisms and adoption.

Control Variables

Although my main interest is to identify the role of the competitive pressure mechanism, it would be misleading to ignore the other three

[27] I also test with different lagged values, and they yield results similar to those shown here.

mechanisms (international pressure, normative emulation, and learning) that have been identified as influencing policy diffusion.[28] Four additional variables also allow me to examine the influence of the competitive pressure mechanism when controlling for conditions related to domestic environmental, economic, and political conditions that would be expected to influence the likelihood of that emission standards will be adopted.

INTERNATIONAL PRESSURE

The mechanism of international pressure works through coercion from foreign actors by using credible threats or economic incentives such as "aid, grants, loans, or security."[29] To assess the international pressure mechanism, I create one variable: *International Aid*. This variable consists of Official Development Assistance (ODA) and other official aid values as a share of GDP (in percentage).[30] This is a rough indicator to capture international pressure to adopt emission standards, but it is the best proxy available, because the environmental protection component often serves as one part of a larger aid project.

NORMATIVE EMULATION

In this mechanism, the increasing number of countries adopting automobile emission standards alters the global norm of environmental management. As more countries adopt emission standards, the notion that it is right to adopt such standards spreads and countries make a decision to follow the path of others.[31] Such emulation takes place through the growth of epistemic communities[32] and transnational social movements.[33] To assess this mechanism, I construct a variable named *Standards*. It is taken from my database and captures the number of countries that have adopted the initial comprehensive automobile emission standards by a specific year. As it is a cumulative number, it captures normative pressure that is created as more countries adopt standards. This normative emulation mechanism is also linked to competitive pressure as the number of countries with emission standards affects how much competitive advantage these standards provide in the international market.

[28] For examples, see Dobbin, Simmons, and Garrett 2007.
[29] Dobbin, Simmons, and Garrett 2007.
[30] World Bank Group 2009.
[31] Meyer et al. 1997.
[32] Haas 1992.
[33] Keck and Sikkink 1998.

LEARNING

By this mechanism, a foreign country's adoption of emission standards provides information to a nonadopter about the effectiveness of that policy. To measure the impact of learning, I construct a variable called *Environmental IGO membership*. This variable consists of membership data for 129 international governmental organizations that are environmental in nature. I have chosen these organizations from the Correlates of War Intergovernmental Organizations (COWIGO) Dataset.[34] To define "environmental organizations," I used Mitchell's definition as those that "seek, as a primary purpose, to manage or prevent human impact on natural resources; plant and animal species (including in agriculture, since agriculture modifies both); the atmosphere; oceans; rivers; lakes; terrestrial habitats; and other elements of the natural world that provide ecosystem services."[35] I have created a variable for each country per year that captures how many environmental IGOs it was a member of in that year.

Environmental Pressure

Concern that cars are polluting the air may provide a sufficient incentive on its own for a country to adopt automobile emission standards. With increasing damage from automobile pollution to health and agricultural yields, it is natural for countries to take measures to reduce the adverse effects. Citizens may also pressure governments to take action by forming NGOs or by punishing politicians for not creating effective environmental policies. The best measure would be the emissions of air pollutants from automobiles that are regulated by these standards (CO, HC, and NO_x). Since there are no data going back to 1980 for these emissions, I instead use the *CO_2 emissions* (in million metric tons) from transport, taken from the International Energy Agency database.[36] *CO_2 emissions* are highly correlated with the number of cars registered in the country, and the number of cars will be a direct determinant of the level of CO, HC, and NO_x emissions. As I analyze only the years in which countries have not adopted standards, these cars are not equipped with catalytic converters. It is thus logical to assume that the amount of pollution increases as the number of automobiles increases. Therefore, I use the variable *CO_2 emissions* as a proxy for the amount of vehicle emissions.

[34] Pevehouse, Nordstrom, and Warnke 2004.
[35] Mitchell 2002–9; Daily 1997.
[36] International Energy Agency 2007.

ECONOMIC LEVEL

Countries may adopt emission standards once they reach a certain economic level, as suggested by the environmental Kuznets curve theory that emissions follow the inverted U-shaped curve along a country's per capita income.[37] It is also usually understood that the higher a country's income, the higher the environmental concern of its citizens.[38] Many countries have become richer over the past three decades, and this may be the primary reason why they have started to adopt emission standards. If this is indeed the case, it may be that adoption of standards is a spurious effect of economic development and/or the mere effect of increased car consumption, not directly related to the suggested mechanisms. I therefore control for *Log Real GDP per Capita* as a rough indicator of a country's level of economic development. If there is a correlation between a country's income and its adoption of emission standards, I should observe a positive coefficient value for this variable. The underlying assumption here is that the country would be more likely to adopt emission standards at higher levels of economic development.

