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Decarbonising through climate legislation,

The effects of five instruments available to governments

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Abstract

The main goal of the Paris agreement is to hold global warming below 2 degrees Celsius. A goal which requires a rapid peak and decline of global emissions. With the adoption of the Paris agreement, countries submitted Nationally Determined Contributions making national climate legislation a key tool for how to reach the goal. While the response so far has failed to reduce global emissions, climate legislation can be helpful in lowering national emissions. This study uses panel data to study the effectiveness of five different types of climate legislation in reducing CO2-emissions. With data covering 141 countries between 1996–2018, a two-way fixed effects model is used to determine a short and long-term effect of implementing a climate law. Laws relying on economic tools such as taxes and subsidies show the greatest effects in advanced economies. CO2 emissions per GDP are reduced by 1.47% within the first three years and by 3.55% when the law has been implemented by four years or more. The rest of the world has been more successful with regulation tools, such as standards and obligations. These laws are associated with short term reductions of 2.94% and long-term reductions 3.46%, worldwide. The three remaining types of laws rely on direct investments, information, or governance tools. None of which show a significant negative effect on emissions.

Keywords: Climate legislation, CO2 emissions, Tax incentives, Command and control regulation, Public good investments

Contents

1. Introduction

In 2015, 196 countries adopted the Paris agreement, a legally binding treaty aimed at reducing climate change (UNFCCC, 2020). The main goal of the treaty is to keep global warming well below 2 degrees Celsius, preferably to 1.5 degrees compared to pre-industrial levels. This requires a peak and reduction of global greenhouse gas emissions quickly. Since 2015, global CO2 emissions has continued to rise at mostly the same pace (IEA 2022).

To reach the goals, large efforts are required from all actors in the economy. Countries that adopted the Paris agreement have constructed Nationally Determined Contributions (NDCs). Intended NDCs outlined the climate targets and actions each country intended to take after 2020. Rogelj et al. (2016) reviewed the Intended NDCs to find that even if the actions would reduce global emissions compared to 2016 levels, by the end of the century the median warming would still increase to 2.6–3.1 ºC by the end of the century.

Worldwide, more than 2600 climate laws and policies have been adopted to reduce or adapt to climate change. However, the effectiveness of these laws is not clear. Le Quéré et al. (2019) analyse the driving factors of emission reduction in 18 advanced economies which have been able to reduce CO2 emissions. They find that these countries to a greater degree have displaced fossil fuels for renewable energy. Policies to support renewable energy have been successful in the 18 countries but not elsewhere. The study does however find support for policies aimed towards energy efficiency in both the decarbonising countries and two different control groups.

Eskander and Fankhauser (2020) use a broader approach to study the effect of all national climate laws and policies worldwide. Using a simple difference in difference approach, they investigate the association between the passing of a climate law and the emissions within the country. They find a negative short- and long-term effect on emissions but that overall, the contribution of climate legislation has been relatively small.

1.1 Purpose

This study will build upon the paper by Eskander and Fankhauser (2020) to further investigate which laws have been effective in reducing greenhouse gas emissions by dividing the policies and into five categories based on the policy instrument which is most heavily used in the legislation. The advantage of a large-scale study with a worldwide perspective is that the results will show which types of policy tools are effective across the world and robust to different cultures, legal systems, and economic circumstances. Different methods will be used to explore if the best course of action varies with other factors within the country. By knowing what has worked so far, governments will be able to design policy with proven results and avoid uncertain methods. The battle against climate change needs to be executed effectively to reach the targets of the Paris agreement and minimize future damage.

1.2 Outline

The paper is structured in the following way. The next section offers further background regarding previous empirical work in the area. The following section is an empirical review of climate legislation and its effects on emissions, followed by a discussion of other factors driving the development in emissions. Section 3 describes the economic theory of how governments can tackle emissions with different policy tools. In section 4, the methodology and data are presented. Section 5 describes the results followed by a discussion in sections 6 and conclusions in section 7.

2. Empirical review

2.1 Climate legislation and emissions

National actions against climate change have largely moved in tandem international processes (Iacobuta et al. 2019). Nationally binding climate legislation and strategy experienced a large uptake right before the Copenhagen Climate Conference in 2009 with large emitters leading the charge. Greenhouse-gas (GHG) emission targets were adopted by many countries after the development of NDCs in accordance with the Paris Agreement. In the early 2000's, between 0–20 percent of total GHG emissions were covered by either strategy and legislation, emissions targets, renewable energy targets or energy efficiency targets. By 2017, coverage had increased to between 70–90% with over 70% of countries having GHG or renewable energy targets, 50% having strategies or legislation and 30% having energy efficiency targets.

Climate change remains one of the largest challenges for the world and the problem is getting worse. Over the period 2005–2021 global CO2 emissions has increased on average by 2.4% annually (IEA, 2022).

Still, some countries have been able to peak and reduce emissions over a sustained period. Lamb et al. (2022), identify 24 countries which peaked sometime between 1970–2008 and had annual reductions on average in greenhouse gas emissions until 2018. The group contains 22 European countries, Jamaica, and the United States. All these countries have in common that large parts of the reduced emissions are in the electricity and heat sector, the sector with most emissions. This indicates a switch from fossil fuels such as coal to clean energy such as solar, nuclear or wind. Most countries also were able to reduce emissions in the industry sector but were less effective in the second largest emission sector, road transport.

Lamb et al. does not attempt to tie the countries reductions to any climate laws or polices in their statistical analysis. While all these countries have adopted multiple national climate laws, with an average of 41 mitigation laws, it is likely that these reductions occurred through other structural change. Half of them has had sustained reductions since the 1990's or earlier and most climate laws were passed in the 2000's.

Le Quere et al. (2019) study 18 of the same countries to find the underlying factors driving their ability to decarbonise. They find that these countries all have been able to displace fossil fuels in favour of renewable energy as well as increase the efficiency in production and consumption of energy. To clarify if climate laws and policy were contributing to the structural change, they do a correlation study between the number of climate laws and policies in place each year within the decarbonising countries and compare to two control groups. The control groups contain countries which have not been able to decarbonise and are categorized by high or low GDP growth. The laws and policies are divided by whether they promote renewable energy, energy efficiency or other climate change mitigation or adaption. All three types show negative correlation with emissions in the peak and decline group. In the control groups, energy efficiency laws did not show significant negative correlation with emissions but with emission intensity. This outcome signals a success in increasing energy efficiency, but GDP growth dampens the effect on absolute emissions. Le Quere et al. also finds that low GDP-growth is one driving factor of decarbonisation within the 18 countries. Neither of the two other types of laws showed significant negative correlations. In the high GDP-growth group, the renewable energy policies show significant positive correlation indicating that renewable energy adds capacity but does not replace fossil fuels. Adaption laws are not attempting to lower emissions. If these are dominating in the control groups "other climate policies", it could explain the absent negative correlation.

