Centro UC
CLAPES UC
Centro Latinoamericano de Políticas Económicas y Sociales

Assessing ‘not in my backyard’ environmental policies: Is carbon leakage worse than we thought?

Johann Caro-Burnett
Luis E. Gonzales C.

www.clapesuc.cl

Documento de Trabajo Nº 85 (septiembre 2020)

Assessing ‘not in my backyard’ environmental policies: Is carbon leakage worse than we thought?*

Johann Caro-Burnett† Luis E. Gonzales-Carrasco ‡

September 2, 2020

Abstract

In the last few decades, high-income and high-productivity countries have pushed their agenda towards environmentally friendly policies. The carbon leakage hypothesis predicts that these policies will increase the emissions in unregulated countries, which happen to be low-income and low-productivity nations. Using a panel at the country level, we show that, because of the productivity differential, heterogeneous regulations have increased net global emissions. These results are a call for international coordination and cooperation in order to achieve a sustainable global economy.

Keywords: Climate Laws; Global Warming; Greenhouse Gas Emissions; SDGs

*We thank Joana Setzer and Arnaud Koehl for valuable input and clarifications on the Climate Change Laws of the World. We also thank participants at the 2020 Bolivian Conference on Development Economics. All errors are ours.

†Hiroshima University and NERPS. johanncb@hiroshima-u.ac.jp.

‡CLAPES UC and Pontificia Universidad Católica de Chile. lwgonzal@uc.cl

1 Introduction

The anticipated effects of climate change range from a threat to our standards of living to total catastrophe. In recent years, national leaders from the large majority of countries have had conversations and signed regional and global agreements to reduce greenhouse gas emissions. The two most notorious examples of such agreements are the Kyoto Protocol (in 1997) and the Paris Agreement (in 2015), which had a worldwide positive effect on the amount of regulations on emissions.

Between 2009 and 2019, at least 1524 laws have been passed, among all countries, either mitigating or adapting to climate change (Eskander et al., 2020).[1] On the other hand, countries have different levels of commitment to climate change (Mehling et al., 2018). For example, in that same period of time, the 36 richest countries have passed an average of 8.63 climate change laws by country, while the 37 poorest countries have passed an average of 5.59.[2]

The carbon leakage theory predicts that heterogeneity of regulations will cause higher emissions in less-regulated countries. What is worse, typically, the developing and low productivity countries are the ones who cannot afford to regulate their emissions.[3] Thus, one would expect that higher productivity is usually positively associated with more stringent regulations. Indeed, going back to the previous example, the average total factor productivity among the 36 richest countries in the last 10 years is three times higher than that of the 37 poorest countries.[4]

In this study, we analyze the effects that heterogeneous regulations have on global emissions. More specifically, we argue that (due to carbon leakage) 'not in my backyard' policies have not only increased the greenhouse gas emissions in unregulated countries, but because of the productivity gap, they have

[1]See figure 4 for an example of the distribution of those laws.
[2]This is, without considering the effectiveness of each country's policies; which would indeed compound the issue.
[3]For example, see the discussion on fairness such as Raworth (2007) and Baer (2002).
[4]See figure 1.

actually increased net global emissions. The rationale behind this hypothesis is very simple: due to lower productivity, unregulated countries need to use more inputs, and thus more energy, in order to supply the regulated-country's demand for products.

For our estimations, we use fuel emissions data from the International Energy Agency (IEA) and climate laws data from the Grantham Research Institute on Climate Change and the Environment (LSE/GRICCE), to construct a country-level panel from 1971 to 2016. In addition, we use covariates, such as GDP, population, capital, measures for trade and measures for productivity from the Penn World Tables (PWT).

Our contribution to the literature can be listed in three main categories: (*i*) We take a quantitative approach to the study of the LSE/GRICCE's data on climate laws; (*ii*) estimate the effectiveness of climate policy-making on a global scale; and finally, (*iii*) attempt to measure the net global effects that carbon leakage has on emissions, and consequently on global pollution. Moreover, to the best of our knowledge, this is the first study to do any of the three mentioned categories.[5]

Our results show that, the effectiveness of climate laws within the country of origin (the country passing the law) seem to work better among high-income countries. Thus, regulations do not work uniformly across all types of countries. Moreover, when we repeat the exercise to study the effect of foreign climate laws on countries' emissions, we show that regulations in high income countries actually accelerate global emissions. Finally, by comparing the predicted emissions of our estimated panel under the observed laws and myopically coordinated laws, we estimate the additional emissions (or the abatement loss) that came from the lack of coordination.

The policy implications of our findings contribute to the efforts on linking nations' climate policy.

[5] Eskander et al. (2020) have descriptive statistics and qualitative analysis using the climate laws data-set. The direct but isolated economic effects of some climate laws have been studied see for example Andersson (2019); Metcalf and Stock (2020). Finally, the carbon leakage literature has mainly focused on regional effects (such as the EU or the US). See the discussion in next section.

Namely, our results are a call for international coordination and cooperation in order to achieve a sustainable global economy. Ideally, high income countries should provide appropriate incentives to low income countries to reduce their emissions too. Since nowadays negative externalities have great international consequences, we believe that it is time to think more about a global economy.

The remaining of this paper is organized as follows: in section 2, we discuss previous studies that inspired our work, present our hypothesis, and discuss our estimation strategy. In section 3, we summarize the data sets used in this study. In section 4, we present the results from the econometric estimation, and in section 5 we propose an example to measure the cost of the lack of coordination in terms for emissions. Finally, we conclude in section 6.

2 Theoretical Motivation

Related Literature

Our study is motivated by theoretical and empirical studies from the *carbon leakage* literature, as well as more general subjects such as energy, environment, economics, law, and economic integration under the carbon pricing linkage. Carbon leakage can be roughly defined as the displacement of CO2eq emissions from regulated nations towards non-regulated nations. The leakage could vary in magnitude, depending on the sector and the scope of the policy (Baylis et al., 2013). After the two mayor agreements in climate change policy, the Kyoto Protocol in 1997 and (to a lesser extent) the Paris agreement in 2015, some countries implemented binding and non-binding constrains to CO2eq emissions. However, the market effects have lead to offsetting emission increases in the countries without active regulations.

Following Wald (2015) the carbon leakage literature is divided in two large branches: (*i*) the theoretical ex-ante approach, that compares different scenarios against a synthetic counterfactual context where the simulated policy generate economic impacts; and, (*ii*) the ex-post approach, which uses historical data of emissions and production to identify the changes of patterns in emissions.

