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Decarbonizing Economies through Carbon Pricing – Is there an ideal policy mix?

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Abstract

Explicit and implicit carbon pricing are indispensable to reduce emissions and direct economies towards carbon neutrality. This report aimed to investigate whether there is a policy mix that is the most effective in emission reduction. A cluster analysis showed that stringent market-based instruments such as the CO2 tax are substantial for effective emission abatement. In a second step, a political feasibility analysis was conducted to investigate how Mexico can improve its environmental policy frameworks. This showed the importance of addressing distributional concerns and introducing country-specific steps to advance national carbon pricing strategies.

Contents

Glossary of Abbreviations

AMLO: Andrés Manuel López Obrador

BAU: Business as Usual

CAD: Canadian Dollar

CAT: Climate Action Tracker

CDM: Clean Development Mechanism

CER: Certified Emission Reductions

CO2: Carbon Dioxide

EC: European Commission

EPS: Environmental Policy Stringency Index

ETS: Emission trading system

EUR: Euro

FFS: Fossil Fuel Subsidies

FiT: Feed-in tariff

GDP: Gross domestic product

GHG: greenhouse gas

GLCC: General Climate Change Law

IEPS: Impuesto especial sobre produccion y servicios (Special Tax Law on Production and Services)

IMCC: Commission on Climate Change

INECC: National Institute of Ecology and Climate Change

LULUCF: Land use, land use change and forestry

MEE: Ministry of Ecology and Environment

NDC: Nationally Determined Contribution

NOK: Norvegian Krone

NOx: Nitrogen oxides

OBPS: Output Based pricing system

OECD: Organisation for Economic Co-operation and Development

PACE-Tool: Political Assessment of Clean air and Environmental Policies Tool

PCF: Pan Canadian Framework for clean growth and climate change

PECC: Special Programme on Climate Change

PPP: purchasing power parity

PRC: People Republic of China

R&D: Research and development

RE: Renewable energy

REA: Renewable energy auction

RET: Renewable energy technologies

RMB: Yuan

SEK: Swedish Krona

SEMARNAT: Secretaría de Medio Ambiente y Recursos Naturales (The Secretariat of Environment and Natural Resources)

SLCP: short-lived climate pollutants (SLCP)

SOx: Sulphur Oxides

STA: State Tax Administration

UN: United Nations

US: United States

USD: US Dollar

UNESCAP: The Economic and Social Commission for Asia and the Pacific

UNFCCC: United Nations Framework Convention on Climate Change

USCBC: US-China Business Council

VAT: Value added tax

Group Part

1. Introduction

Today's policymaking is driven by current and future consequences of climate change. Global greenhouse gas (GHG) emissions lead to a continuous increase of the world's temperature, resulting in extreme weather events like heatwaves, wildfires, or rising sea levels (National Geographic 2019). Recent years register records in peak temperatures, especially in the southern hemisphere, causing around 166,000 deaths between 1998-2017 (WHO 2022). In the future, climate inaction will make regions inhabitable, forcing around 216 million people to migrate within their countries by 2050 (World Bank 2022). Environmental impacts will also have substantial economic consequences and are projected to reduce the world's GDP by up to 18 percent in 2050 (WEF 2021). Weather-related shocks already caused up to 470 billion dollars in economic losses in 2017 (Kruse et al. 2022). As a result, governments are pressured to cut down greenhouse gas emissions and transition towards carbon-free economies. Global consensus on the pressing issue is captured in the Paris Agreement from 2015 where 196 parties signed an international treaty stating their commitment to reduce emissions (EC 2022). Although, historically, environmental policies were difficult to implement, global momentum on the subject and increasing public support for effective climate policies put governments in a position to advance their environmental commitments (Dechezleprêtre et al. 2022).

To offset emissions, states have a variety of policy instruments at their disposal. Those can be categorized into market-based, non-market based (command and control) and technology support instruments. Market-based instruments include carbon taxes and emission trading systems, non-market-based policies refer to performance standards, and policies such as feed-in tariff, renewable energy auctions or government expenditures for research and development classify as technology support instruments (Kruse et al. 2022). The vast variety of instruments leads to countries around the globe taking different approaches to climate mitigation policy.

In the absence of a global policy framework, some climate strategies taken by countries can cause challenges. Common problems include free-riding or carbon leakage, where firms move their production to countries with looser emission regulations (EC 2021). Moreover, given the variety of policy-approaches, the overall success in climate mitigation is dispersed and emission reduction around the globe is heterogenous (Ritchie et al. 2020). Generally, countries are lacking behind to meet the signed targets set in the Paris Agreement (Climate action tracker 2022) which creates the necessity for effective approaches to mitigate further consequences of climate change. In pursuance of transitioning to low-carbon economies, the international consensus moved towards the implementation of comprehensive policy packages, consisting of explicit and implicit carbon pricing, as well as other complementary policies (OECD 2015).

Research focusing on environmental policy usually analyses and compares the effectiveness, for instance in terms of cost, equity or marginal cost of abatement of emissions (MAC), of certain instruments like carbon taxes, trading systems or subsidies (Goulder and Parry, 2008; Stavins, 2019; Sen and Vollebergh (2018); Gugler et al. (2021)). The few studies that focus on policy effects on emission reductions, only analyze the effect of single carbon pricing instruments, mostly explicit ones. While there is a strand of research examining the effects of implicit instruments like FIT or subsidies on innovation and the uptake of renewable energy sources, research examining their effects on emission reductions does not exist to our knowledge. Also, the literature on the performance of policy mixes in terms of emission abatement is sparse. Thus, this work project in cooperation with the Organisation for Economic Co-operation and Development (OECD) aims to contribute to the literature by assessing the effectiveness of policy mixes in emission reduction across 40 countries taking into consideration both implicit and explicit pricing instruments. Moreover, country-focused analyses on the policy package of Mexico will provide an in-depth assessment of the political feasibility of different carbon pricing options depending on the national context.