Eskander and Fankhauser (2020) focus entirely on the relationship between climate legislation and GHG-emissions. Instead of focusing on a few decarbonising countries, they choose a worldwide approach to determine the association between the implementation of a climate law or policy and emissions. With the larger scope, enough laws are covered to separate between mitigation and adaption laws. Using panel-data covering 133 countries between 1999-2016 with a total of 1092 mitigation laws, they investigate both a short and long-term effect of passing a climate law on emission-intensity. CO2 emission to GDP ratio is reduced by 0.78% on average in the first three years after a law is passed and by 1.79% on average after four years or more. It is estimated that climate have been able to reduce CO2 emissions by 38 Gt which is approximately one years' worth of global CO2 output. For other GHG-emissions, the relationship is weaker. There is no significant short-term effect and in the long-term GHG-emission intensity is reduced by 0.65%. The effects are found to be larger in countries with a stronger rule of law and in advanced economies. Eskander and Fankhauser does only attempt one type of categorisation of laws, whether they were implemented through parliament or through executive order/decree. The separation shows that only legislation passed through parliament has a significant effect. A likely explanation is that executive orders more often lack scope and are easily reversible. No attempt is carried out at separating laws by their content.

2.2 Economic variables and emissions

An empirical study of the effects of climate legislation must control for other factors which otherwise would induce omitted variable bias. Grossman and Kreuger (1991) developed the environmental Kuznets curve (EKC), a relationship between income per capita and multiple indicators of environmental degradation. The EKC describes how environmental degradation is a function of income following an inverted U-shape. The theory states that the relationship is affected through three different channels (Apergis, 2017). The scale effect causes emissions to rise. As output increases, all else equal, so will pollutants.

The composition effect will cause emissions to rise during early development and fall in later stages. As an economy develops, its output mix will as well. The simplest economies rely on agriculture. With increasing GDP per capita, countries move on to emission intensive heavy industry. In later development stages, economies generally move to less emission intensive manufacturing, and services. The last effect is technique which will cause emissions to fall, all else equal. Technological advancements lead to changes in the input mix of production with less environmental impact.

The most common model specification is to explain emissions as a quadratic function of GDP per capita. All variables are log-transformed as to disallow non-positive levels of emission per output (Stern, 2004).

Stern (2004) performs a critical review the EKC literature where he argues that the relationship is over-simplified both theoretically and econometrically. It relies on the latter two effects being larger than the scale effect for high GDP per capita levels. Furthermore, there are other driving factors behind composition and technology effects than simply income, leading to different results for different samples. Stern does not find sufficient evidence to prove that the relationship is not monotonic but marginally decreasing with higher GDP per capita. A better model would control for structural changes within the economy. In Stern's review it is concluded that including a trade variable leads to a better specified model and he recommends including control variables for underlying changes in the economy that affects emissions through composition or technique effects.

While the EKC tries to establish a long-term relationship between GDP and emissions, there are also short-term effects. Most empirical research shows that emissions are pro-cyclical. Doda (2014) studies the cyclical component of GDP using panel data covering 122 countries over the period 1950-2011. GDP is decomposed to a growth part and a cyclical part using the Hodrick-Prescott (HP) filter. The HP-filter is performed by solving the following optimization problem (Hodrick and Prescott, 1997):

$$min_{g_t} \left\{ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \right\}$$

subject to $y_t = g_t + c_t$

Where y_t is log GDP, g_t is the growth component which is assumed to vary smoothly over time and c_t is the cyclical component. The smoothness is modelled as the sum of squares of the second difference of g_t. λ is a penalty parameter which penalises variability in the growth series. As g_t is assumed to vary smoothly $g_t - g_{t-1}$ should simplify to a constant, β implying that the growth rate can be written as $g_t = g_0 + \beta_t$. c_t is deviations from the growth path and should average at zero.

Doda finds a strong positive correlation between c_t and emissions implying that CO2 emissions are pro-cyclical. This can be seen as the pure scale effect in the EKC framework as business cycle booms are not driven by technological change or any stable growth of the economy. Doda also finds that the relationship strengthens with GDP-per-capita, that emissions are more volatile than GDP due to changes in c_t and that the volatility of emissions weakens with GDP-per-capita.

3. Theory

This section offers a general discussion of when government intervention is necessary to correct market failures and how governments can use their power to reduce emissions in the different scenarios

3.1 Externalities, taxes and command and control regulation

Economists generally view CO2 emissions as an externality. A negative externality causes damage to welfare of a third party, not involved in the production or consumption of a good, which is not priced in by the market (Rosen and Gayer 2008). In a simple example where a producer causes pollution, they will produce until the marginal benefit, MB is as large as marginal private costs, MPC. MB is assumed to be declining while MPC is not. This leads to the profit maximising quantity of goods. However, with each good produced, there is also a marginal damage to a third party caused by pollution. A welfare maximising quantity would occur when the MB intersects marginal social cost, MSC=MPC+MD. The pollution leads to economic inefficiency with too much production and market failure.

A government setting policy to deal with this externality could consider the logical solution of simply pricing the marginal damage with a Pigouvian tax. If the marginal damage is correctly measured, it would lead to economic efficiency. Rosen and Gayer argues that the MD is extremely hard to measure. A polluters harmfulness will vary with congestion and the number of affected parties. To administer a correctly set Pigouvian tax would be far too expensive for a government. Instead, a simpler taxing scheme can be put in place to move us closer towards economic efficiency, such as emission fees.

A similar tool available to governments are subsidies. Instead of making a producer pay more for each unit produced, the producer is paid more for each unit not produced. The producer will not produce a good if the marginal profit is lower than the subsidy received for lowering its output. The main difference between a tax and a subsidy is the distributional effects. A tax will be costly for the producing firm and the government can redistribute the gains to others while the opposite is true with a subsidy. Subsidies can also be used to make a greener solution more competitive by lowering its cost to produce a similar good with less pollution.

Another commonly used tool is command and control regulation. Through command and control, governments regulate either technology or performance standards. Technology standards offers the polluter the least flexibility in approaches to reduce its emissions. It requires the producer to use a type of technology that reduces emissions either in the production process or emissions from use of the product. Rosen and Gayer (2008) criticises the instrument as producers lack incentives to find more effective ways to reduce emissions which they may not be allowed to use. Performance standards sets emission goals for the polluters. In both cases, the polluters are penalised with sanctions if the standards are not met. Performance standards offer more flexibility to polluters in how they choose to reduce emissions. Their ability to create incentives for technological innovation and cost-effective solutions make them preferable in most cases. However, firms have no incentive to continue reducing emissions when the goal has been achieved. With tax-incentives such as emission fees, the firms always have an incentive to reduce their cost further by reducing emissions. According to Rosen and Gayer, technology standards are only preferable when it is hard to monitor emissions, making the other tools complicated.