EU MEMBERSHIP.

I also control for *EU Membership*, as the EU countries were mandated to implement the Euro 1 equivalent automobile emission standards by 1999. It is equally plausible for the EU members to have adopted these standards even before this year, due to the requirement. It is a binary measure that is set equal to 0 when a country is not a member and at 1 for member states.

ECONOMIC STAKES

Countries may very well be more sensitive to their economic stakes in the automobile industry merely because their automobile exports already constitute a large source of income. I control for the economic stakes of the automobile industry, using a country's automobile exports trade value as a share of GDP (*Auto Exports Share of GDP*) to illuminate that the countries are forward thinking and adopt standards because of the competitive pressure discussed above.

[37] For examples, see Dasgupta et al. 2002; Grossman and Krueger 1995; Panayotou 1997; Stern 2004; and Suri and Chapman 1998.

[38] For example, see Diekmann and Franzen 1999. There has been a debate on this issue, as explained in a more recent study, Franzen and Meyer 2009.

Findings

My analysis includes 129 countries with yearly data from 1980 to 2000. My dependent variable is the dichotomous measure of the adoption of emission standards, and I test the two hypotheses for the mechanisms of policy diffusion using a rare events logit function. In order to compensate for possible correlation and heteroskedasticity across observations, I estimate robust standard errors clustered by country, including five-year dummies in order to account for potential patterns of temporal dependence.[39]

I start with model 1, which includes the competitive pressure mechanism with other control variables for all countries. Model 2 examines the subset of high-income countries, and model 3 looks at the subset of developing countries. The analysis of separate income levels allows for the possibility of different effects across variables conditional on income.

The results give a clear indication that competitive pressure increases the probability that a country will adopt automobile emission standards, when controlling for other variables. The coefficients for the lagged *Emission Standards Share* variable in all models are both positive and significant. This gives support to the hypothesis that a country is more likely to adopt automobile emission standards when a larger share of its automobile exports are imported by countries with emission standards. The coefficients for the lagged *Automobile Exports Status* variable are negative and also significant in all models. These results confirm that the competitive pressure comes from both the importers and other exporters, and countries are more likely to adopt when the pressure is high.

Analyzing the other suggested mechanisms of policy diffusion in the literature, international pressure appears unimportant for the global diffusion of emission standards. The coefficient of the *International Aid* in Table 1 is insignificant in all models. Given the priority of other issues such as security and poverty reduction, adoption of emission standards could be of minor importance for providing international aid. The coefficients of the *Standards* variable provide evidence that the normative emulation mechanism is not negligible, but they become less significant when tested for developing countries. The coefficients of the *Environmental IGO Membership* variable are positive and significant

[39] Beck, Katz, and Tucker 1998 argue the need to include time dummies. It is better to include dummy variables for each year, but it is not possible in my model since the event is rare. Therefore, I created temporal variables for each of the four five-year periods between 1980 and 2000.

TABLE 1
ALL DIFFUSION MECHANISMS

	Model 1 Base	*Model 2 High Income*	*Model 3 Developing Countries*
Diffusion Mechanisms[a]			
Competitive Pressure – Direct Export Pressure			
Emission Standards Share	1.790**	2.051*	2.161*
	(0.711)	(1.128)	(0.912)
Competitive Pressure – Indirect Export Pressure			
Auto Exports Status	−0.271**	−0.202**	−2.524*
	(0.106)	(0.100)	(1.479)
Controls			
International Pressure			
International Aid Share of GDP	−1.68	1.778	−2.587
	(0.152)	(1.229)	(1.966)
Normative Emulation			
Standards	0.112***	0.072**	0.144*
	(0.036)	(0.036)	(0.085)
Learning			
Environmental IGO Membership	0.135**	0.116*	0.175*
	(0.056)	(0.063)	(0.094)
CO_2 Emissions	0.005	−0.006	0.007
	(0.005)	(0.007)	(0.006)
Log Real GDP per Capita	1.057***	1.355	1.408**
	(0.357)	(1.328)	(0.547)
EU Membership	2.810***	2.986***	0.254
	(0.708)	(1.061)	(0.635)
Auto Exports Share of GDP	0.927**	1.082**	3.056
	(0.377)	(0.468)	(0.635)
N	2096	500	1596

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$; robust standard errors in parentheses, clustered by countries; all models include a constant, not shown here

[a]All independent variables are 1-year lagged values.

in all models. This suggests that countries, and especially developing countries, learn the importance of automobile emission standards through environmental intergovernmental organizations. It is important, however, to stress that this proxy may not be the best for capturing learning from other countries.