Taken together, the objective of this work is to answer the following research question:

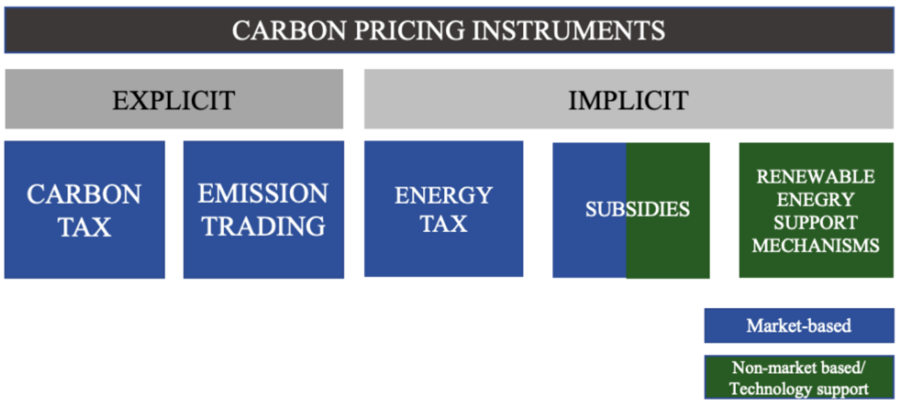
"Is there a policy-mix that is most effective in emission abatement and how can selected countries improve their environmental policy frameworks further?"

To answer this question, in Chapter 2 we begin by briefly introducing the different carbon pricing policy instruments and the economic intuition behind them. Then, an overview of the literature on the effectiveness of policy mixes to reduce emissions is presented in Chapter 3. Chapter 4 outlines the research approach taken in this report. As we define the policy mix of a country based on the OECD Environmental Policy Stringency Index (EPS) we will first explain the composition of this index. After validating the use of the EPS data set for analyzing emission intensity across countries through a bivariate regression, a hierarchical cluster analysis following the Ward's linkage method, will be calculated. With the latter, we intend to group the different countries based on their carbon pricing policy mix carbon and relate it to the associated reductions of emission intensity of the respective subset. Chapter 5 will go into the details of the described analysis and outline the results as well as their implications with regards to the research question. After discussing the "ideal" policy mix found in the cluster analysis and addressing possible limitations inherent in the research approach, the theoretical framework taken in the individual parts is outlined. A political feasibility assessment framework adapted by Peng et al. (2021) will be used for our five country-specific evaluations. In this individual report, the policy mix of Mexico will be outlined and analyzed. Based on the findings of the cluster analysis of the common part, country-specific analyses and insights from the political feasibility framework, country-specific policy recommendations to facilitate the transition to low-carbon economies will be provided for each of Mexico's economy.

2. Introduction to Environmental Policy Instruments

The necessary steps towards transitioning into a carbon-neutral economy, such as incentivizing agents in the markets to transition away from fossil fuels or shifting consumers behavior will require incurring significant costs (OECD 2013). Therefore, governments are facing the challenge of introducing coherent policies that minimize such costs by introducing an effective price on CO2 emissions. With such price on carbon in place, the burden of the damage can be conveyed back to the producers who are not only responsible but will also be incentivized to take measures to avoid it (World Bank 2022). The instruments currently available to policy makers today that have been developed in this pursuit are numerous and differ not only in (cost-) effectiveness but also equity, acceptability and feasibility. They can be divided into explicit, implicit and command-and-control instruments. For the purpose of this report the focus will lie on the first and second (D'Arcangelo et al. 2022, 26-38).

Figure 1. Classification of carbon pricing instruments



Source: OECD Power Point presentation given in class in T3 (OECD 2022).
Note: According to the literature review, there are many ways to classify carbon pricing instruments. In the following report we will refer to the grouping pictured above.

2.1. Explicit

According to economic theory, a well-functioning or perfect market can internalize all externalities. However, agents rarely pay the full social costs of their actions, leading to externalities in the market that must be eliminated. Carbon emissions, among other emissions are such an externality that needs to be addressed. One way to do so would be the creation of markets for the externalities, in this case carbon emissions. This is the underlying principle of the so called "marked-based instruments", which can be divided into price-based mechanisms, such as the most-well known Carbon Tax (Dasgupta 2021). Together with the Emission-Trading-System (ETS), an instrument that has also been developed at a fast pace in the last decades, those instruments are often labeled as "explicit" Carbon Pricing Instruments, as the goal of both is to put a price on each ton of CO2 emitted. These instruments ensure efficiency in resource allocation by providing the correct incentives to all economics agents, while in some cases, they also generate government revenue (OECD 2013).

2.1.1. Carbon Tax

Policymaking in the past was shaped by limiting or banning certain undesirable actions, in the form of command-and-control regulations. In the last decades, however, the focus shifted towards market-based instruments such as carbon taxes. A carbon tax is a market-based instrument that sets a price per ton of carbon emitted (OECD 2011a). In the economic literature it is considered one of the most effective instruments to mitigate emissions and thus offset climate change consequences (Sen and Vollebergh 2018; Stavins 2019). Carbon taxes have already been implemented by many countries around the world, yet the price range varies significantly. According to World Bank Data from 2021, Sweden had the largest carbon tax rate with 137 U.S. dollars per metric ton of CO2-equivalent while other countries as Poland had a lower tax rate around only 1 U.S. Dollar (World Bank 2021).

Benefits and Challenges

The underlying reason for using carbon taxes is that without government intervention, there is no market incentive for private firms to internalize the environmental damage they cause, since negative effects of this externality is not affecting the company directly. As a result, taxes follow the objective of addressing market failures. Compared to carbon taxes, regulations may lead to higher costs. For instance, incentives for certain environmental goods or actions are employed by governments to steer the behavior of the market in a certain direction. For an efficient outcome, this requires an extensive amount of information about continuously changing technologies and market dynamics which makes the right choice difficult. Thus, regulatory instruments may result in higher costs even if other technologies are available that could potentially lead to a better outcome (OECD 2011a).