Two of the most notorious theoretical studies are Bohom (1993) and Copeland and Taylor (1995). They study how unilateral regulations reduce fuel usage, causing a downturn in world-market fuel prices, and thus increasing the consumption of fuels elsewhere. Those theories were later complemented with simulations, by several computable general equilibrium (CGE) models. These CGE simulations have consistently found positive leakage effects at the national or sub national level.[6]

The empirical literature on carbon leakage focused on regional effects. There are several studies on the environmental policies implemented by the EU, and their effects on their members. For instance, Barker et al. (2007) conclude that after the introduction of carbon taxes in six European members there is small or no evidence on leakages around its industries.[7] On the other hand, there are fewer studies on the US economy. One of the most recent ones is Fowlie et al. (2016), who asses the implications of alternative policies imposing constrains to CO2eq emission in the cement industry, to show that regulations exacerbated the market power in the industry, and that carbon leakage of traded goods

[6]Fullerton et al. (2011) and Babiker (2005) uses both multisector and commodities approach in a global set, with no explicit price of CO2eq estimation. Evidence using a range of carbon prices, multi sector breakdown, and considering Kyoto's Annex I countries and non-Annex I, can be found in Burniaux and Martins (2000), Caron (2012), Carbone (2013), Gerlagh and Kuik (2007), Lanzi et al. (2013), Monjon and Quirion (2009) and Kuik (2009) including mineral sector analysis. Paroussos et al. (2015), Kuik and Hofkes (2010), Baylis et al. (2013), Gerlagh and Kuik (2014), Rocco et al. (2020) and Zhang et al. (2020) present long term simulation forecasting considering the irruption of China as a main player in the emissions composition.

[7]Some other examples study the three phases of implementation of the European Trade System (EU-ETS) in the European Union between 2005 and 2020, which were analyzed separately and jointly in the literature with not significant evidence. For example, Cummins (2013) focus just on the phase II (2008-2012) of the EU-ETS in a panel regression, and finds no evidence of leakage. In the same line, Abrell et al. (2011) and Chan et al. (2013) consider phases I and II, and focus on specific sectors such as energy, cement, iron, and steel; they find no evidence of leakage. More recently Verde (2020) summarized the literature, emphasising on the empirical approach, and the general consensus seems to be that there is no evidence of leakage inside EU-ETS.

offsets local reductions.

In addition, our study is related to the Environmental Kuznet Curve (EKC), which addresses the challenges to measure and analyze the relationship between economic development and environmental quality.[8] The EKC proposes an inverse U-shape of emissions as a function of economic development. This relates to our study because it shows how once a country has reached certain threshold, it cares about the environment and can afford to abate. On the other hand, developing countries cannot afford to reduce emissions.[9] Furthermore, following Cohen et al. (2018), a major environmental attention is associated with higher levels of development. There is a growing evidence showing that the reductions of pollutants is associated with higher levels of development (Uchiyama, 2016) and more recently (Özcan and Öztürk, 2019). Overall, it is known that high-income countries tend to introduce both pricing and 'command and control' regulations to mitigate environmental problems.

Hypothesis

To summarize the literature, the carbon leakage hypothesis predicts a non-zero leakage with possible positive net effects on global scales; while its empirical evidence has mixed results focusing only on specific regions (as opposed to the globe). Moreover, the EKC predicts that countries with a high level of development will usually be the ones to regulate their emissions.

Our hypothesis is that the net global effect of carbon leakage is indeed positive. The reason is a combination of two aspects that we believe are widely accepted: (*i*) countries that typically regulate happen to also have higher productivity, and, (*ii*) countries with lower productivity need more inputs for production. Combining those two propositions, it follows that the observed higher levels of reg-

[8] To date, the EKC approach was tested in different contexts, such as global pollutants (like CO2eq) and local pollutants, like sulfur dioxide, nitrogen oxide, carbon monoxide, suspended particulate matter (PM).

[9] This point also relates to the topic of fairness; namely, who should abate? Some attempts to address this topic are Morrow (2017); Rodríguez-Fernández et al. (2020); Shue (1995), to cite a few.

ulation in productive countries has outsourced the production of emitting goods to less productive countries. Those less productive countries, in turn, ended up using even more fossil fuels; and, thus, increasing net global emissions.[10]

Thus, from our hypothesis, one would expect to find the following empirical results: (i) although climate laws from developed countries may have a negative effect on their own emissions, (ii) those laws will actually have a positive effect on net global emissions, or equivalently, a positive effect on the emissions of the average country.

Indeed, there are several studies supporting (theoretically) the international linkage of climate laws. For example, Mehling et al. (2018) states that, although targets are not binding, the Paris agreement has achieved a key condition for success: setting a precedent of cooperation. Then, they proceeds to analyze and propose possible ways to implement regulations that are linked across nations.[11]

Estimation Strategy

We model emissions as a function of a country's own laws and foreign laws. We construct a panel at the country level, with data on emissions, laws, and macroeconomic variables. We use country and time fixed effects, to capture country specifics (culture, institutions, neighborhood, etc) and time specifics (time trends and fluctuations). In order to measure the effect that foreign laws have on each country, we want to distinguish whether the foreign law came from a wealthy country or not. Thus, we classify the laws in four groups according to GDP per capita quartiles. Finally, we estimate our model using linear regressions.

[10]In other words, one can see the marginal cost of abatement as the 'cost of opportunity' from reducing the production of emitting goods. This cost of opportunity is directly related to productivity: the loss from not producing is high if productivity is high.

[11]Other examples are Agostini et al. (1992); Parry et al. (2016); Chan et al. (2018); Schmalensee and Stavins (2019); Aldy and Stavins (2020); Nordhaus (2015).

Although we agree that the approval of a climate law is not a random event, we are skeptical to believe this fact severely affects our results. First of all, it is not clear that climate laws depends on a country's emissions. The political economy literature has shown us that politicians mostly react to their prospects of power (see for example Downs (1957); Mayhew (1974)), and this holds true regarding climate laws (Downton and Pielke Jr, 2001). One possible counter-argument could be that due to the recent notorious changes in climate, the younger generations are pushing their governments to address this issue. However, our usage of time fixed-effects captures the mentioned changes in the trend.[12] Second, and more importantly, we focus on how foreign laws affect a country's own emissions. Thus, it is difficult to believe any arguments implying that regulations from one country depend on the emissions of another country.

3 Data

We use three data sets: climate laws from the LSE/GRICCE, emissions from the IEA, and macroeconomic variables from PWT. Since our variables come from three different sources, there are mismatches regarding the availability on some countries. We describe the size of our sample in detail below.

3.1 Climate Laws

We use the Climate Change Laws of the World (CCLW) data set from the LSE/GRICCE. There is data from 199 countries from 1947 to 2020, listing all laws on emissions on each of those countries.[13]

[12] Another counter-argument could be that the Kyoto protocol is an example of governments passing laws based on emissions. However, even if we include a dummy variable to capture Kyoto protocol countries in the relevant periods, our results remain.

[13] The data-set is meant to be comprehensive; thus, any missing laws should be very exceptional cases. There is an additional region labeled EU. For those laws, we added each of them to the respective EU countries taking into account the year they joined the organization.

Laws are categorized by type of framework or type of response. We defined a law as having some degree of mitigation if either the framework or the response have the word 'mitigation.' For our purpose, we consider either all regulations, which we will refer as *laws*, and the laws that are not exclusively meant to adapt to damages, which we will refer as *mitigation laws.*

Thus, our main variable $laws_{i,t}$ will be the sum of all approved laws by country i on year t. Alternatively, our results are robust to mitigation laws (as defined above), and dummy variables for having any law, or a dummy variable for having any mitigation. Similarly, we want to define a measure for foreign laws.[14] In addition, we want to explicitly make a distinction of foreign laws by different income groups of countries. To do so, we divided the list of countries of each year t in four groups $G(t) \in \{1, 2, 3, 4\}$, which we achieved by using income data as described in section 3.3.[15] The variable $ext.laws_{i,t,G(t)}$ represents the laws from all countries in group $G(t)$ that are foreign to country i. More precisely, let $I_{i,G(t)}$ be the indicator function for the event 'country i belongs to group $G(t)$.' Then, $ext.laws_{i,t,G(t)} = -I_{i,G(t)} laws_{i,t} + \sum_{j \in G(t)} laws_{j,t}$.