From the coefficient of the *CO_2 Emissions* variable, domestic environmental pressure does not appear to play much role in the policy diffusion of automobile emission standards. It does not support the argument that countries try to remedy the deterioration of air quality and that the increase in pollution leads to a higher likelihood of adopting emission standards. Government intervention does not appear to be triggered simply by increasing air pollution.

The coefficients for the *Log Real GDP per Capita* variable are positive and significant in models 1 and 3, providing support for the hypothesis that countries' income is positively correlated with their adoption of emission standards in developing countries. It makes intuitive sense that for developed countries, GDP per capita is not a particularly important factor for the decision to adopt the standards. The coefficients for the *EU Membership* variable are positive and significant in models 1 and 2. This also makes sense, as all EU countries were required to follow certain regulations by 1999. The coefficients for the *Auto Exports Share of GDP* are positive and significant in models 1 and 2 at the 90 percent confidence level. It comes as no surprise that the larger the income a country receives from automobile exports, the more likely it is that the country will adopt emission standards.

These main results do not differ by including some limited automobile production data obtained from Ward's Automotive Yearbook for a smaller sample with twenty-five countries for twenty years,[40] and the coefficient of this production variable is insignificant (not shown here). This indicates that an increase in the production level is not necessarily related to a higher likelihood of the adoption of standards, holding everything else constant. The level of automobile industry development, therefore, is a negligible factor, at least in the limited model. This result supports my argument that the diffusion is due to the competitive pressure in the global economy rather than to the development of the automobile industry.

In summary, my results in models 1–3 indicate that competitive pressure is an important mechanism driving policy diffusion in the case of automobile emission standards. Both direct and indirect export pressures are important for diffusion of these environmental standards, and it works for developing countries as well.

What Is the Impact of Adoption?

I now consider whether the adoption of emission standards affects a country's automobile exports. If a country adopts emission standards as a means by which vehicle manufacturers gain technologies and become competitive in the international market, it is probable that a country's

[40] Detroit: Ward's Communications. Data exist for twenty-five countries that are large producers of automobiles.

decision to adopt such standards leads to more automobile exports. In order to assess the impact of adopting emission standards, I propose an additional hypothesis that the adoption of a policy results in an increase in a country's automobile exports trade value. I include developing countries in my model to demonstrate that the adoption of emission standards leads to greater competitive *advantage*, rather than to *disadvantage*.

The literature on trade is vast, and many empirical models have used the standard gravity model of trade to estimate trade flows. There are theories on the impact (or nonimpact) of the GATT/WTO, alliances, democracies, or various agreements such as preferential trade agreements (PTAs) on bilateral trade.[41] Here, I evaluate the impact of emission standards on bilateral automobile exports. If the adoption of emission standards enhances competitive advantage, we should observe an increase in automobile exports as a country adopts standards when an importer has also adopted them. At the same time, we should expect adoption of standards in an exporting country would reduce its exports to an importer that does not have standards in place.

Further, automobile exports should decrease as the number of countries with similar standards increases over time, because competitive advantage in having emission standards drops when more countries compete within the same market. If an exporter has not yet adopted the standards, the increase in the number of countries adopting them would result in having to compete with other countries that are more likely to have adopted standards, which acts as a disadvantage for nonadopters. If an exporter has already adopted the standards, this increase in the number of countries that have adopted standards causes competition with more countries that meet the requirement to win the market. In either case, the result is a reduction in the trade value of automobile exports, because countries have to compete with more countries in order to win a market share.

In this article, following the above logic, I provide the first comprehensive econometric study of how the adoption of emission standards affects automobile exports. I test the following hypotheses.

> —H2.1. Competitive Advantage of Standards Adoption: adoption of emission standards brings competitive advantage to a country that exports automobiles when importers have also adopted standards. As a result, adoption of standards by both an importer and an exporter leads to an increase in automobile exports.

[41] For examples, see Mansfield and Bronson 1997; Mansfield, Milner, and Rosendorff 2000; and Kono 2007.

—H2.2. Number of Countries with Standards: the premium earned by exporters from adopting standards will decline in value as more countries adopt such standards.