An important characteristic and benefit of the carbon tax is the fact that it raises revenue for governments which can be used for various societal purposes that may lower the social cost of the policy (Stavins 2019). Nonetheless, besides the revenue-raising effect of this instrument, there are also potential drawbacks. Goulder and Perry (2008) highlight, that the main negative effect of a carbon tax is that the costs of the environmental instrument are shifted to the consumer, resulting in higher prices for fuels or other energy-intensive goods. This "tax-interaction effect" leads to an efficiency loss which is why distributional impacts of this policy must be considered (Gouder and Parry 2008). The impacts of a carbon price on households are split into "use-side-impacts", meaning how a policy influences relative prices of goods and services, and "source-side-impacts", implying how a carbon price influences nominal wages or capital transfers. While "use-side-impacts" of a carbon tax can be seen as usually regressive (when tax revenues are not recycled), since costs are shifted to individuals as underlined prior, the "source-side-impacts" are progressive. Alterations in nominal wages or capital income through usage of tax revenue, for instance "lump-sum recycling of tax revenue" or tax cuts have progressive impacts. Since "source-side-impacts" outweighs "use-side-impacts" due to tax revenue recycling the overall impact of carbon taxes is progressive, thus beneficial (Stavins 2019).

Another advantage of carbon taxes is that they provide a continuous incentive to abate emissions and innovate from a private company perspective. Technology-based regulations which set a certain standard only incentivize economic agents to adjust behavior until the standard is met, while taxes incentivize to maximize abatement to not incur additional costs. As a result, taxes can facilitate innovation since it is in the agent's best interest to minimize the costs of their operations. For instance, a carbon tax on fossil fuel incentivized auto-manufacturers to diversify car production towards ecological ways of transportation. Thus, more green innovation can diminish the social cost of policies addressing challenges regarding the climate change and the environment (OECD 2011a).

2.1.2. ETS

Emission Trading Systems are quantity-based mechanism to control pollution. Like the carbon tax, ETSs are part of incentive-based systems, but unlike the former instrument that focuses on price control, these instruments work through quantity control, which then indirectly has consequences for price. The distinguishing feature of emission trading systems is the transferability of permits (marketable permits) to pollute between the different individual sources. To talk more specifically about ETSs we need to differentiate them into two categories: cap-and-trade systems and baseline-and-credit systems (IEA 2020).

In cap-and-trade systems, an overall cap ("cap") on the number of emissions allowed in a given sector or area is initially chosen. Then a competent authority chooses the method of the initial allocation of permits, the sum of which must correspond to the chosen "cap". The authority can decide whether to sell the permits (auctioned permits) or to distribute them for free according to historic emissions (grandfathering approach) or even on an arbitrary basis (free initial allocation) (OECD 2013).

The concept of a baseline-and-credit system is similar, however, no cap is utilized. Instead, authority sets a standard for emissions (baseline) under a normal scenario and every firm must try to stay below this limit. If a company manages to pollute below the baseline it will earn credits. In both cases, with both permits and credits, companies that pollute less can sell the permits/credits to those that pollute more, creating an incentive to reduce emissions to the point where the abatement cost is equal to the gain from their sale (OECD 2013).

Benefits and Challenges

The cap-and-trade system bears multiple advantages. The idea of cap and trade is based on two specific points: companies will be encouraged to lower their emissions because there is a low cost to do so, while companies that have emission credits can sell them for extra profit. In addition, by having a predetermined maximum amount released, one can have a better idea of what is happening to the air quality and be able to work to reduce the maximum levels over time (Gaille 2015). The government often buys emission credits when they are available and then sells them at a higher price to businesses when they are needed. The income from these purchases helps to supplement the resources that taxpayers provide to the government (Gaille 2015). Finally, in the presence of cost uncertainty when the marginal benefit function exceeds that of the marginal cost function, then a quantity instrument is likely to be more efficient (smaller deadweight loss due to mistaken predictions of future costs). Karp and Traeger (2018) found that this is the case of pollution, and that quantity instruments are more efficient under cost uncertainty.

However, the system also has its limitations. The success of any cap-and-trade program depends on how it is designed, starting with the cap. For example, if the cap is set too high, companies can buy permits and set them aside for the future when the cap gets lower. Firms and agencies can buy credits or permits and choose not to use them, keep them indefinitely, and increase artificially the price. Such cost uncertainty (price volatility) in a cap-and-trade system can be an impediment to capital investment (Pindyck 2017) and could undermine political support for climate policy and discourage investment in new technologies, as well as research and development (Aldy and Stavins 2012). Another important factor is that for fossil-fuel intensive industries, the cost of converting to more renewable resources can be very high. Emission credits and penalties for exceeding a cap are frequently cheaper than a conversion to a new energy source. Consequently, there is no real incentive for these industries to change their practices (Kenton 2020). Finally, different nations may have different standards on what the cap should be. Some nations create more emissions than others. Some may be very lenient about emission limits and credits and others may be very strict, creating the possibility of carbon leakage (European Commission 2021).

In what concerns baseline-and-credit systems, they are still quantitative instruments but less binding than cap-and-trade since they allow the "cap" (baseline) to be exceeded at the cost of paying penalties. All the advantages and limitations mentioned above can also be applied to this instrument, except for some minor differences. While this makes it possible to decrease the problem of cap setting, it does not allow for precisely defining ex-ante the amount of emissions produced (Gaille 2015).

2.2. Implicit Carbon Pricing Instruments

Besides the explicit carbon pricing instruments there are also other instruments available to policy makers that price CO2 emissions not directly per ton of emissions produced but rather implicitly. Common implicit instruments are energy taxes, feed-in tariffs and subsidies. (D'Arcangelo et al. 2022). Taxes on energy like fuel and abatement subsidies classify as well as "market-based instruments" as they also introduce a market context. These implicit tools price not carbon emitted but rather the volume of resources used, or CO2 emissions abated. Renewable energy support mechanisms on the other hand, are so called "technology support" instruments or “non-market-based”, utilized in practice to support the investment in new research and development, technologies, energy sources etc. (OECD 2013). Each of these instruments will be explained below.