Table 1: Climate Change Laws of the World

Variable	Obs	Mean	Std. Dev.	Min	Max
All laws	3868				
Mitigation laws	732				
Laws/year		87.85	57.23	28	175
Miti. Laws/year		23.95	24.51	0	68
Laws/country		59.46	36.88	1	112
Miti. Laws/country		9.03	5.85	0	22
Year				1947	2019

CCLW data-set from the LSE/GRICCE. A law is defined as mitigation if either the type of *framework* or the type of *response* of the law have the word *mitigation*.

[14] The results are available upon request.
[15] Countries change income classification over time.

3.2 Emissions

We use fuel emissions data from the IEA. The sample includes 145 countries from 1971 to 2017, and emissions are measured in million metric tons. Thus, we define $emissions_{i,t}$ as country i's own fuel emissions in year t.

Table 2: CO2 emissions from fuel in million metric tons

Variable	Obs	Mean	Std. Dev.	Min	Max
National Emissions	6113	166.96	636.25	0.06	9257.93
Growth Rate		3.33%	0.13	-77.03%	377.38%
World Emissions		21715.77	5482.87	13333.23	31461.51
World Growth Rate		1.90%	0.02	-1.27%	5.95%
Year				1971	2017

Emissions data from the IEA. Most of the observations for the growth rate are between -10% and 20%. See the histogram on figure 5.

3.3 Covariates

Our most relevant covariate is productivity. We use PWT's total factor productivity (TFP) as a measure of productivity. To define the productivity of a country, we want a measure of TFP that is standardized by the purchasing power parity (PPP), but, at the same time, captures the TFP's growth over time. In order to do so, we use the PPP adjusted TFP (variable name: $CTFP$), which is normalized at USA=1 (in all years). Then, we re-normalize it to real USA's TFP to adjust for productivity growth (variable name: $RTFPNA$). Thus, our measure of country i's productivity on year t is $TFP_{i,t} = CTFP_{i,t} \times RTFPNA_{USA,t}$.[16]

The remaining covariates for country i in period t are GDP per capita $gdp.pc_{i,t}$, stock of capital

[16] Alternatively, we also used GDP per worker as a measure of productivity. Our results remain robust to this modification. The results are available upon request.

per capita $cap.pc_{i,t}$, population $pop_{i,t}$, and exports $csh.e_{i,t}$ and imports $csh.m_{i,t}$ of goods, both as a fraction of GDP. All these variables are also from the PWT. In addition, we also use want PWT's gdp to classify countries by income rank. For each year t, we divided the list of countries in four income categories of about the same size: *High Income*, *Medium-High Income*, *Medium-Low Income*, and *Low Income*.[17]

Table 3: Productivity and Others

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP	9985	269192.80	1070178	19.78	18400000
Population	9985	30.74	114.57	0.00	1409.52
Capital	9959	908.76	3976.40	0.01	106000
RTFPNA	6006	0.99	0.35	0.23	7.11
CTFP	6006	0.71	0.29	0.02	3.61
TFP	6006	0.62	0.25	0.02	2.84
GDP/Labor Force	8841	29436.33	45683.89	485.81	1343052
Exports/GDP	9985	0.23	0.26	-1.50	3.06
Imports/GDP	9985	-0.31	0.68	-26.74	23.16
Year				1950	2017

Data from the PWT. GDP is expressed in real 2011 million USD, at chained PPP, and capital stock is measured in real 2011 billion USD, at chained PPP.

3.4 Policy Effectiveness

Since institutions affect the impact or effectiveness of a law, one should not expect to believe that that laws from different countries have the same impact. As a robustness check, we adjust the impact of laws by measures of policy effectiveness. We use two measures for this purpose. The first one is

[17]There is a mismatch between countries with emissions data and GDP data in the sample. Thus, simply using percentiles would end up in very heterogeneous sized groups. In order to solve this issue we: (i) divide countries with existing GDP data in 5 quintiles. Groups 1 to 3 remain untouched. Groups 4, 5 and the remaining mismatched countries, are all collapsed as the 4th group. This is not perfect, but it's a reasonable approximation, since most countries that mismatch are usually small and low income economies. In addition, we also used Human Development Index (HDI) to classify countries into four groups as a robustness check. However, the HDI index only starts from 1990, and there are also mismatched countries. Nevertheless, our results remain robust when using the HDI index. The results are available upon request.

Kaufmann's Government Effectiveness Estimate (GEE).[18] There are two drawbacks of this measure: (*i*) the sample only starts in 1996 and even after that some years are missing; and (*ii*) the measure captures all government policies, which includes a large range of industries. In addition, using all data described in the previous sections, we created our own Climate Law Effectiveness (CLE) index. The methodology is explained in appendix B. The advantages of this index are that the sample obviously matches our sample, and that it is specific to climate laws. The disadvantages from both indexes is that the unit of measure is subjective and does not have a clear interpretation.[19]

Table 4: Policy Effectiveness

Variable	Obs	Mean	Std. Dev.	Min	Max
GEE	9408	-0.06	0.97	-2.48	2.44
CLE		0.04	1.00	-4.59	2.76

Both indexes were normalized to have a SD of 1. However, there are a few mismatches between Kaufmann's GEE, that is why the measured SD slightly differs from 1. In addition, our CLE was constructed from the existing data. Thus, all observations are available.

4 Results

4.1 Basic Results

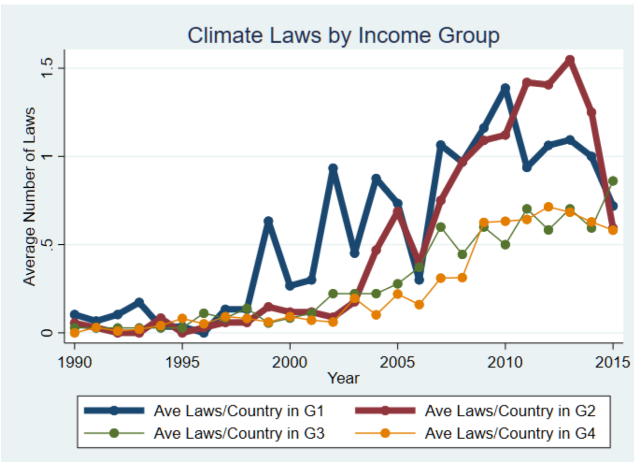
As previously explained, we categorized the list of countries by income group for each year. We argue that income captures development, and thus following the theoretical prediction of the EKC, one would expect that the number of laws are correlated with the income group. In addition, the most relevant driving force that links the inverse U-shape of the EKC and abatement is technological advance, which

[18] Kraay et al. (2010)

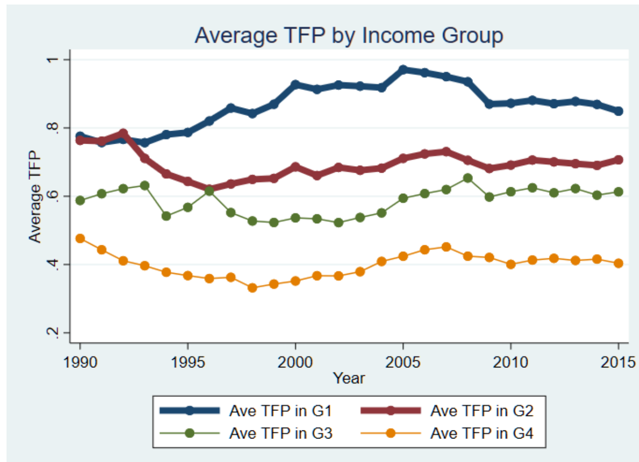
[19] We matched Kaufmann's units to get an index, roughy speaking, between -2.5 and 2.5. Then, the adjusted measure of *law* will be 100% plus the score of the index used.

we measure as the TFP. Thus, to strengthen our claim, we also show that the TFP is associated with the income group. These two relations are displayed in figure 1.