I measure the impact of emission standards on automobile exports using a gravity model with dyadic data from 1980 to 2000. The gravity model is a standard framework to estimate bilateral trade flows.[42] It estimates (the natural logarithm of) trade value based on (the logs of) the distance and income of the two countries. In order to account for as many extraneous factors as possible, I also include other conditioning variables that are commonly known to affect trade.[43]

Dependent Variable

My dependent variable for the gravity model is the natural logarithm of dyadic automobile exports trade value in each year. In my regression, the dependent variable $\ln Export_{ijt}$ is substituted by $\ln(Export_{ijt} + 1)$ to include the zero export values after taking the logarithms.[44]

Independent Variables

I have theorized that the adoption of emission standards brings competitive advantage to a country that exports automobiles when importers have adopted such standards and that such competitive advantage declines as more countries adopt emission standards. Therefore, I create four independent variables to test these hypotheses: *Exporter Standards*, *Importer Standards*, *Both Standards*, and *Log Number of Standards*. The first independent variable, *Exporter Standards,* is a dummy variable that captures the exporter's adoption of emission standards (with exporter adopting standards = 1). The second variable, *Importer Standards,* is also a dummy variable, and this captures the importer's adoption of emission standards in the same way as *Exporter Standards*. The third variable, *Both Standards,* is the interaction term of the two previous variables, and it indicates the adoption of emission standards by both exporting and importing countries. The fourth variable, *Log Number of Standards,* counts the (log of the) cumulative number of countries that have adopted the standards by each year.

The coefficient of the first variable, *Exporter Standards*, captures the impact of an exporter's adoption of emission standards on its automobile exports when importing countries have no standards. Combining it with the second variable, *Importer Standards*, and the third variable,

[42] For further discussion of the gravity model, see Anderson and van Wincoop 2003.
[43] See Table A2 in the appendix for descriptive statistics and sources.
[44] Cf. Liu 2009.

Both Standards, allows me to analyze the impact of the adoption by an exporter on its automobile exports to countries that have already adopted emission standards. I expect a positive coefficient for the variable *Both Standards*, as the adoption of emission standards by an exporter is predicted to increase its competitive advantage when importers have already adopted emission standards. By contrast, I expect a negative coefficient for the variable *Importer Standards* because it would negatively affect trade if an importer adopted emission standards while an exporter did not. For the fourth variable, *Log Number of Standards*, I expect a negative coefficient, as the increase in countries with standards leads to severe competition.

Control Variables

I control for the geographical distance between the two countries in a dyad (*Log Distance*), the product of the real GDP in the two countries (*Log Product Real GDP*), and the product of the real GDP per capita in the two countries (*Log Product Real GDP p/c*).[45] Following the literature, I control for sharing a land border (*Contiguity*) and the existence of military alliances between the two countries (*Alliance*).[46] As past literature also includes democracy levels (*Joint Democracy*), autocracy levels (*Joint Autocracy*), military disputes between the two countries (*MID*), and the historical colonial relationship (*Colony*), this study also controls for them. Furthermore, based on literature on the impact of GATT and WTO on trade, I include a *GATT/WTO* variable that is binary.[47] I also control for having a common official language (*Language*) and preferential trade agreements (*PTA*), as well as for membership in the European Union (*EU*). As real exchange rates have been found to be important in the gravity model,[48] I also control for the real exchange rates for both exporters and importers (*Log Exporter Exchange Rate* and *Log Importer Exchange Rate*).

In order to control for the automobile industry's specific trends, it would be ideal to include passenger car production numbers. I expect

[45] It is a common practice to have the GDP per capita and GDP in product form, and it accords with theories of international trade.

[46] I include defense pact and entente as the existence of alliance.

[47] There is a debate whether GATT/WTO membership increases trade or not. For example, Rose 2004 finds that GATT/WTO has no effect on trade. Goldstein, Rivers, and Tomz 2007, by contrast, argue that the GATT/WTO increases trade "for countries with institutional standing." Subramanian and Wei 2007 find that the impact of GATT/WTO on trade is uneven and depends on "*what* the country does with its membership, with *whom* it negotiates, and *which products* the negotiation covers."

[48] Soloaga and Winters 2001; Martinez-Zarzoso and Nowak-Lehmann 2003. A country's real exchange rate is defined as the local currency value of $US 1 multiplied by the US GDP deflator divided by the country's GDP deflator.

that the more cars a country produces, the more likely it is that it exports cars; thus, such a country would have higher trade values. However, as there is lack of data regarding passenger car production in developing countries, my model would be biased toward developed countries if I included this variable. This is especially problematic in trying to understand the mechanism for different income levels. Since the main results, on average, do not change when I run tests with a limited data set, I do not include this variable in my model. It would also be ideal to include sectoral level employment, foreign direct investment, and/or comparative advantage variables, but such data for the automobile industry are not available on a comprehensive basis.