2.2.1. Renewable Energy Support Mechanisms

Energy policies establish the objectives for a nation's future energy use. By fostering market stability and boosting investor confidence, they enable the realization of energy support. Thus, these policies have a significant impact on how energy technologies are developed in the future. Since renewable energy technologies (RET) are not as established as conventional fossil-fuel based power generation technologies, governments can make use of supportive policy instruments to boost RETs in their countries. The two main support mechanisms, which can be categorized as implicit carbon pricing, are feed-in tariffs (FiT) and renewable energy auctions (REA).

2.2.1.1. Feed-in Tariff

Feed-in tariff is an implicit carbon pricing tool for accelerating renewable energy technology investment by granting long-term contracts to renewable energy (RE) producers, with the exact provisions typically depending on the cost of generation of each technology. The policy usually guarantees RE generators specified payments per unit (e.g. Euro per kWh) over a set period of time and provides price certainty by setting that the energy produced will be bought by the supplier as a last resort (RE21 2022). The establishment of such schemes is viewed as critical for the promotion of RET development, as the installation of a RE system incurs several costs for both the owner and the grid utility, including capital and installation costs, operational and maintenance costs, and costs of interconnecting and maintaining the installation on the grid. FiT systems are designed to aid RET's technological maturation, with the goal of reaching grid parity over a short period of time (Haas et al. 2008).

In 2021 92 countries worldwide applied the FiT scheme (REN21 2022). Each country's government appears to determine the FiT rate based on the capital, operational, and investment costs of the specific RE source (Campoccia et al. 2014), the regular cost of RE generation, plus a fixed price or auction-based price incentive usually set by legislators (Couture et al. 2010).

Feed-in tariffs are market-based instruments incentivizing the use of RET and the change of behavior within energy markets. They aim at improving energy efficiency and reducing the demand for traditional energy sources. Other broader market-based instruments include those that span energy markets, like cap-and-trade systems and carbon taxes, and are usually applied to the carbon content of energy. While those tools certainly have a place in addressing energy efficiency, they are often better at raising revenues rather than changing behavior, since energy price elasticities tend to be low (Eyre 2013). FiT limits the application of the price mechanism to the change in demand rather than the total demand. As a result, the amount of money raised for any given change in demand is significantly less, and the efficiency change to revenue transfer ratio is larger. Consequently, the political risks associated with raising large revenues on energy use are minimized (Eyre 2013).

Benefits and Challenges

The strengths of the FiT system are manifold. Firstly, a feed-in tariff offers a lot of design flexibility. Each government can set eligibility, contract duration, purchasing obligation, and capacity individually. Furthermore, the tariff level can be set based on national market conditions, with the option of promoting certain renewable energy technologies, innovations, or regional renewable energy development. Secondly, FiT increases investor confidence by providing long-term investment stability and helps manufacturers to broaden their time horizons when planning their operations, thereby promoting investments in renewable energy industries (UNESCAP 2012). Thirdly, FiT schemes are the most efficient policy for encouraging RE sources, since their mechanism's simplicity, stability, and fairness result in low administration and transaction costs, making it the most efficient policy for encouraging renewable energy sources (IPCC 2011). Finally, FiT methods that are properly implemented help society as a whole by creating jobs and lowering carbon emissions and their negative consequences. In the long run, FiTs can be viewed as a major engine of local and national economic growth and, in particular, green industry innovation.

Feed-in tariffs, however, also bear some challenges (UNESCAP 2012). To start with, finding the right tariff level is challenging: it must be established at a level that allows businesses that choose RE to compete with traditional fossil-fuel-based energy providers. Finding this level requires adaptability and a thorough understanding of the energy market's mechanics. Furthermore, capacity and cost management can prove problematic and policy makers must ensure that public resources are well handled and that they are not diverted from other, more critical development priorities. Lastly, grid access poses another key challenge. The FiT requires all renewable energy producers, including residential, commercial, and industrial customers, federal, state, and local government agencies, and non-profit organizations, to have assured, non-discriminatory grid access. This poses a problem for energy infrastructure, which may be required to connect frequently far renewable energy sources to a well-established grid that is typically concentrated in a city. The grid access guarantee may reduce the motivation for renewable energy installations to be located in the most cost-effective places (UNESCAP 2012).

2.2.1.2. Renewable Energy Auctions

Another instrument to support renewable energy technologies are renewable energy auctions (REA). In recent years, REA have become a popular policy tool, particularly in developing economies (Lucas, Ferroukhi and Hawila 2013). Several countries even have transitioned from FiTs to auction-based systems (Kruse et al. 2022). When a country follows a REA system, "(…) the government issues a call for tenders to install a certain capacity of renewable energy-based electricity" (p. 6, Lucas et al. 2013). Project developers submit a bid with an estimated cost per unit of power at which they are willing to take up the project. The winning bidder is given a power purchasing agreement after the government assesses the bids based on price and other factors. When well-constructed, the auction scheme's built-in price competition boosts cost effectiveness and enables price discovery for electricity derived from renewable sources, preventing potential windfall gains and underpayments. While REA have attractive attributes, they only reward the winning bids and frequently favor big companies that can pay the transaction and administrative costs (Lucas et al. 2013).

The two main auction models are sealed bid auctions and iterative process auction. In the former, each bidder submits their proposal, which includes the price and estimated power output, whereby the bidders cannot view one another's proposals. In an iterative process, also known as descending clock auction, the government announces a price for a RE production project. The bidders then state how much power generation they are willing to provide for this price. The auctioneer then gradually lowers the price, which causes the bidders to lower their offered generation quantities. This cycle is repeated until the amount of new renewable energy the government wants to invest in meets the quantity generation proposed. A third auction type is a hybrid version of the two (Lucas et al. 2013).

Similarly to feed-in tariffs, REA incentivize the use of renewable energy sources. Ideally, renewable energy auctions lead to cost-efficiency, in other words, to low awarded prices. This is the case, when there is high and fair competition in the auction, speculative over/ underbidding is mitigated and the bidder risk is low (Anatolitis, Azanbayev and Fleck 2022).