3.2 Public goods, natural monopolies, and emissions

Some market failures are better handled by making the government the sole proprietor of a good. Governments can also reduce emissions through investments in markets with public ownership.

Pure public goods are defined as goods that are non-rival and non-excludable (Hindricks and Myles, 2013). Non-rival implies zero marginal cost. A person’s ability to consume the good is not affected by another person consuming the good. Non-excludable implies that it is expensive or impossible to exclude another person from consuming the good. The most common example is national defence where there is no extra cost of defending another person and it is hard to exclude another citizen from reaping the benefits of national security. Public goods are often provided by the government as no one has an incentive to reveal their true preferences and pay a private producer for a public good.

Nature-based solutions and ecosystems can be viewed as a public good. Nature-based solutions are generally actions to restore, protect, and manage eco-systems (Chausson et al. 2020). Examples include reforestation, afforestation and protection of marine areas and wetlands. Nature-based solutions have been shown to help climate mitigation through capturing of emissions and help with climate adaption.

The provision of education is often seen as an impure public good (Rosen and Gayer 2008). Governments help educate citizens and workers on climate friendly solutions through many channels and invest in research and development within the same area. By increasing the society's environmental human capital, an economy will have a better chance to reduce emissions.

Governments can also be large polluters through their own activity. Natural monopolies are markets characterized by a barrier to entry in form of a large, fixed cost and increasing returns to scale (Hindricks and Myles, 2013). In these markets, marginal costs are constant or comparatively low to fixed costs. With a constant MC, average cost at market equilibrium output level, y, will be $AC(y) = \frac{FC+MC(y)}{y} \leq p(y)$. Multiple firms cannot enter the market as if the market is split, average cost will increase above average revenue for at least one firm, $AC(y/2) = \frac{FC+MC(y)}{y/2} < p(y)$. A monopoly will have market power as they can manipulate the price by manipulating output. A profit maximizing monopoly will thus choose output to maximize profit:

$\pi = \big(p(y) - c(y)\big) * y.$

The FOC for profit maximisation leads to $p = MC - y\frac{dp}{dy}, \quad \frac{dp}{dy} < 0$

As the price is a falling function of output, the price of the good will be larger than under perfect competition, generating welfare loss and market failure. Governments often chose to intervene and have public ownerships of firms in these markets.

Large infrastructure such as road networks, public transport, and electricity supply are often natural monopolies run by government. These sectors are also accountable for a large share of global emissions (Lamb et al. 2022). Governments can reduce emissions by investing in more sustainable reconstructions of public goods and natural monopolies such as eco-friendly transport systems or a more efficient energy provision system.

4. Method and data

4.1 Climate legislation data

Data regarding climate legislation is from the Grantham Research Institute on Climate Change and Environment who developed the climate laws database. It covers national legislation for 196 countries and supra-national legislation passed through the European Union. 141 countries are included in this study due to lack of data on other observables. A law is defined broadly to include any legal document with full legal force, passed through the legislature or executive decision-making body (Grantham Research Institute, 2022).

The laws are first categorized into four types of policy responses to climate change. Laws are only included in this study if they belong to the mitigation category, the laws with a focus on reducing greenhouse gas emissions. The other three categories, adaption, disaster risk management and loss and damage all focus on preparation for consequences of climate change in different ways.

Laws are further categorized by the instrument the law aims to use. The database recognizes a total of 23 categories of which 19 are used in the sample. These categories are grouped by the Grantham Research Institutes own typology based on Hood and Margetts (2007) NATO typology. What follows is an explanation of the original NATO typology and how it is translated in the typology used in the database according to Nachmany et al, (2019)

NATO is an acronym for Nodality, Authority, Treasure, and Organisation and encompasses all available “tools” to the government.

Nodality refers to government nodes being a part of an information or social network and gives government the ability to spread or gather information. It is translated to the group *Information* which includes policies aiming to educate and train (spread) or to increase research and development (gather). This category can be viewed as investment in informational public goods

Authority refers to the usage of legal or official power to demand, forbid, guarantee, adjudicate. This is translated to the group *Regulation* which includes laws regarding standards and obligations, building codes, zoning, and spatial planning, and disclosure obligations. The category can be tied command and control regulation.

Treasure refers to the usage of financial means to influence others or purchasing goods. This tool is split into two. *Economic* includes laws aimed at influencing through financial means such as subsidies, taxes, and similar tools. *Direct investments* include policies in which government makes expenditures on public goods or social safety nets.

Organisation refers to usage of physical abilities to act directly and is translated into *Governance.* The category includes polices aimed at creating institutions and assigning responsibilities within government, designing processes, plans and strategies, and monitoring. This category cannot easily be tied to any economic theory as it mainly acts as a supportive tool, making sure that governmental work is performed informed and efficiently.

Laws are coded into five different dummies, based upon the policy instrument used. They are active from the year which they were passed. Many laws rely on multiple instruments leading to a total of 2163 observed laws and 3385 observations of instrument usage. The database also describes other events related to the law. Any event describing a replacement or repeal is coded as -1, indicating the removal of a law for future time periods. Any event describing an amendment, update, revision, added decree or other clear indication of law-strengthening is coded as a separate dummy denoting an amendment.

Table 4.1 shows how many times each instrument has been used and in how many countries an instrument has been used. In parenthesis are the number of laws passed through parliament. The most used instrument is governance which is a part of 80% of all climate legislation and used in every country. This is not surprising as laws and policies require some form of organisational structure for implementation monitoring and follow through. The least used instrument both regarding amount of countries and number of laws is direct investment which only accounts for 7% of all laws. In almost every category, a slight majority of laws are passed through parliament. The regulation instrument is only passed as an executive order/decree in 16% of cases.

Table 4.1. The use of instruments by countries and laws

Instrument:	Number of countries	Number of laws
Regulation:	94	726 (610)
Standards, obligations and norms	92	709 (601)
Disclosure obligations	8	8 (7)
Zoning and spatial planning	17	20 (7)
Economic:	92	345 (246)
Subsidies	62	155 (104)
Tax Incentives	84	227 (167)
Insurance	4	4 (1)
Climate Finance Tools	1	1 (0)
Direct Investments	88	166 (82)
Provision of Climate Funds	68	107 (74)
Nature based solutions and eco systems	54	71 (34)
Early warnings systems	11	15 (2)
Other	7	8 (3)
Governance	141	1750 (1018)
Capacity Building	111	533 (325)
Institutional Mandates	94	195 (103)
International Cooperation	65	136 (64)
Processes, Planning and Strategies	139	1485 (837)
MRV	80	209 (125)
Subnational and Citizen Participation	69	171 (136)
Information	95	398 (261)
Education, Training and Knowledge	75	262 (188)
Research and Development, Knowledge Generation	77	170 (80)

Figure 4.1 shows the passage of laws over time. 250 laws using the governance instrument were passed in 2009. Very few laws are passed before 2003, after which all categories except Direct investment begin to be used more frequently. There is large variation year to year with the biggest increases close to international conventions.