I estimate bilateral exports of automobiles using a standard model in the following form:

$$\ln Export_{ijt} = \beta_0 + \gamma_1 Std_{it} + \gamma_2 Std_{jt} + \gamma_3 Both_{ijt} + \gamma_4 \ln(Std_j) + \beta_1 \ln Dist_{ij} + \beta_2 \ln(GDP_{it} \times GDP_{jt}) + \beta_3 \ln(GDP_{it}/Pop_{it} \times GDP_{jt}/Pop_{jt}) + \beta_4 Contiguity_{ijt} + \beta_5 Alliance_{ijt} + \beta_6 Democracy_{ijt} + \beta_7 Autocracy_{ijt} + \beta_7 MID_{ijt} + \beta_8 Colony_{ij} + \beta_9 GATT_{ijt} + \beta_{10} Language_{ijt} + \beta_{11} PTA_{ijt} + \beta_{12} EU_{ijt} + \beta_{13} \ln(Exchange_{it}) + \beta_{14} \ln(Exchange_{jt}) + \sum_t \phi_t T_t + \sum_t \delta_t C_t + \varepsilon_{ijt}$$

where i and j denote exporter and importer, respectively; t denotes time; β, ϕ, and δ are vectors of coefficients; T_t is a dummy variable for each year t; and C_i is a dummy variable for each exporting country i. This model, therefore, includes year-specific and country-specific "fixed" effects. The parameters of interest are γ_1, γ_2, γ_3, and γ_4.

Findings

I test the two additional hypotheses using the gravity model of trade. I estimate the model using ordinary least squares (OLS), computing robust standard errors clustering by country dyads. I include fixed effects for years and exporting countries in order to control for time-specific and country-specific patterns.[49] I show benchmark regression results in Table 2. My base specification including all countries (labeled "Base") is at the very left of the table. This model works well, and it conveys the usual features of a gravity model. These traditional gravity effects are all highly statistically significant, as was estimated from the literature. Overall, the gravity model appears to perform consistently in explaining the variations in bilateral automobile exports.

[49] Beck, Katz, and Tucker 1998.

TABLE 2
AUTOMOBILE EXPORTS TRADE VALUES

	Base	*EU*	*Non-EU*	*Developing Countries*
Exporter Standards	0.121*	0.360*	0.122*	0.587***
	(0.063)	(0.195)	(0.066)	(0.167)
Importer Standards	−0.738***	−0.206	−0.768***	−0.377***
	(0.094)	(0.188)	(0.100)	(0.126)
Both Standards	1.422***	0.894***	1.490***	0.400
	(0.107)	(0.280)	(0.120)	(0.264)
Log Number of Standards	−0.248***	−0.173	−0.219***	0.623***
	(0.041)	(0.131)	(0.043)	(0.111)
Log Distance	−0.734***	−0.872***	−0.746***	−0.379***
	(0.043)	(0.140)	(0.045)	(0.074)
Log Product Real GDP p/c	0.460***	0.297	0.465***	0.189***
	(0.032)	(0.219)	(0.032)	(0.057)
Log Product Real GDP	0.366***	0.931***	0.352***	0.210***
	(0.018)	(0.069)	(0.018)	(0.032)
Contiguity	0.991***	0.287	0.961***	1.085***
	(0.133)	(0.194)	(0.151)	(0.214)
Alliance	0.566***	0.240	0.400***	0.894***
	(0.099)	(0.164)	(0.118)	(0.213)
Joint Democracy	0.054	2.519***	0.026	−0.106
	(0.058)	(0.324)	(0.058)	(0.111)
Joint Autocracy	0.427***		0.450***	0.863***
	(0.146)		(0.146)	(0.182)
MID	−1.073***		−1.067***	−0.874
	(0.340)		(0.339)	(0.536)
Colony	0.699***	0.704	0.757***	0.904***
	(0.134)	(0.525)	(0.135)	(0.291)
GATT/WTO	0.359***	−0.480	0.378***	0.253**
	(0.069)	(0.352)	(0.070)	(0.126)
Language	0.440***	1.688***	0.439***	0.120
	(0.085)	(0.536)	(0.087)	(0.169)
PTA	0.258***	−0.055	0.269***	0.056
	(0.077)	(0.218)	(0.084)	(0.108)
EU	0.651***			2.320***
	(0.134)			(0.535)
Log Exporter Exchange Rate	0.784***	1.493***	0.801***	−0.255*
	(0.083)	(0.370)	(0.085)	(0.135)
Log Importer Exchange Rate	−0.027**	0.025	−0.029**	0.030
	(0.011)	(0.035)	(0.011)	(0.021)
R^2	0.73	0.81	0.72	0.67
N	47322	3225	44097	8806