Benefits and challenges

The main benefit of REAs is that they offer guaranteed purchases at fixed prices as well as guaranteed access to the grid. Moreover, when well-designed, the auction scheme's built-in price competition enhances cost effectiveness and enables price discovery for power derived from renewable sources, preventing potential windfall gains and underpayments. Inherent long-term guarantees can result in better financing options and lower prices (Lucas et al. 2013). Finally, if there is high competition in renewable energy auctions, it leads to cost efficiency and the revelation of the de facto market price of different RE technologies (Laumanns 2014). There are also certain challenges which should be kept in mind when planning the implementation of renewable energy auctions. To start with, if auctions are not regularly scheduled, they may cause discontinuations in the development of the market. Secondly, small and medium enterprises might be discouraged from participation in the auctions given the high transaction costs caused by investments in project planning, feasibility studies and risk assessment, and the associated risk of not getting returns on the money spent if they are not succeeding in the auction (Lucas et al. 2013). Thirdly, REA imply high administrative costs, potentially deterring countries from implementing this policy (Laumanns 2014).

2.2.2. Subsidies and low-carbon R&D expenditures

Subsidies are another carbon pricing tool that can be utilized to either (in)directly reduce the use of something that has a proven negative impact on the environment or to provide a relief of opportunity cost an agent is facing (Goulder and Parry 2008; Dasgupta 2021). In the context of pollution abatement, it often describes financial payments or transfers from the government targeted to reduce damaging emissions, which would classify the instrument as an explicit, market-based carbon pricing instrument. Governments for instance reward emission producers with a lump-sum transfer for every unit of emissions that they reduce below a baseline to support a certain industry, business or individual with the overarching goal of promoting an activity that the government considers beneficial not only to the economy but also to society at large (Dasgupta 2021). As every additional unit of emission produced implies a cost to the firm (in foregone subsidy opportunities) the incentives provided by subsidies can be compared to those from emission taxes (Goulder and Parry 2008).

Furthermore, subsidies can also be leveraged to incentivize the use of low-carbon technologies by governments financially supporting the research and development of renewable energy sources, energy efficiency, carbon capture and storage nuclear as well as other cross-cutting technologies and research (Kruse et al. 2022). These public expenditures on R&D are usually designed to compensate for market failures that would under normal circumstances generate insufficient investments from the private sector (C2ES 2008). Lastly subsidies can also be given to individuals (e.g. by tax relieves) to promote behavior that is beneficial for society and the environment. Financial incentives to install solar panels or buy electric vehicles are examples for such subsidies that are designed to support individuals to comply with environmental standards (Steurer 2015). These last two subsidy-instruments mentioned classify as implicit and non-market-based instruments, which the following analysis will focus on.

Benefits and Challenges

Abatement subsidies have been applied and used widely across most OECD countries in the last decades, mostly in the form of grants, tax allowances or investments that are expected to lead to environmental improvements (Perman et al. 2003). One main benefit of the tool, which in-part can explain its attractiveness and acceptance (especially across firms) is that marginal reduction costs across heterogenous firms are equalized and the form and level of reducing is up to the respective firm (Goulder and Parry 2008). However, when evaluating its cost-effectiveness, the instrument performs weaker than taxes or tradable allowances in terms of pollution abatement. As described above, subsidies and R&D support are lowering production costs which often leads to increased output. As a result, to accomplish the same target emissions reductions as under the other two policies mentioned, regulators would need to set the marginal price of emissions (the subsidy rate) higher than under the other policies, leading to too much abatement from input substitution and too little from reduced output. Poorly designed subsidies might therefore end up increasing the cost of decarbonization and result in ineffective governmental transfers (Goulder and Parry 2008). Additionally, in many countries, initiatives of the public finance directed towards emission abatement subsidies end up fostering activities that are more harmful then beneficial to ecosystems and biodiversity, through increases of production and eventually pollution. Such harmful subsidies include for instance financial support for sectors such as fossil fuels, agriculture or fisheries. Recent OECD data suggests that annually around US$500 billion per year are spent across governments on subsidies which essentially harm biodiversity and our environment (OECD 2020). Lastly, when considering also subsidies offered to individuals in forms of tax relieves, regressivity also poses a problem as the desired economic behavior that is artificially supported is mostly undertaken by those who can afford to. This is for instance the case with solar panels or electric vehicles (D'Arcangelo et al. 2022).

2.2.3. Energy Tax

Energy taxes are pricing instruments which include, among others, fuel excise taxes, electricity consumption taxes (OECD 2019) and taxes on air travel (Goulder and Parry 2008). Energy taxes are imposed on energy products for transport purposes, energy products for stationary purposes (natural gas, oil) and greenhouse gases (i.e. carbon content of fuels). A well-designed energy tax represents the most direct way to correct externality (the cost of the harm to others) provoked by specific activities or products. It directly addresses the market failure by internalizing environmental costs into the market prices. Energy taxes are a relevant source of revenue in many countries. For countries that are oil and gas producers, they can be the dominant source of government revenue. Increasing reliance on energy-related and petroleum products for taxation explains why non-oil-producing governments can be strongly affected by fluctuations in the international price of raw oil and oil products (Bacon 2004). Energy taxation revenue usually goes into the government general budget, with all other tax revenues and it is not earmarked for specific use. Nonetheless, in some countries, taxes on transportation fuels are directly associated to government expenditure for road maintenance and construction, to ensure that those who use the road system correspond to those who carry the burden of most of the costs linked to it. Different sources of energy are subject to distinct forms of taxation. Tax revenues from activities of oil and gas extraction can be highly important, especially for countries based on oil and gas production. For coal, rents are much smaller in most cases and the tax receipts from royalties are not dominant in the economy. Indeed, most of the world's large coal producers are also large economies: the relative size of the coal sector is less dominant than the oil sector in the small economies where oil is produced (Bacon 2004).