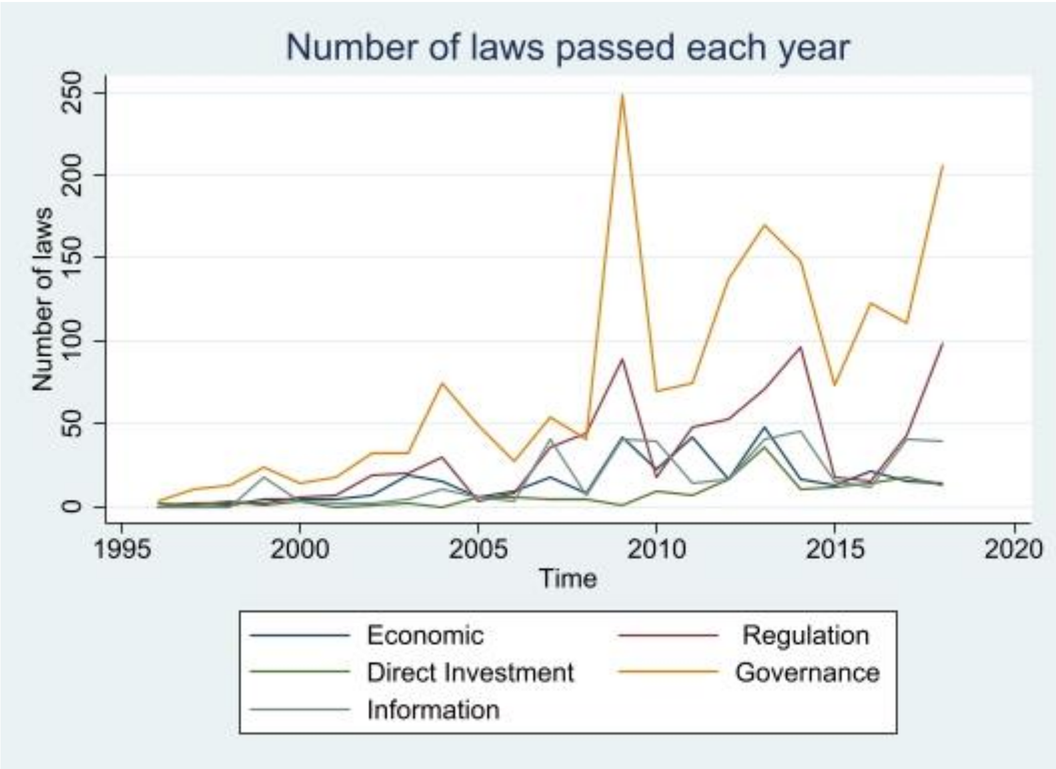

Figure 4.1. Total laws using instrument passed each year

4.2 Method

The method used follows Eskander and Fankhauser (2020) and is a difference in difference model using panel data with two-way fixed effects. The base model is given by the following equation:

$$y_{i,t} = \beta_j^s * S_{i,j,t}^s + \beta_j^l * S_{i,j,t}^l + \beta_j^a * S_{i,j,t}^a + \gamma * X_{i,t} + \alpha_i + \mu_t + \varepsilon_{i,t}$$

The dependent variable $y_{i,t}$ is the logged CO2 emission intensity for country *i* at time *t*. Emission intensity is the ratio of CO2 emissions to GDP (mtCO2e/GDP). By using emission intensity instead of absolute emission levels, the variable is standardized and confounding factors such as economic activity and country size become less important in the model. Dechezleprêtre and Sato (2017), reviews empirical literature on environmental regulations impact on firms' competitiveness and do find negative effects in pollution and energy-intensive sectors in the short run. The effects are small within sector and assumed in this study to be inconsequential for GDP but could bias results towards zero.

The impact of a law, using policy instrument j, on emission intensity is divided into a short-term effect, β_j^s, and a long-term effect, β_j^l. A law passed at time *t* should reasonably influence emissions in all future periods. The effect will likely be increasing with. It is assumed that the passing of a law has no contemporaneous effect as many laws are not implemented directly after its passage. It takes time for an economy's actors to adapt to a law and some are phased in with increasing stringency over time. To reduce the number of lags, the effect is assumed to be the same for the first three years after a passage allowing us to create variable containing the stock recent laws, $S_{i,j,t}^s = \sum_{k=1}^{3} L_{i,j,t-k}$. $L_{i,j,t}$ is a dummy equal to 1 for each law using instrument j. The short-term effect is expected to be smaller as actors are still adapting. All laws which have been passed more than three years ago are also assumed to be fully implemented and have the same effect. They are collected in the stock of older laws, $S_{i,j,t}^l = \sum_{k=1}^{t-4} L_{i,j,k} + S_{i,j,0}$. $S_{i,j,0}$ contains the number climate laws passed within the country before 1993. $S_{i,j,t}^a$, is a stock of recent amendments to laws which generally imply a larger scope for an existing law.

$X_{i,t}$ is a vector of control variables. It includes log of GDP per capita and its second polynomial to control for an Environmental Kuznets curve. To further control for emissions procyclical tendency, a Hodrick-Prescott decomposition is used to filter out the cyclical component of GDP which also is used as a determinant. Further economic factors include imports share of GDP to control for changes in imported emissions over time as well as services share of GDP to control for a change in emission-intensiveness in the economic activity. The annual temperatures deviation from its long-term average is included to control for higher energy use due to weather which could affect emissions.

The final control is a measure of rule of law from the Worldwide Governance Indicators. This measure captures *"the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence"* (cited by Kaufman, et al., 2010). This is included as laws and policies may not be as effective in lowering emissions when actors within the state are less likely to follow them.

Further, α_i is country fixed effect to control for all unobserved time-invariant characteristics of a state such as geographical factors and culture. μ_t is a time fixed effect controlling for shared unobservable time variant factors such as technological development and global shocks to energy prices. $\varepsilon_{i,t}$ is an error term containing the remaining unexplained variation.

By controlling for multiple factors and using the great variance in law implementation between countries and over the time, the method can determine the average short- and long-term effect on emissions of implementing a law. The large problem with this methodology being of course that laws vary greatly in scope and ambition. The results will be able to tell us which instrument has worked best so far but not why. While it is possible that the instrument showing the largest effects is the best type for emission reduction, another possibility is that the instrument has had the strongest laws and policies.