Figure 1: Income, Productivity and Climate Laws



(a) Income Group and Laws



(b) Income Group and Productivity

4.2 Own Regulations

As a benchmark, we first estimate a model on how a country's own regulations affect their emissions. Our dependent variable is the log of emissions. Our main explanatory variables are the measure for laws, productivity, and their interaction. In addition, we control by other variables that clearly affect emission, such as log of GDP per capita, log of population, log of capital stock, and exports and imports both as a share of GDP. Finally, we use country fixed effects, year fixed effects, and a combination of income-group and year fixed effects whenever pertinent. Thus, our first model is:

$$lemissions_{i,t} = \beta_0 + \beta_1 laws_{i,t} + \beta_2 laws_{i,t} TFP_{i,t} + \beta_3 TFP_{i,t} + Controls_{i,t} + \nu_i + u_t + e_{i,t} \quad (1)$$

Table 5 shows the results for the above estimation. Columns (1) and (2) estimate the effects of the average law on the average country's own emissions. The difference between them is that column (1) assumes that the time fixed effect is the same for all countries, while column (2) allows for it to have different effects depending on the income group. Column (2) shows that the the average law of the average country has been ineffective at best.

Table 5: Emissions, Regulations and Productivity

	log emissions					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
laws	0.0870***	0.0288	-0.0828*	-0.0909*	0.0670**	0.157***
	(0.0205)	(0.0220)	(0.0462)	(0.0452)	(0.0306)	(0.0415)
laws*Productivity	-0.142***	-0.0571**	0.0629	0.106	-0.100*	-0.305***
	(0.0293)	(0.0289)	(0.0477)	(0.0629)	(0.0518)	(0.0910)
Productivity	-0.544***	-0.680***	-0.504***	-0.890***	-0.325	0.116
	(0.0762)	(0.0860)	(0.110)	(0.132)	(0.218)	(0.195)
log gdp/pc	1.364***	0.755***	7.290***	-2.437***	6.078***	-0.888
	(0.187)	(0.235)	(0.712)	(0.533)	(0.609)	(0.529)
(log gdp/pc)^2	-0.0410***	-0.00296	-0.333***	0.192***	-0.303***	0.0814**
	(0.0106)	(0.0134)	(0.0337)	(0.0278)	(0.0329)	(0.0329)
log pop	1.545***	1.514***	1.382***	2.326***	1.430***	1.417***
	(0.0468)	(0.0653)	(0.0772)	(0.0631)	(0.131)	(0.134)
log capital	-0.0805***	-0.128***	-0.00566	-0.0485	0.0216	0.0397
	(0.0189)	(0.0280)	(0.0561)	(0.0477)	(0.0497)	(0.0522)
exports/gdp	-0.135**	-0.127*	0.192**	-0.522***	0.211	-0.714***
	(0.0595)	(0.0691)	(0.0910)	(0.125)	(0.126)	(0.172)
imports/gdp	-0.281***	-0.228***	0.0870	-0.502***	-0.388***	-1.089***
	(0.0487)	(0.0593)	(0.0851)	(0.112)	(0.122)	(0.233)
Constant	-9.657***	-6.387***	-37.29***	4.360*	-31.54***	-0.602
	(0.810)	(0.991)	(3.714)	(2.350)	(2.698)	(1.972)
Observations	4,337	4,337	1,240	1,124	956	1,017
Country F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Time F.E.	Yes	–	Yes	Yes	Yes	Yes
Time*Group F.E.	–	Yes	–	–	–	–
Income Group	All	All	High	Mid-Hi	Mid-Lo	Low

Panel of emissions and own regulations. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The variable *law* represents the number of regulations of a country in a year, and its effectiveness was adjusted by our CLE index. Errors were clustered by year on column (1) and by year-group on columns (2) to (6). Robust errors are displayed in parenthesis.

On the other hand, the previous result that 'the average law' is ineffective is no longer true if we do a sub-sample analysis. Columns (3) to (4) show that regulations of higher income countries actually reduce their own emissions. On the other hand, Columns (5) and (6) show the opposite result: policies in low-income countries are associated with increases in emissions.[20] Thus, one could mistakenly conclude that low income countries should not pass environmental policies, or at least heavily improve their effectiveness. Nevertheless, this analysis does not show how the decisions of one country affect the other. That is, the effects of foreign policies are either not taken into consideration.

4.3 Foreign Regulations

Figure 1 and table 5 showed us that the income groups heavily affect the relationship between climate laws, productivity and emissions. Next, we study how foreign regulations affect the emissions of the average country. Our dependent variable is still the log of emissions, we still use own regulations and the control variables from equation (1). In addition, we add and focus on foreign regulations $ext.laws_{i,t,G(t)}$ as the main explanatory variable. Finally, we want to study how the effects of regulations persist over time. Thus, our testable model is describe by the following equation:

$$\begin{aligned} lemissions_{i,t} &= \beta_0 + \beta_1 laws_{i,t-\tau} + \beta_2 laws_{i,t-\tau} TFP_{i,t-\tau} + \beta_3 TFP_{i,t-\tau} \\ &+ \sum_{g(t-\tau)=1}^{4} \left[\gamma_{1,g(t-\tau)} ext.laws_{i,t-\tau,g(t-\tau)} + \gamma_{2,g(t-\tau)} ext.laws_{i,t-\tau,g(t-\tau)} TFP_{i,t-\tau} \right] \\ &+ Controls_{i,t} + \nu_i + u_t + e_{i,t} \text{ , for } \tau = 0,1,2,3,4 \end{aligned} \tag{2}$$

[20] The results on columns (5) and (6) are robust to using Kaufmann's Governance Effectiveness and not adjusting at all. The coefficients for law on columns (3) and (4), although remain negative, become insignificant when changing the adjustment for law effectiveness.

where τ represents the lag on the policy variable, and we are mainly interested in estimating the set of γ parameters.