Benefits and Challenges

As established above, energy taxes can take different forms: from retail gasoline excises to wellspring royalties on crude oil. These types of taxes are broadly used as environmental policy tools in several countries. Energy taxes not only allow to address market failure, but they also represent a very effective way for governments to raise substantial revenues. Furthermore, energy taxes can be implemented to discourage certain activities and behaviors deemed socially harmful. Additionally, energy tax leave consumers and firms free to decide how to change their behavior to limit and stop socially harmful activity. For instance, countries imposing taxes on motor fuels increase the costs of driving diesel vehicles, without specifying how to reduce emissions or indicating more sustainable alternatives. In this way, while not directly identifying clean generating technologies to shift to, governments encourage citizens to evaluate a wide range of options to reduce their impact on environment. Compared to other environmental policy instruments like subsidies, energy taxes, although indirectly, provide a greater range of abatement options and greater flexibility of response (Braathen and Greene 2011). Despite presenting consistent advantages, energy taxation also bears some challenges such as unintended consequences such as businesses and residents leaving the taxed jurisdiction or adopting energy sources to circumvent the tax without reducing emissions. Energy taxes also raise questions about their distributional impact and equity. For example, imposing taxes on fossil-based energy for transportation or heating can have a severe negative impact on lower income households. However, distributional issues arising from energy taxes could be counteracted through other distributive policy measures such as a decrease in the personal income tax rate. Also, concerns in terms of competitiveness between countries imposing different energy taxes need to be closely assessed. International coordination on environmental policy is required to reduce advantages arising from relocation of taxpayers (Shahzad 2020).

2.3. Policy Mix Literature

The following literature review has the objective of giving an overview of the existing academic research on the effect of singular policies and policy packages on emission abatement and of defining this report's contribution to the body of literature.

It is well recognized that evaluating the effectiveness of carbon pricing in reducing CO2 emissions is a difficult undertaking (Sumner et al. 2011; Meckling et al. 2017). This is partially because coverage and intensity of carbon pricing policies vary among jurisdictions. Additionally, it is challenging to adequately distinguish the effects of carbon pricing from those of command-and-control climate and energy policy tools, such as regulations for the energy sector (Somanathan et al. 2014; Narassimhan et al. 2018). The emission reductions from climate change mitigation programs can be estimated using a variety of methods. Depending on whether the methodology is country-specific or used across countries and the policy scope it covers, the different options produce varying types of outcomes.

The different technological methods used to calculate the emission reductions caused by carbon pricing policies can be divided into two main categories: 1) the ex-post regression method, and 2) the ex-ante analytical method. In the first, emission reductions are attributed to already implemented policies using statistical and economic techniques. After establishing a baseline, the predicted linkages between policies and emissions can be utilized in simulations to calculate the emission reductions of policies over the long term. The second approach, which is based on economic theory (i.e., modeling the behavior of enterprises, individuals, and governments) and knowledge of countries' economic structures, can offer forward-looking insights on the effects of policies before they are enacted. Each of the two approaches can be applied either taking a country-specific or a homogeneous cross-country perspective and may be focused on the effect of singular policy instruments or policy packages.

The country-specific approach evaluates the emission reductions for a separate nation, often applying a methodology unique to a country, depending on data availability and the availability of country specific models. In the North American setting, Murray and Maniloff (2015) assessed the impact of the Regional Greenhouse Gas Initiative (RGGI) in the northeast of the US through the development of a statistical method of CO2 emissions in the US, finding that the RGGI decreased power sector emissions by 24 percent between 2009-2012. Schmalensee and Stavins (2017) find a less significant impact of the RGGI policy framework using a different econometric approach. In a Norway-specific ex-post study Bruvoll and Larsen (2004) decompose the observed emission changes between 1990 to 1999 and apply a general equilibrium simulation to discern the effect of different carbon pricing policies.

Focusing on the effectiveness of specific pricing instruments, numerous studies used an ex-post approach to examine the effect of the fuel tax (see for example Datta, 2010 for India, Li et al., 2014 for the US and Yan and Crookes, 2009 for China) and found significant effects in reducing emissions in both developed and developing nations. Another branch of studies focuses on the impact of established carbon taxes on emissions in various country, such as a work by Lin and Li (2011) who found a significant negative impact of carbon tax on per capita CO2 emissions using an ex-post difference-in-difference approach. Another case in point is a report by Dussaux (2020) which uses precise firm-level data specific to France to assess the effects of the French carbon tax using the ex-post regression approach.

Country-specific ex-ante studies are frequently commissioned by governmental entities. In the Netherlands, Daniëls and Koelemeijer (2016) from the Dutch Environmental Assessment Center estimate national emission reductions using a model that employs a combination of quantitatively estimated elasticities and sector-specific expert judgement. Another example is South Africa, which biennially creates a report, using a country-specific ex-ante analytical model covering all sectors, to estimate emission reduction related to the national policy mix (DFFE 2021). In the academic literature several authors take a similar approach. For example, Dissanayake et al. (2020) evaluate the future impact of introducing different possible pricing instruments, including carbon tax, fuel tax and ETS for Indonesia. Calderón et al. (2016) conducted a similar ex-ante analysis in the Colombian context, as well as Alton et al. (2014) for South Africa.

The homogenous country-approach can also be implemented by either evaluating through an ex-post regression or ex-ante analytical method. Both allow for the consistent estimation of emission reduction of single instruments or a set of policies across countries. Research by Galeotti, Salini, and Verdolini (2020) is an illustration of the ex-post regression and homogeneous country approach. The economists use cross-country regressions to evaluate and compare the effects of several environmental policy stringency (the degree to which policies put a price on environmentally harmful behavior) indicators on energy efficiency. Similarly, Brunel and Levinson (2013) proposed a stringency approach. While taking into account the sectoral structures of different OECD countries, the researchers proposed a method to ascribe reductions in emission intensities to different mitigation policies. Haites (2018) analysed the emission development under 10 carbon tax and ETS regimes across 12 jurisdictions from 1991 to 2015, finding mixed results about the effectiveness of the two instruments. Narassimhan et al. (2017) analysed carbon pricing policies across 15 regions around the globe, highlighting the potential of even modest carbon prices for emission reductions, particularly those with high policy stringency. Best and Burke (2020) analyse the impact of carbon pricing for reducing emissions across 142 countries, using different ex-post econometric modelling methods while controlling for structural factors and other impactful policies relevant for CO2 emissions.