Two alternative models are used to investigate legislative quality. First, laws are divided by whether they enter into force through parliament or as an executive order. Eskander and Fankhauser find legislative acts to be more effective than executive orders, most likely due to being more powerful.

Secondly, laws are interacted with the rule of law indicator to get laws weighted by the country's ability to enforce them. Unlike Eskander and Fankhauser, in this study the stocks of recent and older laws at time *t* are interacted with the rule of law indicator at time t, instead of the indicators value within the year the law was passed. While the previous works was interested in the role of implementation capacity, this study will instead focus on enforcement capacity. This formulation also makes it possible to include observations back to 1996 instead of 1999.

Both economic variables and laws are expected to have different effects in advanced economies compared to developing economies. Therefore, A regression is performed on these two groups separately. IMF's classification is used to determine whether a country is considered advanced (IMF 2021).

Eskander and Fankhauser chose to lag all variables except rule of law. This is done to deal with endogeneity issues but in both EKC literature and in Doda's paper on the effects of the business cycle, common practice is to use contemporaneous variables (Stern, 2004; Doda, 2013). As a robustness test, the main regression is carried out with lagged control variables to check for differences. A final robustness check uses CO2 emissions per capita instead of emissions per GDP as the dependent variable. Emissions per capita is another way to standardize emissions across countries which removes the possibility of effects through the GDP channel.

4.3 Data

The data on emissions, GDP, and the shares of GDP which represents imports and services are all retrieved from the World Bank's World Development Indicators (World Bank, 2022). GDP per capita and emission intensity use constant 2017 PPP adjusted international dollars. CO2 emissions are measured by those released from the burning of fossil fuels and the manufacture of cement which make up a vast majority of all human-made CO2 emissions.

Data on rule of law is retrieved from the World Bank's Worldwide Governance Indicators (World Bank, 2022). It is originally constructed as a measure on a scale between -2.5 to 2.5. It is reconstructed as a scale between 0-2 so it can be interacted with the law variables. The reconstruction uses the following method: $r_{i,t}^{new} = \frac{r_{i,t}^{orig} - r_{min}^{orig}}{r_{max}^{orig} - r_{min}^{orig}} * 2$. $r_{i,t}^{new}$ is the transformed rule of law indicator. It is created by subtracting the lowest rule of law, r_{min}^{orig}, value within the sample from the original measure, $r_{i,t}^{orig}$ and dividing by the full range of the original scale. It is multiplied by 2 to make the weight of a law in a country with average rule of law equal to one when interacting laws with the indicator.

Average annual temperature for each country is retrieved from the World Bank's Climate Change Knowledge Portal (World Bank, 2022). The deviation from long-term average is calculated as $dt_{i,t} = t_{i,t} - \overline{t_i}$ where $t_{i,t}$ is the average annual temperature in country *i* in year *t* and $\overline{t_i}$ is the average within country temperature over 1996-2018.

Summary statistics for the variables are shown in table 4.2. In parenthesis are within country standard deviation. In the average year, a country implements 0.667 laws. The cyclical component of GDP is denoted HP-filter. Temperature deviation and HP-filter both show means close to zero as expected. Laws, temperature deviation and HP-filter show relatively large standard deviation within country while the other variables to a greater degree vary between countries. In a few small countries, the ratio of imported goods and services to GDP are larger than one with Singapore reaching the highest level in 2008 of 2.083.

Table 4.2. Summary statistics

Variable	Mean	Std. dev.	min	Max
Emission intensity	0.247	0.213 (0.087)	0.023	1.977
Passed laws	0.667	1.415 (1.236)	0	13
Economic	0.106	0.360 (0.334)	0	4
Direct Investment	0.051	0.237 (0.228)	0	3
Governance	0.540	1.178 (1.039)	0	10
Information	0.123	0.370 (0.335)	0	5
Regulation	0.224	0.652 (0.554)	0	6
Rule of law	1.006	0.465 (0.090)	0.000	2
GDP per capita	17605.67	18566.91 (3451.521)	506.151	120647.8
HP-filter	-1.38e-07	1084.035 (1084.035)	-10611.02	11931.66
Imports	0.453	0.248 (0.084)	0.0002	2.083
Service	0.531	0.114 (0.040)	0.109	0.824
Temperature dev.	-0.0001	0.434 (0.434)	-2.145	1.58

Figure 4.2 Shows the trend in emission intensity 1996-2018 for advanced and developing economies. While both show a declining trend over time, it is much steeper for advanced economies. As the trends show large differences, the model specification with advanced and developing economies separated is likely be more trustworthy.

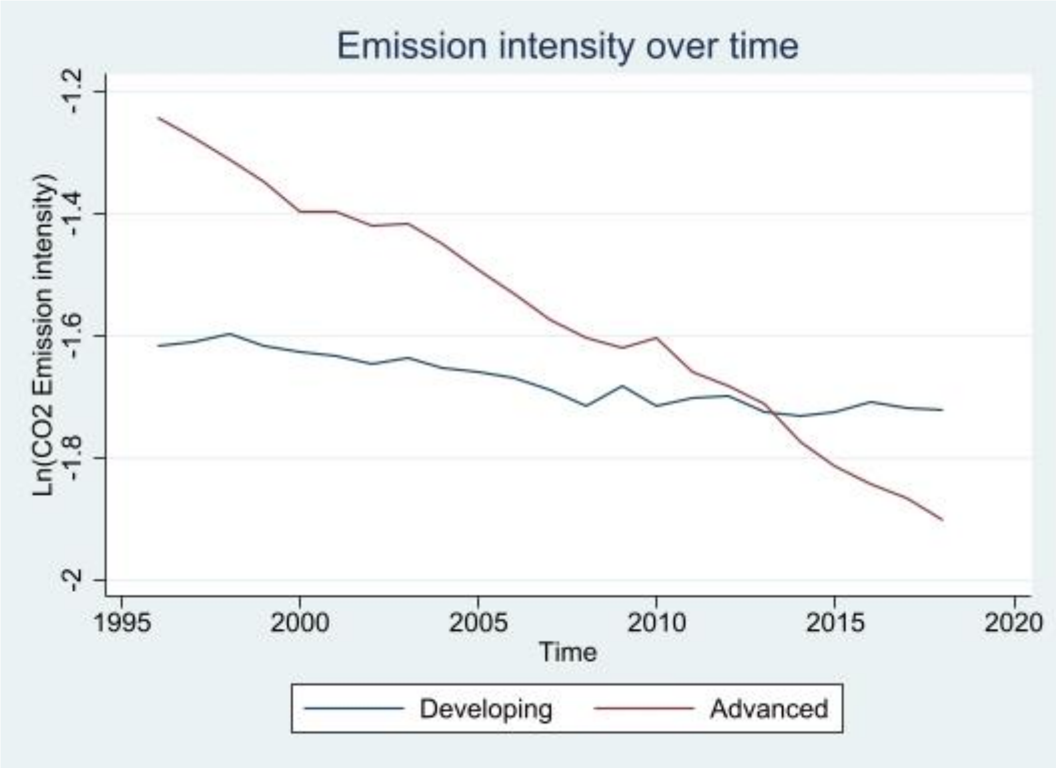

Figure 4.2. Average ln(CO2 Emission intensity) over time, advanced and developing economies

5. Results

Table 5.1. shows the results of the baseline model. In Panel a, all laws are included in the same stock while panel b show results when the laws are grouped their instruments. In panel a, all control variables are reported. To save space, control variables are not included in panel b or table 5.2. No control variable changes significantly in these model specifications.