Table 6: Foreign Regulation

	log emissions				
VARIABLES	(1)	(2)	(3)	(4)	(5)
law	-0.0614*	-0.00869	-0.00568	-0.00678	-0.00924
	(0.0327)	(0.0220)	(0.0233)	(0.0230)	(0.0224)
law*Productivity	0.0600	-0.0149	-0.0184	-0.0154	-0.0122
	(0.0469)	(0.0292)	(0.0310)	(0.0309)	(0.0296)
ext.laws.G1	0.0199	0.0272**	0.0421***	0.0485***	0.0421***
	(0.0125)	(0.0122)	(0.0123)	(0.0141)	(0.0121)
ext.laws.G1*Prodctvt	-0.00430	0.000530	-0.00279	-0.00173	-0.000926
	(0.00452)	(0.00408)	(0.00556)	(0.00494)	(0.00531)
ext.laws.G2	0.0295***	0.0377***	0.0278*	0.0213	0.0225
	(0.00892)	(0.0119)	(0.0141)	(0.0141)	(0.0141)
ext.laws.G2*Prodctvt	-0.0103*	-0.0137***	-0.0111*	-0.00687	-0.00856*
	(0.00528)	(0.00479)	(0.00564)	(0.00543)	(0.00458)
ext.laws.G3	-0.0256*	0.00915	0.0203	0.0275	0.0430*
	(0.0154)	(0.0156)	(0.0214)	(0.0238)	(0.0237)
ext.laws.G3*Prodctvt	0.00990	0.0106	0.00861	-0.00238	-0.00701
	(0.0148)	(0.0155)	(0.0179)	(0.0165)	(0.0164)
ext.laws.G4	-0.0605***	-0.0314**	-0.0284	-0.00437	0.00590
	(0.0163)	(0.0134)	(0.0198)	(0.0221)	(0.0207)
ext.laws.G4*Prodctvt	-0.00279	-0.00393	-0.000917	-0.00585	-0.00488
	(0.0105)	(0.0111)	(0.0140)	(0.0151)	(0.0147)
Productivity	-0.374***	-0.331***	-0.296***	-0.270***	-0.225**
	(0.0982)	(0.0949)	(0.0943)	(0.0933)	(0.0937)
Observations	3,826	3,753	3,681	3,609	3,528

Panel of emissions and foreign regulations. * $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$. Control variables and a constant term were used, but omitted from the table for brevity. All regressions have country fixed effects and a combination of group and year fixed effects. Errors were clustered by year-group. Robust errors are displayed in parenthesis. Laws were adjusted by our index CLE. See appendix B.

Table 6 estimates equation (2). Column (1) to (5) estimate the effect of foreign laws on a the average country's emissions. Column (1) uses the same period's law, while column (τ) uses regulations from period $t - \tau + 1$. The coefficients for $ext.laws.G1$ are all positive and significant for columns (2) to (5). This shows that lagged climate laws implemented by the richest countries have actually increased the emissions of the average country. For instance, the largest coefficient for this variable is 0.0485 in column (4). Since emissions are in logarithms, the estimated coefficient is a semi elasticity with the following interpretation: an increase of one law passed by one of the high-income countries multiplies the emissions by $e^{0.0485}$, which represents almost a 5% increase.

Moreover, our results from tables 5 and 6 are robust to several modifications. Namely, (i) restricting the sample to post-cold war era; (ii) using world bank data for emissions instead of IEA's data; (iii) using the number of mitigation laws in a year, a dummy indicating if there is any law in a year, and a dummy indicating if there is a mitigation law in a year; (iv) using Kaufmann's GEE or not adjusting the laws.

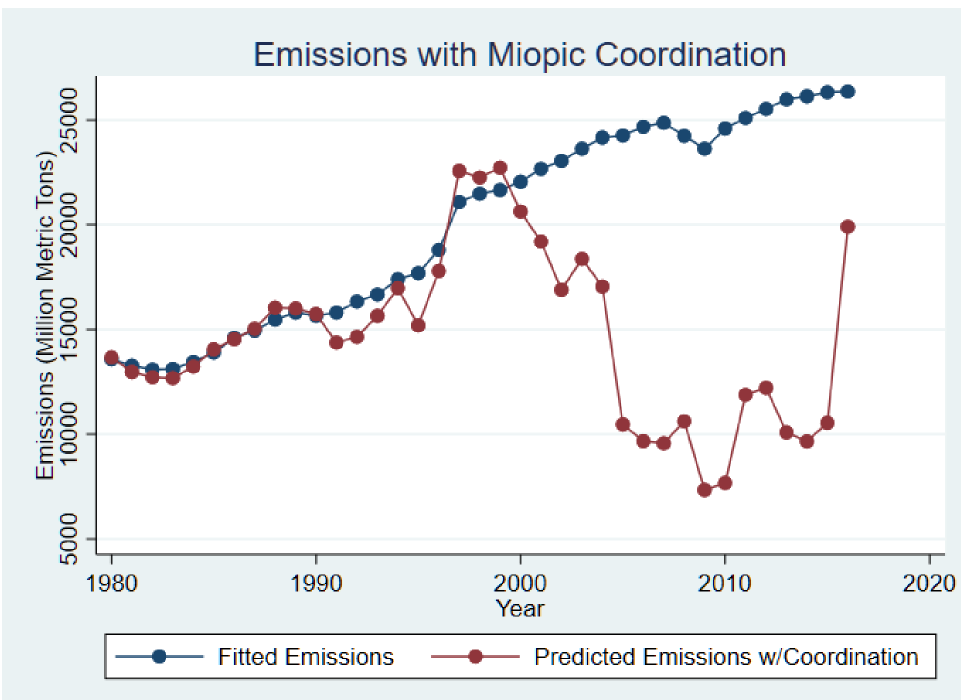
5 Measuring Non-Coordination

The results from table 6 show that foreign laws from developed countries increase the emissions of the average country, and, to some extent, foreign laws from developing countries decrease the emissions on the average country. In this section, we re-estimate the model specification from table 6, but use simultaneously current and lagged foreign laws up to three periods. That is:

$$\begin{aligned} lemissions_{i,t} &= \beta_0 + \sum_{\tau=0}^{3} \Bigg[\beta_1 laws_{i,t-\tau} + \beta_2 laws_{i,t-\tau} TFP_{i,t-\tau} + \beta_3 TFP_{i,t-\tau} \\ &+ \sum_{g(t-\tau)=1}^{4} \Big[\gamma_{1,g(t-\tau)} ext.laws_{i,t-\tau,g(t-\tau)} + \gamma_{2,g(t-\tau)} ext.laws_{i,t-\tau,g(t-\tau)} TFP_{i,t-\tau} \Big] \Bigg] \\ &+ Controls_{i,t} + \nu_i + u_t + e_{i,t} \text{ , for } \tau = 0, 1, 2, 3, 4 \end{aligned} \tag{3}$$

Then, we compare two case scenarios. The first one is the fitted emissions that the model would predict between 1980 and 2016. For the second scenario, we replace the laws by the yearly average law, and then predict the alternative emissions that would come from ‘myopic coordination,’ where we define myopic coordination as a sub-optimal coordination such that countries mimic each other instead of taking into account the advantages of the differentials in productivity. On the other hand, since the right hand side of equation (3) is linear in foreign laws, we believe that the analysis already over-compensates for using a sub-optimal coordination. Figure 2 shows the comparison of these two scenarios. We calculate that the accumulation of emissions under the coordination scenario would be 60% of its uncoordinated (using the observed laws) counterpart.

Figure 2: Comparing no coordination and myopic coordination, from 1980 to 2016.