***p < 0.01, **p < 0.05, *p < 0.1; regressand: log real trade value of automobile exports; OLS with year and country dummies (intercepts, year, and country dummies not listed); robust standard errors in parentheses, clustered by country-dyads

To analyze the Competitive Advantage of Standards Adoption hypothesis, I performed a Wald test of the hypothesis that the coefficients of the exporter's adoption of emission standards (*Exporter Standards*) and the adoption by both (*Exporter Standards* + *Importer Standards* + *Both Standards*) are identical. The test result yields an F-value of 101.17, thereby strongly rejecting the possibility that the coefficients are identical and supporting the Competitive Advantage hypothesis. Also supporting the Competitive Advantage hypothesis are the results that an exporter alone having standards leads to an insignificant increase in exports and that an importer alone having standards leads to a significant decrease. These results make it clear that it is beneficial for an exporter to adopt emission standards only when an importer has also adopted them. This base model suggests that on average both an exporter and an importer adopting standards will produce a 120 percent increase (since $e^{-0.658+1.465} -1 \approx 1.24$) in dyadic automobile exports, compared with only an exporter having standards.

My findings also support the hypothesis fully that the gain in exports that accrues when both countries have adopted emission standards erodes as more countries adopt such standards. The base model in Table 2 shows that an increase in the number of countries adopting standards has a significant effect on automobile exports. As I had hypothesized, automobile exports decrease as more countries adopt emission standards.

The rest of Table 2 contains a set of robustness checks. The second column includes only EU dyads. The third column includes only non-EU dyads. Finally, I analyze the developing countries separately.[50] The key results—an exporter's adoption of standards is associated with an economically and statistically significant increase in exports when importers have adopted standards—are robust in the EU and non-EU models, although they are insignificant in the model that contains only developing countries.[51] The result for developing countries appears to counter my hypothesis and merits further exploration, which I provide later in this section.

The other hypothesis, that an increase in the number of countries with emission standards is associated with a decrease in exports, has mixed results. The results support my hypothesis only in the non-EU model and they are not statistically significant for the EU model. In

[50] I include those countries that belong to upper-middle-income and lower-middle-income categories in the World Bank Group category (see fn. 7).

[51] The F-values for the Wald tests are 10.26, 79.97, 0.05 for EU, non-EU, and developing country dyads, respectively.

the model that includes only developing countries, the result is positive and significant. This is probably because the exports of the countries with newly adopted standards have to compete more with domestic producers in the importing country than with other exporting countries, especially if the newly adopted countries are developing countries while the importing partner is a developed country. It is also possible that the stringency of emission standards matters. In this article I examine the impact of the initial adoption of the first comprehensive emission standards, or higher, as it is the first major technological leap in emissions regulation. However, many countries have continued to increase the stringency of emission standards after the initial adoption, thus creating separate markets based on different regulation levels.

In order to disentangle the impact of the income levels and automobile exports, I run a model for three different income levels: high, upper-middle, and lower-middle, based on the World Bank categories.[52] The result is shown in Table 3. For all categories, the adoption of emission standards, ceteris paribus, is related to an increase in automobile exports. Furthermore, the Wald test results demonstrate that for high-income- and upper-middle-income countries, adopting emission standards is related to a further increase in automobile exports when importers have also adopted them, holding everything else constant.

However, that is not the case for lower-middle-income countries. For them, adopting the standards alone, ceteris paribus, is related to a statistically significant increase in automobile exports, but the coefficients of the adoption of both an importer and an exporter are not significantly different statistically from those of only the exporter's adoption. This may suggest that the reason lower-middle-income countries gain from adopting standards is different from the reason higher-income countries gain. These countries may gain by being able to signal to other developing countries that they have the capacity to produce automobiles with catalytic converters.

The results in Table 3 further suggest that the number of countries that adopt standards has a negative impact on automobile exports only for high-income countries. For all other countries, there is again a positive impact—a finding that does not support my hypothesis. This may be because some of the developing countries can gain comparative advantage under higher competition by using their low labor costs, among other things. It is also possible that some of the developing countries still export only to those that do not require emission standards.

[52] See fn. 7.