Emissions moves as expected with most of the variables. The relationship with GDP is positive but negative with its second polynomial indicating that GDP rises with increased production, but the marginal increase is diminishing due to compositional and technological change. Emissions also show a the business cycle. There are no significant effects from the service share of GDP, possibly due to low variation within the variable. Surprisingly emissions tend to increase with imports share of GDP signalling that there is no large component of outsourcing emission intensive production in this period. There is also a negative relationship with temperature deviation. The sample includes many countries with a warm climate and thus, it is likely that increased energy use through cooling has a dominating effect. When studying the general implementation of a law, all coefficients show a negative sign but only the stock of older laws show a significant effect. As emission intensity is in log form, the coefficient indicates that in the long-term, climate legislation reduces emissions by

1.08%. This sample with more countries and years included, show smaller effects than the Eskander and Fankhauser (2020) results.

Panel b shows the regression when laws are divided by policy instruments. There are large differences between the different types of climate legislation with only two showing significant negative effects and one even showing a positive relationship. The economic instrument, mostly including taxes and subsidies has a negative sign on all three stocks, the recent, the amended and the older stock of laws. Only the long-term effect is significant, reducing emissions by 2.39%.

Direct investments and governance tools show no significant effects at all. 40% of the direct investment are into nature-based solutions which do not reduce the amount of emissions produced. They capture CO2 to reduce the amount of atmospheric CO2 which is not what the dependent variable measures. Investments, in green public goods also take a long time to produce and most investments are recent (see figure 4.1). Therefore, it is not surprising that the variable shows no effect. Information tools, containing research and development as well as training and education even has a positive effect on emissions both in the short-term (3.2%) and long-term (3.4%).

Regulation based tools, dominated by standards, obligations, and norms, seem to be working best as intended. In the short-term emissions are reduced by 2.94% and in the long term by 3.46%. There are no significant effects from amended laws in any category. Most likely there are too few observations. A model which included amended laws in the recent stock was tested, showing no different results.

Table 5.1. Effects of climate legislation on emissions

Panel a. Effect of all laws on emission VARIABLES	Emission Intensity	Panel b. Effects of instrument on emissions VARIABLES	Emission Intensity
Laws, Recent	-0.00273 (0.00255)	Economic, Recent	-0.00135 (0.00879)
Laws, Amended	-0.00766 (0.00711)	Economic, Amended	-0.00882 (0.0162)
Laws, Older	-0.0108*** (0.00167)	Economic, Older	-0.0239** (0.0112)
Ln(GDP per capita)	2.223*** (0.619)	Direct investment, Recent	0.0190 (0.0147)
Ln(GDP per capita)²	-0.152*** (0.0345)	Direct investment, Amended	-0.00766 (0.00711)
Imports	0.185* (0.108)	Direct investment, Older	0.000538 (0.0190)
Service	-0.0571 (0.250)	Information, Recent	0.0320** (0.0130)
Rule of law	-0.164 (0.101)	Information, Amended	-0.00754 (0.0192)
Temperature dev.	-0.0400*** (0.0106)	Information, Older	0.0344** (0.0140)
HP-filter	1.70e-05*** (5.46e-06)	Governance, Recent	-0.00169 (0.00509)
		Governance, Amended	0.00212 (0.0102)
		Governance, Older	0.00394 (0.00619)
		Regulation, Recent	-0.0294*** (0.00832)
		Regulation, Amended	0.00964 (0.0108)
		Regulation, Older	-0.0346*** (0.00790)
Number of countries	141	Number of id_c	141
R-squared	0.401	R-squared	0.427
Country FE	YES	Country FE	YES
Year FE	YES	Year FE	YES

Note: Both columns display a two-way fixed effects regression of the impact climate legislation on ln(CO2 emissions per GDP). The regression in column 2 divides laws by government tool it uses. Both regressions include the same control variables. Robust standard errors are presented in the parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5.2 explores the models with a focus on legislative quality. In column 1, the stock of laws is weighted by the rule of law indicator in country *i* at time *t*. The mean value of an implemented law will be the mean of the rule of law indicator, 1.005. It will be 2 in the country where rules are followed to the greatest degree and close to zero where it is followed the least. In this specification, all significant coefficients move towards zero, but changes are relatively small. The coefficients show the effects in countries with average rule of law. The effects in a country at the 75th percentile of the rule of law scale would be the coefficient time 1.5 leading to about 25–50 % larger effects than the main model. By the same logic, effects in countries with low rule of law will be close to zero. This model has slightly lower R^2 meaning the interacted laws explain less than the main model. Column 2–4 explores the possibility of different effects of legislative acts and executive orders. Column 2 and 3 show regression with only legislative acts and executive orders respectively. The negative effects from economic and regulation tools are only statistically significant when laws are passed through parliament. Most likely comprehensive laws with large scope and strong penalties can only be passed through parliament. Policy set by the executive branch does not hold enough weight to have a significant effect. The positive relationship between information tools and emissions remains for both types of implementations but the increase is much larger for executive acts. When using both in the same regression all effects weaken in significance due to multicollinearity.