The above exercise shows that it is possible to reduce emissions with coordination. On the other hand, the exact magnitude is clearly far from perfect for several reasons. First, we are restricted to the data. Our sample size is the intersection of three main data-sets, and, thus, even the predicted model without adjustments already has lower emissions to begin with. Second, we assume that other variables are not affected. Namely, GDP did not change between the two scenarios. Third, our exercise exclusively focuses on the trade-off between production and abatement. On the other hand, technological progress can increase abatement without compromising production. Although technological progress is controlled by TFP, we do not explicitly focus in that variable.

In addition to the points describe above, one adjustment that we can make with the available data is to take into account that productivity is decreasing as as function of production (or production exhibits diminishing returns to scale). This would imply that the change in laws should also have a decreasing impact on carbon leakage, as productivity from regulated and unregulated countries slowly converge. Thus, a concave transformation of the variable *laws* in equation (3) should make the comparison between the predicted emissions with actual laws and with modified laws less dramatic. We used two alternative specifications, one is quadratic and the other one is logarithmic. The comparisons are displayed in figure 3.

Figure 3: Comparing the efficiency loses w, from 1980 to 2016.

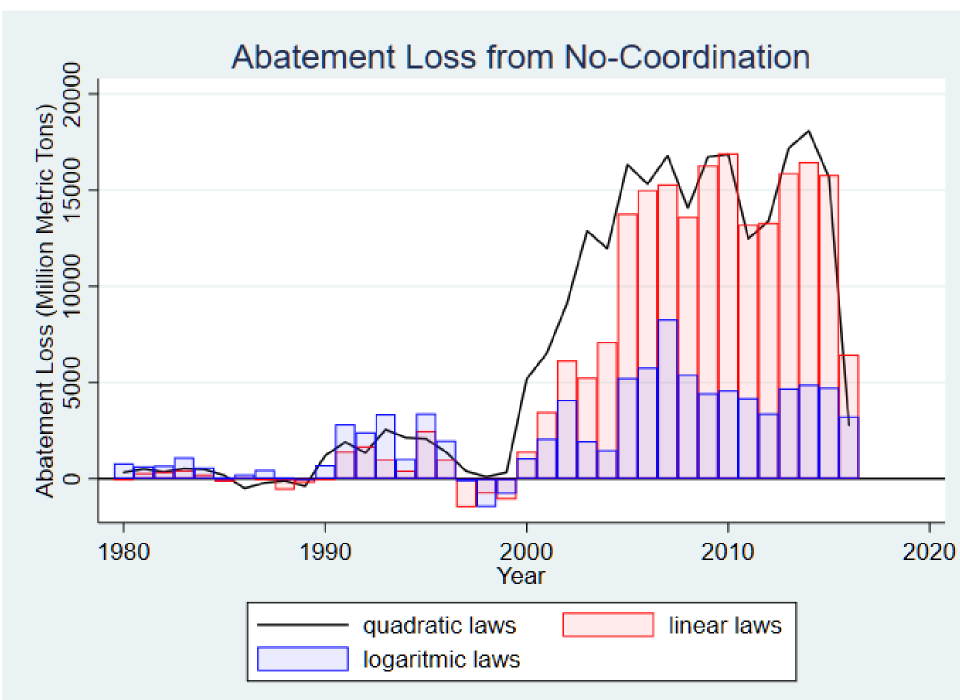


Figure 3 shows the the differences between the predicted emissions with actual laws and with modified laws for three different functional forms for the variable *laws*: linear (the difference between the two lines in figure 2), quadratic and logarithmic. The quadratic function is almost identical to the linear one, but the logarithmic presents a much smaller difference. More importantly, in all cases the alternative scenario with modified laws had lower emissions than the scenario with observed laws.

Two interesting points from figure 3 are that, (*i*) there seems to be a small but positive global abatement attained exactly at the beginning of the Kyoto protocol, which can be attributed to the fact that regulations are effective in the own country, specially for high-income countries. However, (*ii*) the net effect quickly became negative (or positive loss in the graph) after year 2000. This also relates to evidence of recent emissions take-off, especially from developing nations.[21]

6 Conclusions

We have studied the global effect of uncoordinated (or at least only partially coordinated) regulations that originally attempted to reduce greenhouse gas emissions. Although we show that industrialized countries' own regulations have decreased their own emissions, we also show that regulations from those same countries increased emissions in unregulated countries. More importantly, the net effect has been an increase in global emissions. Our results are relevant considering the current state of climate laws distribution and heterogeneous productivity around the world.

Theoretically, the reason to our findings is that abating one additional metric ton of CO2eq represents a higher cost of opportunity in high-productivity countries. Unfortunately, those countries are also the ones regulating. Thus, we would be better off by finding a mechanism such we first reduce emissions in low-productivity countries.

[21]For example, see (Zhang et al., 2020; Rocco et al., 2020; Sengupta and Bhardwaj, 2004; Arroyo-Currás et al., 2015).

To estimate how present and past foreign laws affect emissions, we constructed a panel with data from the majority of countries. We also compared the predicted emissions from the empirical model with a hypothetical scenario. On the predicted emissions, we used the actual heterogeneous laws observed in the data, and on the hypothetical scenario we assumed that each country implemented the average yearly number of laws. This exercise shows that, in the hypothetical scenario, global accumulated emissions from 2008 until now would be half as much as the predicted ones. Although these results are only for illustration, rather than for policy evaluation, there is no doubt that moving the regulations in the direction proposed would decrease global emissions.

The immediate implication is clearly adverse: the lack of global coordination and planning has had a detrimental effect on the goals to stop/slowdown climate change. Partial coordination, such as the Kyoto protocol, is not enough to achieve a sustainable global plan for emissions. Although the Kyoto protocol allows for the incumbents to substitute their own abatement for a measurable reduction in a third party's emissions, this mechanism was only meant to be used as a secondary source of abatement. Thus, we believe laws ideally need to be coordinated, which is an idea already proposed in the literature (for example Mehling et al. (2018)).

Moreover, there are a few different tools that can be used to provide the right incentives to all countries. The one that is most appealing, at least theoretically, is a global cap-and-trade. A second solution would be a global carbon tax, as proposed by the IMF (2019). Based on our productivity rationale, a global version of standard environmental economics policy techniques will make high income countries purchase emission rights from low income countries. We believe this sounds appealing from the efficiency perspective and also from the fairness perspective.

Of course, there are difficulties to such international agreement. Some countries may not be willing to participate. Some countries may sign and misreport their (difficult to measure) emissions. In addition, there are few other technical difficulties. For instance, there is no obvious way to setting the emissions cap. Should it be a flat cap for all countries? Or should it be determined by population? Or GDP per-capita? Or based on historical emissions? This discussion of setting the cap goes back to a lingering issue in the environmental economics field: property rights. Another difficulty is that countries have to be willing to maintain their allegiance to the agreement even in the difficult years to come. This relates to the self-enforcing mechanisms on international agreements (Caro-Burnett, 2018).

One relevant variable that is beyond the scope of this study is technology. Implicitly, our theoretical rationale relies on the fact that there is a trade-off between production and abatement. However, technology could allow for an improvement in both directions (i.e. expand the Pareto frontier). Empirically, we controlled for total factor productivity which is a standard measure for technology. However, it would be interesting to explicitly incorporate and focus on technological progress theoretically and possibly empirically. Nevertheless, our conjecture is that, since the marginal cost of abatement is higher in developed countries, the first countries where experimental technologies are adopted should be developing countries.