OECD's work is an illustration of the ex-ante homogenous cross-country approach. It uses a standardized set of assumptions to analyze emission reductions of changes in climate policies across macroeconomic sectors and geographies in a Computable General Equilibrium model (Chateau, Dellink and Lanzi 2014). On an EU member state level, van Sluisveld et al. (2017) analyse and contrast the ex-ante emission reduction strategies of five member countries towards the 2050 goal of reducing emission levels by 80%-95% compared to 1990 levels.

As it becomes clear throughout the review, most studies assessing emission reductions focus on the effect of singular carbon pricing policy instruments with academic attention clearly lacking on the performance and interaction of policy mixes. Moreover, while the literature on the impact of explicit carbon pricing policies (i.e. carbon tax and ETS) is relatively advanced, implicit instruments are rarely considered. While there is extensive literature on the impact of implicit instruments such as FiT or subsidies on innovation and renewable energy adoption (see for example Baldwin et al., 2017, Carley et al. 2017) research assessing their impact on emission reductions could not be found. Against this backdrop, this paper contributes to the existing literature in three main ways. Firstly, our findings add to previous cross-country studies assessing the performance of different policy mixes, which have been scarce until this date. Secondly, by considering both implicit and explicit policy instruments, this research contributes a more inclusive approach to estimating the effect of carbon pricing on emissions. Thirdly, to our knowledge the present work will represent the first research looking at the relationship between the policy stringency of the national policy mix and emission reductions.

3. Research Approach

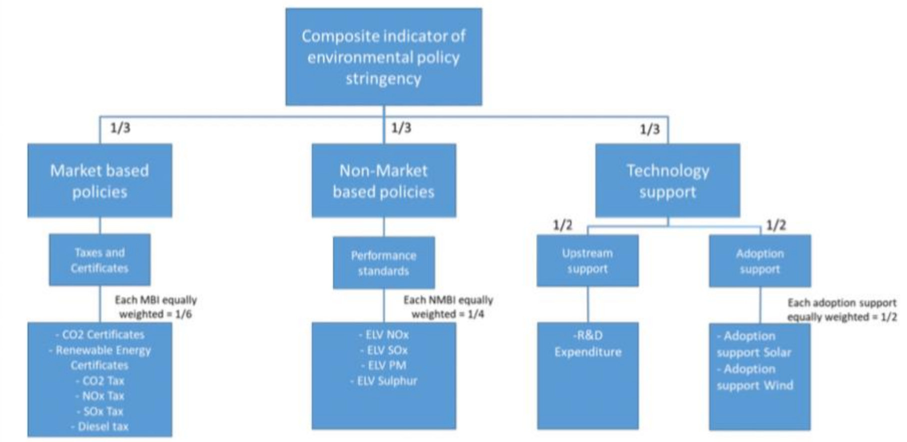
The purpose of this analysis is to determine whether there is an environmental policy mix that performs better in the abatement of emissions. To illustrate the combination of economic instruments countries used throughout time, we introduce the OECD Environmental Policy Stringency Index (EPS). Thus, the "*policy mix*" is defined as the stringency of those different instruments based on that indicator (See chapter 3.1 for more details). This research takes into account EPS data from 1990 – 2020 in 40 countries and the yearly changes of the instrument's stringencies. In order to evaluate the effect of a policy mix, we use data on the countries' emission intensity, which depicts the amount of emissions per unit of GDP. The objective of the analysis is to cluster countries with a similar policy mix and emission intensity to highlight if a certain combination of instruments delivers a better outcome. Our research approach is based on two components: the initial bivariate regression and the cluster analysis which are explained in the following chapters. However, important to note is that the methodology of this paper only allows for establishing correlations, rather than causational relationships.

3.1. EPS Index

The Environmental Policy Stringency Index (EPS) is a country-specific measure for the stringency of environmental policy (Botta and Kozluk 2014). After first being introduced in 2014 by Botta and Kozluk, the EPS has been updated to cover 40 countries with data ranging from 1990 to 2020 (Kruse et al. 2022).

The EPS21 includes 13 policy instruments, and it primarily focuses on air pollution and climate change policies (Kruse et al. 2022). In particular, it comprises three equally weighted sub-indices, grouping market-based (taxes, permits and certificates), non-market-based (performance standards) and technology support policies, respectively. The latter are subdivided into upstream (R&D support) and downstream support measures, (feed-in-tariffs and auctions), as represented in Figure 2 (Kruse et al. 2022).

Figure 2. The 2021 Environmental policy stringency index (EPS21)



Note: The figure shows the aggregation structure of the revised EPS index (referred to as "EPS21").
Source: OECD.

For the purpose of the construction of the EPS (2014) and the updated version EPS21, policy stringency is described as "a higher, explicit or implicit, cost of polluting or environmentally harmful behavior" (Botta and Kozluk 2014 pp.14). For instruments like taxes, this definition implies that higher prices per unit of pollutant correspond to higher levels of policy stringency. In the case of implicit tools, like feed in tariffs or subsidies to R&D, a higher level of stringency is given by higher subsidies. However, the stringency of the different environmental policy is expressed in a variety of units. For instance, carbon price is measured in US$ per tonne of CO2 emissions and emission threshold for NOx is measured in milligrams of pollutants per cubic meter (Kruse et al. 2022). In order to successfully provide a comprehensive aggregation of the diverse policy types into an index of policy stringency, a common scale is required.