Table 5.2. Legislative quality,

VARIABLES	(1) Rule of law weighted	(2) Legislative (only)	(3) Executive (only)	(4a) Legislative (both)	(4b) Executive (both)
Economic, Recent	-0.00106 (0.00570)	-0.00420 (0.00879)	0.0132 (0.0207)	-0.00749 (0.00943)	0.0146 (0.0185)
Economic, Amended	-0.00344 (0.00978)	-0.0150 (0.0213)	-0.00799 (0.0287)	-0.00711 (0.0204)	-0.0203 (0.0262)
Economic, Older	-0.0150** (0.00747)	-0.0223** (0.0108)	-0.0395 (0.0313)	-0.0219* (0.0121)	0.0149 (0.0307)
Direct investment, Recent	0.0163 (0.0120)	-0.0156 (0.0178)	0.0666*** (0.0230)	-0.00548 (0.0174)	0.0280 (0.0218)
Direct investment, Amended	-0.00891 (0.0360)	-0.0557 (0.0567)	-0.00650 (0.0897)	-0.0693 (0.0638)	-0.0466 (0.0796)
Direct investment, Older	2.79e-05 (0.0158)	-0.0102 (0.0216)	-0.0309 (0.0367)	-0.0122 (0.0240)	-0.0286 (0.0503)
Information, Recent	0.0245* (0.0127)	-0.0117 (0.0138)	0.0630*** (0.0183)	-0.0194 (0.0157)	0.0487*** (0.0170)
Information, Amended	-0.0120 (0.0120)	0.00292 (0.0219)	0.0601 (0.0749)	-0.0134 (0.0224)	0.0693 (0.0549)
Information, Older	0.0337*** (0.0125)	0.0354** (0.0137)	0.0594*** (0.0226)	0.0286 (0.0213)	0.00380 (0.0305)
Governance, Recent	-0.00126 (0.00303)	0.00268 (0.00601)	-0.0257*** (0.00945)	-0.00193 (0.00612)	-0.00123 (0.00777)
Governance, Amended	0.00247 (0.00592)	-0.00151 (0.0105)	0.0132 (0.0396)	0.0104 (0.00981)	0.0149 (0.0335)
Governance, Older	0.000811 (0.00369)	0.00508 (0.00598)	0.00926 (0.0111)	-0.00786 (0.00747)	0.0277** (0.0109)
Regulation, Recent	-0.0213*** (0.00558)	-0.0270** (0.0103)	-0.0110 (0.0150)	-0.0116 (0.00995)	-0.0190 (0.0133)
Regulation, Amended	0.00757 (0.00677)	0.0136 (0.0109)	0.0198 (0.0294)	0.0113 (0.0113)	0.0121 (0.0276)
Regulation, Older	-0.0251*** (0.00550)	-0.0336*** (0.00769)	-0.0108 (0.0152)	-0.0197* (0.0111)	-0.00307 (0.0198)
R-squared	0.426	0.424	0.388	0.444	
Number of countries	141	141	141	141	
Country FE	YES	YES	YES	YES	
Year FE	YES	YES	YES	YES	

Note: Each columns displays a two-way fixed effects regression of the impact climate legislation on ln(CO2 emissions per GDP). In column 1, laws are weighted by the country's enforcement capacity, (Stock of laws * Rule of law). Column 2-4 separates legislative acts from executive orders. All regressions use the control variables reported in table 5.1, panel a. Robust standard errors are presented in the parentheses
*** p<0.01, ** p<0.05, * p<0.1

The remaining robustness checks are reported in table 5.3. Column 1 and 2 show regressions including only advanced and developing economies respectively. In this table, control variables are once again included as all variables show a great difference when economies are grouped. Both the coefficients on GDP per capita and GDP per capita squared is doubled in size for advanced economies compared to developing economies. This is consistent with EKC literature. Developing countries will have lower peaks in the EKC due to better technology available and stronger pressure to reduce emissions at lower income levels (Stern, 2004). The advanced economies and is less affected by the economic cycle. This is consistent with Doda (2014) showing that the volatility of emissions weakens with GDP per capita. In advanced economies, the service share of GDP has a negative effect on emissions as expected as the service industry has low emission intensity. The relationship with temperature deviation remains negative despite a clear majority of advanced economies having a colder climate.

The effects of climate legislation vary greatly between the groups. In advanced economies the short-term effect of economic tools show significance, and the economic tools show much larger effects. Implementation of a climate related tax or subsidy reduces emissions by 1.47% in the short term and by 3.55% in the long-term. In developing economies, all significant effects of economic tools are lost, and coefficients even flip sign. The positive effect of information tools has disappeared for advanced economies. The long-term effect of information tools is only significant at a 10% level in developing economies, but coefficients remain of similar size.

Regulation tools are the only ones which still show a negative effect in developing countries. The effect remains around 3% both in short and long-term. For advanced economies short-term effects of regulation are only significant at 10% level and effects are only half of those in developing economies. The advanced economies share lots of similarities. The time fixed effects and can pick up much more of the trend in emission intensity. control variables and laws explain more of the variance leading to an R^2 of 0.897. The developing countries however have more outliers who divide from the shared path leading to a worse model fit.

In column 3, the regression is tested with lagged control variables to see if any results change in a model more robust to endogeneity problems. While there are some minor changes to coefficient values, results remain approximately the same for all variables included and no variable loses its significance. The same holds true when using emissions per capita as dependent variable in column 4, showing that results are robust over different standardisation methods.

Table 5.3 Robustness checks: economy groupings, lagged controls and emissions per capita

VARIABLES	(1) Advanced economies	(2) Developing economies	(3) Lagged controls	(4) Emission per capita
Economic, Recent	-0.0147** (0.00596)	0.0188 (0.0146)	-0.000576 (0.00836)	-0.00125 (0.00880)
Economic, Amended	-0.0265 (0.0166)	-0.0224 (0.0306)	-0.0130 (0.0156)	-0.00926 (0.0161)
Economic, Older	-0.0355*** (0.00779)	0.000566 (0.0198)	-0.0238** (0.0109)	-0.0240** (0.0112)
Direct investment, Recent	0.0105 (0.0163)	0.0237 (0.0183)	0.0210 (0.0142)	0.0188 (0.0147)
Direct investment, Amended	-0.00387 (0.0326)	-0.0369 (0.0891)	-0.0178 (0.0520)	-0.0193 (0.0566)
Direct investment, Older	0.0189 (0.0246)	-0.0103 (0.0253)	-0.00427 (0.0193)	0.000462 (0.0190)
Information, Recent	-0.00605 (0.0117)	0.0438*** (0.0153)	0.0306** (0.0127)	0.0322** (0.0130)
Information, Amended	0.00569 (0.0160)	0.0145 (0.0317)	-0.00260 (0.0196)	-0.00743 (0.0192)
Information, Older	-0.000811 (0.0142)	0.0327* (0.0167)	0.0347** (0.0142)	0.0346** (0.0140)
Governance, Recent	0.00362 (0.00322)	-0.00482 (0.00803)	-0.00225 (0.00484)	-0.00177 (0.00509)
Governance, Amended	0.00619 (0.00642)	-0.00264 (0.0244)	0.00117 (0.00972)	0.00208 (0.0102)
Governance, Older	0.00869* (0.00462)	0.00438 (0.0116)	0.00501 (0.00599)	0.00403 (0.00620)
Regulation, Recent	-0.0108* (0.00576)	-0.0301** (0.0142)	-0.0252*** (0.00803)	-0.0293*** (0.00833)
Regulation, Amended	0.0229** (0.00911)	-0.00584 (0.0226)	0.0129 (0.0104)	0.01000 (0.0108)
Regulation, Older	-0.0152** (0.00589)	-0.0336** (0.0133)	-0.0356*** (0.00791)	-0.0348*** (0.00796)
Ln(GDP per capita)	3.285*** (0.967)	1.555** (0.675)	1.935*** (0.619)	2.893*** (0.611)
Ln(GDP per capita)^2	-0.209*** (0.0491)	-0.119*** (0.0397)	-0.137*** (0.0343)	-0.136*** (0.0342)
Imports	0.0647 (0.136)	0.207* (0.119)	0.155 (0.107)	0.171 (0.104)
Service	-1.100** (0.508)	0.0819 (0.250)	-0.0591 (0.253)	-0.00232 (0.242)
Rule of law	0.385 (0.336)	-0.316 (0.229)	-0.0953 (0.0987)	-0.142 (0.0990)
Temperature dev.	-0.0313*** (0.00668)	-0.0409** (0.0167)	-0.0290*** (0.00972)	-0.0396*** (0.0103)
HP-filter	1.51e-05*** (3.63e-06)	2.21e-05** (1.06e-05)	2.12e-05*** (5.26e-06)	1.60e-05*** (5.42e-06)