Table 3
Automobile Exports Trade Values by Income Levels

	High	*Upper-Middle*	*Lower-Middle*
Exporter Standards	0.332***	0.202	2.366***
	(0.074)	(0.200)	(0.370)
Importer Standards	−0.658***	−0.554***	−0.173
	(0.164)	(0.176)	(0.168)
Both Standards	1.292***	0.715**	−0.116
	(0.162)	(0.286)	(0.644)
Log Number of Standards	−0.602***	0.509***	0.947***
	(0.054)	(0.159)	(0.209)
Log Distance	−0.784***	−0.449***	−0.242***
	(0.056)	(0.104)	(0.088)
Log Product Real GDP p/c	0.495***	0.202**	0.232***
	(0.039)	(0.092)	(0.067)
Log Product Real GDP	0.403***	0.281***	0.099***
	(0.022)	(0.049)	(0.038)
Contiguity	1.201***	1.417***	0.700***
	(0.213)	(0.322)	(0.211)
Alliance	0.634***	1.294***	0.112
	(0.129)	(0.263)	(0.239)
Joint Democracy	0.039	−0.325**	0.091
	(0.068)	(0.149)	(0.160)
Joint Autocracy	0.039	0.758	0.993***
	(0.231)	(0.677)	(0.187)
MID	−0.961**	0.003	−1.064*
	(0.445)	(0.742)	(0.563)
Colony	0.675***	0.888**	0.713**
	(0.174)	(0.383)	(0.353)
GATT/WTO	0.480***	0.201	0.121
	(0.082)	(0.200)	(0.156)
Language	0.454***	0.534**	−0.160
	(0.122)	(0.261)	(0.170)
PTA	0.209*	−0.041	0.290**
	(0.116)	(0.149)	(0.147)
EU	0.415***	2.300***	
	(0.153)	(0.588)	
Log Exporter Exchange Rate	−0.049	−0.249	0.084
	(0.130)	(0.165)	(0.083)
Log Importer Exchange Rate	−0.052***	−0.004	0.053**
	(0.013)	(0.035)	(0.027)
R^2	0.72	0.59	0.71
N	35194	4817	3989

***p < 0.01, **p < 0.05, *p < 0.1; regressand: log real trade value of automobile exports; OLS with year and country dummies (intercepts, year, and country dummies not listed); robust standard errors in parentheses, clustered by country-dyads

An increase in the number of countries with standards may, therefore, lead to higher exports for these countries.

Conclusion

Contrary to the conventional wisdom that developing countries lack environmental management, I find that many countries have adopted automobile emission standards to stay competitive in the international market, even without any international agreement to do so. Event history analysis supports the hypothesis that the global diffusion of automobile emission standards is driven by both direct and indirect export pressures.

Scholars and policymakers find competitiveness to be an important factor for trade in the global economy, and this partially explains the current increase in the study of policy diffusion. The recent policy diffusion literature, however, has concentrated mainly on economic policies, and even when environmental policies were studied, they lacked data, especially for developing countries. Therefore, past research focusing on the diffusion of automobile emission standards did not and could not go beyond explaining the mechanism qualitatively to estimate the impact of policy adoption on automobile exports. The result in this article, using the novel data of countries' initial adoption year of comprehensive automobile emission standards, suggests that the past studies are not sufficient for understanding why governments decide to adopt environmental standards from other developed countries even when there is no requirement that they do so.

Within the competitive pressure mechanism, I suggest two mechanisms—one directly from countries' importers (direct export pressure) and the other from their economic competitors (indirect export pressure). The former originates directly from the countries' export markets, whereas the latter is from their competitor firms for the same market. Because of those two types of pressure, firms acquire technologies in order to continue exporting in the case of the former and to be competitive in the international market in the case of latter. Both mechanisms suggest that countries adopt standards when firms that have acquired the technologies lobby the government so as not to be disadvantaged in the local market. Because automobile manufacturers without technologies tend to pursue higher profits by producing cheaper, low-quality cars, it is important for governments to intervene to adopt emission standards.

As expected from these competitive mechanisms, all countries that have adopted comprehensive automobile emission standards indeed export automobiles, unless they are EU members. The relationship between the direct export pressure for standards' adoption and policy diffusion is empirically strong and proves the findings of the past qualitative research focused on the diffusion of emission standards among the rich countries.

Next, I tested whether the adoption of emission standards leads to more automobile exports. Based on the understanding that it should affect only countries' exports, I used the gravity model of trade to analyze the impact of the adoption of standards on a country's automobile exports, differentiating between when the importer does and does not have standards. For high-income and upper-middle-income countries, the increase in automobile exports is higher, ceteris paribus, when the importer has also adopted standards than when only the exporter has adopted them. Interestingly, my research further suggests that adoption by lower-middle-income countries—regardless of the importers' adoption status—leads to their competitive *advantage*, rather than *disadvantage*, in exporting automobiles. The adoption of these stringent environmental standards indeed helps these developing countries that have adopted them to increase their automobile exports.