There is no doubt that there is more research needed. However, our results are clear and ex-post obvious. Ideally, all countries should coordinate, and emissions should first be reduced in countries where the marginal cost of (opportunity of) abatement is low. We hope our study is a first step in the right direction towards a better understanding in this exciting and immensely relevant topic.

References

Abrell, Jan, Anta Ndoye Faye, and Georg Zachmann (2011) "Assessing the impact of the EU ETS using firm level data,"Technical report, Bruegel working paper.

Agostini, Paola, Michele Botteon, and Carlo Carraro (1992) "A carbon tax to reduce CO2 emissions in Europe," *Energy Economics*, Vol. 14, pp. 279–290.

Aldy, Joseph E and Robert N Stavins (2020) "Rolling the Dice in the Corridors of Power: William Nordhaus's Impacts on Climate Change Policy,"Technical report, World Scientific Publishing Company.

Andersson, Julius J. (2019) "Carbon Taxes and CO2 Emissions: Sweden as a Case Study," *American Economic Journal: Economic Policy*, Vol. 11, pp. 1–30.

Arroyo-Currás, Tabaré, Nico Bauer, Elmar Kriegler, Valeria Jana Schwanitz, Gunnar Luderer, Tino Aboumahboub, Anastasis Giannousakis, and Jérôme Hilaire (2015) "Carbon leakage in a fragmented climate regime: the dynamic response of global energy markets," *Technological Forecasting and Social Change*, Vol. 90, pp. 192–203.

Babiker, Mustafa H (2005) "Climate change policy, market structure, and carbon leakage," *Journal of international Economics*, Vol. 65, pp. 421–445.

Baer, Paul (2002) "Equity, greenhouse gas emissions, and global common resources," *Climate change policy: A survey*, pp. 393–408.

Barker, Terry, Sudhir Junankar, Hector Pollitt, and Philip Summerton (2007) "Carbon leakage from unilateral environmental tax reforms in Europe, 1995–2005," *Energy Policy*, Vol. 35, pp. 6281–6292.

Baylis, Kathy, Don Fullerton, and Daniel H. Karney (2013) "Leakage, Welfare, and Cost-Effectiveness of Carbon Policy," *American Economic Review*, Vol. 103, pp. 332–37.

Bohom, Peter (1993) "Incomplete International Cooperation to Reduce CO2 Emissions: Alternative Policies," *Journal of Environmental Economics and Management*, Vol. 24, pp. 258–271.

Burniaux, Jean-Marc and Joaquim Oliveira Martins (2000) "Carbon emission leakages: a general equilibrium view,"Technical report, OECD.

Carbone, Jared C (2013) "Linking numerical and analytical models of carbon leakage," *American Economic Review*, Vol. 103, pp. 326–31.

Caro-Burnett, Johann (2018) "Optimal Voting Rules for International Organizations, with an Application to the United Nations," URL: https://goo.gl/bdM79W, Working Paper.

Caron, Justin (2012) "Estimating carbon leakage and the efficiency of border adjustments in general equilibrium—Does sectoral aggregation matter?" *Energy Economics*, Vol. 34, pp. S111–S126.

Chan, Gabriel, Robert Stavins, and Zou Ji (2018) "International climate change policy," *Annual Review of Resource Economics*, Vol. 10, pp. 335–360.

Chan, Hei Sing (Ron), Shanjun Li, and Fan Zhang (2013) "Firm competitiveness and the European Union emissions trading scheme," *Energy Policy*, Vol. 63, pp. 1056 – 1064.

Cohen, Gail, João Tovar Jalles, Prakash Loungani, and Ricardo Marto (2018) "The long-run decoupling of emissions and output: Evidence from the largest emitters," *Energy Policy*, Vol. 118, pp. 58–68.

Copeland, Brian R and M Scott Taylor (1995) "Trade and transboundary pollution," *The American Economic Review*, pp. 716–737.

Cummins, Mark (2013) "EU ETS market interactions: The case for multiple hypothesis testing approaches," *Applied Energy*, Vol. 111, pp. 701 – 709.

Downs, Anthony (1957) "An economic theory of political action in a democracy," *Journal of political economy*, Vol. 65, pp. 135–150.

Downton, Mary W and Roger A Pielke Jr (2001) "Discretion without accountability: Politics, flood damage, and climate," *Natural Hazards Review*, Vol. 2, pp. 157–166.

Eskander, Shaikh M, Sam Fankhauser, and Joana Setzer (2020) "Global Lessons from Climate Change Legislation and Litigation,"Technical report, National Bureau of Economic Research.

Fowlie, Meredith, Mar Reguant, and Stephen P. Ryan (2016) "Market-Based Emissions Regulation and Industry Dynamics," *Journal of Political Economy*, Vol. 124, pp. 249–302.

Fullerton, Don, Dan Karney, and Kathy Baylis (2011) "Negative Leakage," CESifo Working Paper Series 3379, CESifo.

Gerlagh, Reyer and Onno Kuik (2007) "Carbon leakage with international technology spillovers,"Technical report, FEEM working paper.

——— (2014) "Spill or leak? Carbon leakage with international technology spillovers: A CGE analysis," *Energy Economics*, Vol. 45, pp. 381–388.

IMF (2019) "Fiscal Monitor: How to Mitigate Climate Change,"Technical report, International Monetary Fund - Fiscal Monitor.

Kraay, Aart, Daniel Kaufmann, and Massimo Mastruzzi (2010) *The worldwide governance indicators: methodology and analytical issues*: The World Bank.

Kuik, Onno (2009) *Climate change policies, international trade and carbon leakage: An applied general equilibrium analysis*: LAP Lambert Academic Publishing AG & Company KG.

Kuik, Onno and Marjan Hofkes (2010) "Border adjustment for European emissions trading: Competitiveness and carbon leakage," *Energy policy*, Vol. 38, pp. 1741–1748.

Lanzi, Elisa, Damian Mullaly, Jean Château, and Rob Dellink (2013) "Addressing competitiveness and carbon leakage impacts arising from multiple carbon markets: a modelling assessment,"Technical report, OECD.

Mayhew, David R (1974) "Congressional elections: The case of the vanishing marginals," *Polity*, Vol. 6, pp. 295–317.

Mehling, Michael A, Gilbert E Metcalf, and Robert N Stavins (2018) "Linking heterogeneous climate policies (Consistent with the Paris Agreement)," *Envtl. L.*, Vol. 48, p. 647.

Metcalf, Gilbert E and James H Stock (2020) "Measuring the Macroeconomic Impact of Carbon Taxes," in *AEA Papers and Proceedings*, Vol. 110, pp. 101–06.

Monjon, Stéphanie and Philippe Quirion (2009) *Addressing leakage in the EU ETS: Results from the CASE II model*: Citeseer.

Morrow, David R (2017) "Fairness in allocating the global emissions budget," *Environmental Values*, Vol. 26, pp. 669–691.

Nordhaus, William (2015) "Climate clubs: Overcoming free-riding in international climate policy," *American Economic Review*, Vol. 105, pp. 1339–70.

Özcan, Burcu and Ilhan Öztürk (2019) *Environmental Kuznets Curve (EKC): A Manual*: Academic Press.