R-squared	0.897	0.288	141	141
Number of countries	34	107	0.405	0.463
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Note: In column 1 and 2 economies are separated using IMFs (2021) economy groupings. In column 3, all control variables are lagged one period. Column 4 uses ln(CO_2 emissions per capita) as dependent variable. Robust standard errors are presented in the parentheses *** p<0.01, ** p<0.05, * p<0.1

6. Discussion

The analysis performed in this paper suggests that the policies most supported by public economic theory are the ones that work best. If an externality problem cannot be solved by clearly defined property rights, which is the case with air pollution, the most agreed upon method to correct the market is through taxing schemes (Rosen and Gayer, 2008; Hindricks and Myles, 2013). Taxing schemes allows the polluter the most flexibility in finding an economically efficient way to reduce emissions. It also requires that the government can construct a scheme which creates enough incentive for the polluter to reduce their emissions and has the capacity to monitor the market. This seems only to be the case for advanced economies. As shown in table 5.3, effects are heightened for these countries when the groups are split, while no reducing effect remains in the regression over developing economies. The most plausible explanation is that only advanced economies have selected high enough tax incentives for polluters to react. The coefficients on the stocks of economic laws is also among the ones most affected by the rule of law interaction. If the effect of economic instruments is dependent on rule of law, a reasonable conclusion is that developing countries also have a problem of monitoring and penalising polluters.

Command and control regulation is generally not preferred as it offers less flexibility and less incentive to continue reducing emissions (Rosen and Gayer, 2008). As this study explores the emission ratio to GDP, the results indicate that regulation tools may have not been inefficient. If command and control tools were less efficient than tax incentives, the reduced emissions per GDP would smaller for regulation tools compared to economic tools as the denominator would be more negatively affected as well. This is the case in advanced economies but not in the main model, nor for developing economies. Most likely, developing economies have been able to legislate more stringent command and control laws but they can be the preferred tool moving forward if countries lack ability to monitor a taxing scheme. It is the policy tool that has shown most robust effects in the study and should be in policy makers minds as they continue the fight against climate change.

Remaining instruments do not show any decreasing effects on emissions. It is important to keep in mind the limitations of the model. The explanatory variables are the passage of climate laws and policy. The time between the decision to invest in a public good, to when the project is finished is often long, hence, no short-term effect is expected. The time span of the sample is only 22 years. It's likely that many of the large-scale projects have not even been finished. The climate mitigating effects of nature-based solution cannot be captured by the dependent variable as it measures emissions produced and not emissions in the atmosphere. Even if these are removed, direct investments show no significant effect.

Information tools show a positive effect, but this is likely driven by a multicollinearity issue. A regression was tested without inclusion of other policy tools. it shows a significant negative long-term effect driven by advanced economies. At the same time, excluding other laws could cause missing variable bias. The positive effect could indicate that the developing countries who chose to invest in information tools, performed worse. While the government can be a good collector and distributor of knowledge, there is not as clear of market failure to correct. R&D and training might be better handled by the private. The information category consists of public goods with a strict climate mitigation goal and show no sign of success. It is used more than tax incentives and cannot be recommended based on the results. Other public goods with a wider purpose are important, and the government should consider climate effects when designing these projects. Designing policy for reducing emissions should nevertheless rely on tools with a more direct link to the externality for certainty in results.

The study confirms Eskander and Fankhauser's (2020) results that implementation form matters. Legislative acts show significant effects while executive branch policies do not. In most countries the executive branch does not have the power to implement orders/decrees with the same power as a law. They are also easily over-ruled by the next party to win the vote which means they are more often short-lived. For government policy to have effect, it requires the full power of the law.

The main model can explain a rather large share of within variation with R^2 of 0.43. The explanatory power is doubled when only regressing advanced economies, but it falls heftily for developing economies. While regulation tools seem to work worldwide, a further divide among the developing countries to improve model fit could maybe answer more about underlying foundations necessary for policy tools to work. Further research can investigate if the growth pace of the economy matters for legislative effectiveness by grouping economies like Le Quere et al. (2018). Another approach could analyse how effective different policy tools are in different sectors of the economy.

The largest problem with the methodology in this study is that all laws are coded as dummies with the same value while their ambitions vary greatly. It relies on a relationship that states that more laws lead to less emissions which is not necessarily true. Using both a taxing scheme and a performance standard in the same sector may not be optimal. Multiple tax incentives covering a sector each, may not reduce more emissions than one economy wide emission fee. The introduction of another climate law would generally imply that a country widens the share of emissions covered by legislation and the study can show that countries have been more successful when they have implemented laws relying on regulation or economic policy tools.

7. Conclusion

This study has researched five different types of instruments available to government when designing mitigating climate legislation. The results show that the tools with the strongest support by public economic theory and direct ties to correcting a negative externality are more effective in reducing emissions. Economic instruments relying on tax incentives and subsidies show the greatest effects in advanced economies, able to reduce emissions per GDP by 1.5% on average within the first three years and by 3.5% in the long term. For the remaining countries regulation tools, mostly relying on standards, norms, and obligations prove to be more effective with short and long-term reductions around 3%. Other policy tools show no clear reducing effects. In both cases, legislative acts passed through parliament are shown to be more effective than executive orders/decrees. Policy needs the full power of the law to be effective.

To reach the goals of the Paris agreement, the world needs to act quickly, and governments play a key role. Climate legislation can be a strong force moving us in the right direction, but policy makers need to make informed decisions and design laws with certainty of results. This study gives a clear case that performance and technical standards has been successful worldwide, implying that most of the world can build a successful framework using command and control regulation. Tax incentives and subsidies are theoretically more efficient. If developing economies want to use these tools, they must be more ambitious in their execution.

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