There has been a recent debate whether there is a race to the top or to the bottom of environmental regulation, especially in developing countries. The results here highlight that governments adopt emission standards from rich countries, creating the race to the top. It is striking that even developing countries are following the path of the developed countries and that they are also increasing their automobile exports. The evidence shows that when developed countries adopt standards, developing countries systematically consider the intervention in order to ensure that firms exporting vehicles with technologies are not disadvantaged in the local market. Furthermore, all the results are consistent in that both competitive pressure mechanisms—direct and indirect export pressure—are important.

Such findings have important policy implications. For some environmental regulations, such as automobile emission standards, I find that globalization and increased interdependence create conditions that support the policy diffusion of stringent emission standards. The results illustrate that the divide between countries with and without standards actually provides an incentive for the latter to adopt tighter emission standards. From this perspective, further tightening of environmental standards may be considered a successful path to better managing environmental problems globally. As long as they are product standards that can work as nontariff barriers and are technology driven, such tightening of regulations could be diffused through the competitive pressure mechanism, causing a race to the top. Further research into the diffusion of domestic environmental standards should lead to a better understanding of how to promote global environmental management.

Appendix

Table A1
Descriptive Statistics of Independent Variables for Standards Adoption[a]

Variable	*Mean*	*Std. Dev.*	*Minimum*	*Maximum*
Emission Standards Share	0.115	0.250	0	1
Auto Exports Status	0.232	1.44	0	18.4
International Aid	0.981	2.33	−0.795	36.8
Standards	16.2	13.3	2	40
Environmental IGO Membership	16.6	5.04	0	36
CO_2 Emissions	14.2	28.6	0.1	260
Log Real GDP per Capita	8.39	1.05	5.85	10.9
EU Membership	0.0907	0.287	0	1
Auto Exports Share of GDP	0.0724	0.306	0	3.79

[a] This is the descriptive statistics of 2096 observations for 1-year lagged variables.

Table A2
Descriptive Statistics of Independent Variables for Gravity Model[a]

Variable	*Mean*	*Std. Dev.*	*Data Source*	*Description*
Log Dyadic Auto Exports	12.1	4.53	(1)	log of the auto exports trade value
Exporter Standards	0.468	0.499	(2)	dummy = 1 if exporter has standards
Importer Standards	0.207	0.405	(2)	dummy = 1 if importer has standards
Both Standards	0.104	0.305	(2)	dummy = 1 if both have standards
Log Number of Standards	2.85	0.930	(2)	log of the cumulative number of countries with standards
Log Distance	8.36	0.948	(3)	log of the geographical distance between capitals (km)
Contiguity	0.0605	0.238	(3)	dummy = 1 if countries share a border
Log Product Real GDP p/c	18.0	1.46	(4)	log of the product of real GDP per capita
Log Product Real GDP	51.3	2.44	(4)	log of the product of real GDP
Alliance	0.142	0.349	(3)	dummy = 1 if there is an alliance

TABLE A2 *cont.*

Variable	*Mean*	*Std. Dev.*	*Data Source*	*Description*
Joint Democracy	0.435	0.496	(3)	dummy = 1 if both countries score higher than six in the Polity IV[b] democracy levels in a year
Joint Autocracy	0.0369	0.189	(3)	dummy = 1 if both countries score higher than six in the Polity IV autocracy levels in a year
MID	0.002	0.0448	(3)	dummy = 1 if there is an ongoing MID at the beginning of a year
Colony	0.0607	0.239	(5)	dummy = 1 if a country was ever in a colonial relationship with the other
GATT/WTO	0.284	0.451	(6)	dummy = 1 if both countries are members of GATT/WTO
Language	0.187	0.390	(5)	dummy = 1 if both countries share a common official language
PTA	0.212	0.409	(7)	dummy = 1 if an exporting country has a preferential trade agreement with the importer
EU members	0.0681	0.252	(8)	dummy = 1 if both countries are EU members
Log Exporter Exchange Rate	2.59	2.19	(9)	log of the real exchange rate by exporters
Log Importer Exchange Rate	2.83	2.27	(9)	log of the real exchange rate by importers

DATA SOURCES: (1) United Nations Commodity Trade Statistics Database (UN Comtrade) 2010; (2) author's database found at www.mit.edu/~esaikawa/database.html; (3) Bennett and Stam 2000; (4) Gleditsch 2002; (5) CEPII, Distances Database; (6) World Trade Organization 2012a; (7) updated from Goldstein, Rivers, and Tomz 2007; (8) EUROPA; (9) International Financial Statistics (IFS) 2012.

[a] This is the descriptive statistics of 56136 observations of all variables.

[b] For details, please refer to Polity IV Project: Political Regime Characteristics and Transitions, 1800–2007. At http://www.systemicpeace.org/polity/polity4.htm.

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