Paroussos, Leonidas, Panagiotis Fragkos, Pantelis Capros, and Kostas Fragkiadakis (2015) "Assessment of carbon leakage through the industry channel: the EU perspective," *Technological Forecasting and Social Change*, Vol. 90, pp. 204–219.

Parry, Ian et al. (2016) "Reflections on the international coordination of carbon pricing," *Global Carbon Pricing*, p. 13.

Raworth, Kate (2007) "Adapting to Climate Change: What's needed in poor countries, and who should pay," *Oxfam Policy and Practice: Climate Change and Resilience*, Vol. 3, pp. 42–88.

Rocco, Matteo V, Nicolò Golinucci, Stefano M Ronco, and Emanuela Colombo (2020) "Fighting carbon leakage through consumption-based carbon emissions policies: Empirical analysis based on the World Trade Model with Bilateral Trades," *Applied Energy*, Vol. 274, p. 115301.

Rodríguez-Fernández, Laura, Ana Belén Fernández Carvajal, and María Bujidos-Casado (2020) "Allocation of Greenhouse Gas Emissions Using the Fairness Principle: A Multi-Country Analysis," *Sustainability*, Vol. 12, p. 5839.

Schmalensee, Richard and Robert N Stavins (2019) "Policy Evolution under the Clean Air Act," *Journal of Economic Perspectives*, Vol. 33, pp. 27–50.

Sengupta, Ramprasad and Geetesh Bhardwaj (2004) "Consumption pattern, trade, and greenhouse gas leakage in India," *Environment and Development Economics*, pp. 335–352.

Shue, Henry (1995) "Avoidable necessity: global warming, international fairness, and alternative energy," *Nomos*, Vol. 37, pp. 239–264.

Uchiyama, K (2016) *Environmental Kuznets Curve Hypothesis and Carbon Dioxide Emissions*: Springer Japan, 1st edition.

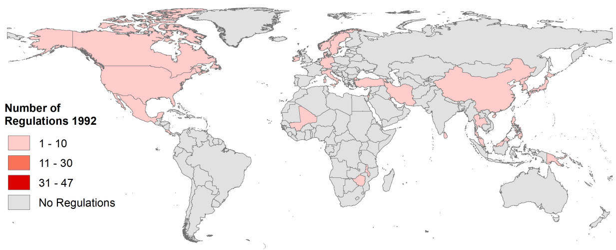
Verde, Stefano F (2020) "The impact of the EU emissions trading system on competitiveness and carbon leakage: the econometric evidence," *Journal of Economic Surveys*, Vol. 34, pp. 320–343.

Wald, J (2015) "Carbon leakage: theory, evidence and policy,"Technical report, Presentation given at the PMR Webinar on Carbon Leakage.

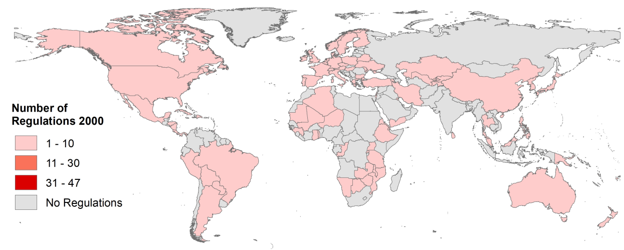
Zhang, Peng, Guangzhi Yin, and Maosheng Duan (2020) "Distortion effects of emissions trading system on intra-sector competition and carbon leakage: A case study of China," *Energy Policy*, Vol. 137, p. 111126.

A Figures

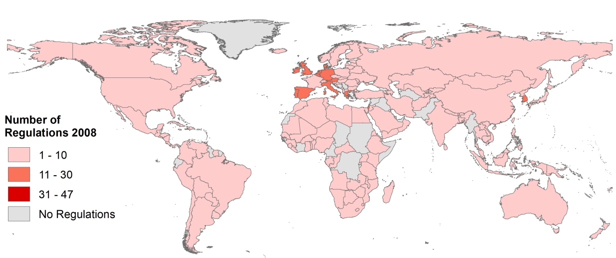
Figure 4: Evolution of the number of laws by country, years 1992, 2000, 2008, and 2016



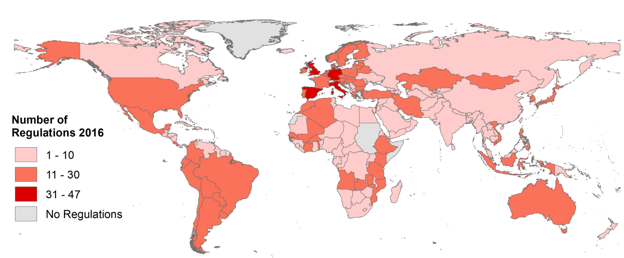
(a) Year=1992



(b) Year=2000

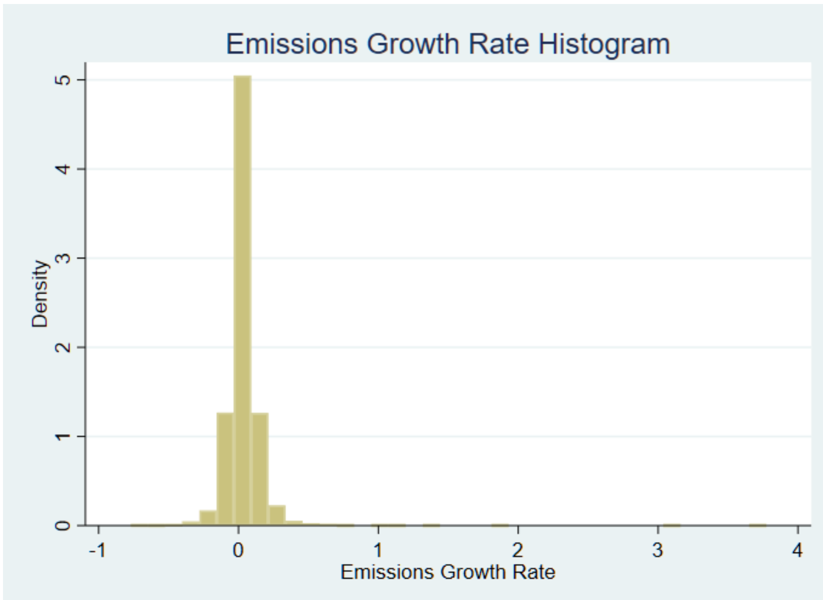


(c) Year=2008



(d) Year=2016

Figure 5: Histogram of emissions growth rates



B Climate Laws Effectiveness

As an alternative to Kaufmann's GEE, we used our data to measure which country-year pairs have relatively more effective laws. We estimated a model similar to equation (1), but without the *laws* variables:

$$lemissions_{i,t} = \beta_0 + \beta_1 TFP_{i,t} + Controls_{i,t} + \nu_i + u_t + e_{i,t}$$

Then, we compared the predicted log-emissions ($fitted\_lemissions_{i,t}$) with the observed counterpart. We measure effectiveness as:

$$CLE_{i,t} = \left(-lemissions_{i,t} + fitted\_lemissions_{i,t}\right), \text{ if } laws_{i,t} > 0$$

Then, we re-normalized this index to have a SD of one, similar to Kaufmann's GEE.

Centro UC
CLAPES UC
Centro Latinoamericano de Políticas Económicas y Sociales

clapesuc

@clapesuc

clapes_uc

clapesuc