The index is built by selecting policies for the countries under analysis and scoring their stringency on a scale from 0 to 6, where 0 represents minimum stringency (not stringent) and 6 represents the maximum level of stringency (Botta and Kozluk 2014; Kruse et al. 2022). For every policy instrument considered in the analysis, the raw data is organized from the least to the most stringent observations recorded in the 1990-2020 period (Kruse et al. 2022). The minimum score of stringency is allocated to observations with no policy in place, while the highest score of 6 is assigned to the observations surpassing the 90^{th} percentile of observations that have the policy in place. The attribution criteria for the intermediate scores (1 to 5) are obtained by dividing the difference between the 90^{th} and the 10^{th} percentiles into five parts which define the thresholds (Kruse et al. 2022).

The OECD Environmental Policy Stringency Indicator (EPS), introduced by Botta and Koźluk (2014) and updated by Kruse et al. (2022), offered a valuable contribution to this literature, by allowing for the first time the assessment of an extensive set of policies, across several countries and a wide time period. Several empirical studies extensively employ the Environmental Policy Stringency indicator to evaluate impacts of stricter environmental policies on environmental and economic outcomes and to provide related cross-country comparisons (OECD 2021; Dechezleprêtre et al. 2019). For instance, empirical analyses using EPS have shown that environmental policies have generally small impact on economic outcomes like trade, productivity, or employment, but they produce winners and losers among firms, industries, and regions. When looking at the effects of environmental policies, least productive firms from polluting sectors are negatively affected, while more productive firms and low-polluting sectors are positively affected by more stringent environmental policies (Albrizio, Koźluk and Zipperer 2017; Garsous Koźluk and Dlugosch 2020).

For the sake of this analysis, 6 out of the 13 EPS policy instruments have been selected and assessed. In particular, we will examine implicit and explicit carbon pricing tools, including CO2 tax, fuel taxes, and ETS system as market-based policies and feed-in-tariff system, auctions and R&D government expenditure, as technology support policies.

3.2. Bivariate regression

The underlying hypothesis of our analysis is that an environmental policy mix, based on the EPS index, can explain the variation in the emission intensity of a country. In order to evaluate whether this assumption holds, we run a bivariate regression with the 40 countries in the EPS index between 1990-2019 and the corresponding intensity of emissions. Assuming that this hypothesis can be answered in the affirmative, this would imply that a better policy mix with higher overall value of policy stringency, leads to better emission abatement, thus lower intensity of emissions. Consequently, this finding functions as a basis for the cluster analysis which takes into account both variables described prior.

The main rationale for choosing emission intensity per capita over other indicators for GHG pollution is the fact that it is possible to control for variables such as population, economic performance, inflation, and purchasing power within the regression. As a result, the robustness and validity of the regression are increased. The values for emission intensity are based on World Bank data and are obtained in *kg of CO2 emitted over the GDP per capita in $* (with fixed prices for the year 2017).

3.3. Cluster Analysis

After establishing the validity of using the EPS data set for analyzing emission performances across countries through the bivariate regression, a cluster analysis will be conducted. The aim of this analysis is to determine whether there is an ideal policy mix in terms of its impact on emission reduction. Through the cluster analysis, we intend to group the country set based on their policy package of explicit and implicit carbon pricing and relate it to the associated reductions of emission intensity of said group. For this purpose, only carbon pricing instruments were included in the cluster grouping (carbon tax, ETS, Diesel tax, government expenditure on R&D, FiT, REA) while excluding other complementary policies from the EPS data set. The choices for the most suitable method of cluster analysis, the type of linkage and the stopping rules were made based on a profound literature review. A hierarchical method for clustering was chosen, since research by Kettering (2006) on the prevalence of different clustering methods showed that hierarchical approaches are most frequently used among researchers. Hierarchical clustering is an algorithm which divides observations into clusters based on their similarity. In a hierarchical clustering process, each observation is first treated as a distinct cluster. Then, it repeatedly completes two actions: First, determine the two clusters that are most similar to one another, and then combine those two clusters. This iterative procedure is continued until all clusters are combined. There are different methods of hierarchical cluster analysis. Following the literature about the best hierarchical methods for cluster analysis (Mojena 1977; Milligan 1980), this work used Ward’s linkage method. Hereby, the linkage function determining the distance between two clusters is computed as the increase in the "error sum of squares" (ESS) after combining two clusters into a single cluster. Ward´s method chooses the successive clustering steps in minimizing the increase in ESS at each step. To determine the number of groups the Duda-Hart stopping rule was applied (Milligan and Cooper 1985), finding that the optimal number of clusters is 10.

4. Analysis

As outlined in the research approach, the analysis to answer the research question is divided into two parts. First, we run a bivariate regression and secondly, we employ a cluster analysis to understand if an ideal environmental policy mix exists that leads to lower emission intensities. Before drawing conclusions and lessons learned from our evaluation, we present the results from our analysis and highlight several limitations inherent in the employed methodology.

4.1. Bivariate Linear Regression

To establish whether the EPS index can explain the variation in a country's emission intensity and thus function as a basis for the cluster analysis, we run a bivariate linear regression. Two data sets lay the foundation for this analysis with OECD data for EPS and World Bank figures for emission intensity. The following table depicts an overview of the variables:

Table 1. Overview over the variables in the regression

Variable	Explanation	Source
OECD Environmental Policy Stringency index (EPS)	Yearly environmental policy stringency for 13 different instruments for countries between 1990-2019.	OECD Economics Department data set. Available at request.
CO_2 emissions (kg per 2017 PPP $ of GDP)	Emission intensity for 40 selected countries based on the EPS index per capita with data available between	World Bank (2022): Available online at World Bank data.

We regress the EPS of each 40 countries for every year between 1990 - 2018 with the emission intensity of each corresponding country between the years 1991 - 2019. In other words, this regression employs an artificial lag of one year between both variables. The key assumption is that implemented policies do not lead to an immediate effect which would be observable in the emission intensity of a country. We assume that emissions in a certain year are affected by policies implemented in previous years. Correspondingly, we take this into account by evaluating the effect of a policy at *year t* on the emission intensity in *year t+1*. Moreover, the null-hypothesis and alternative hypothesis are defined as following:

H_0: Variation in a country's emission intensity is not explained by the EPS index

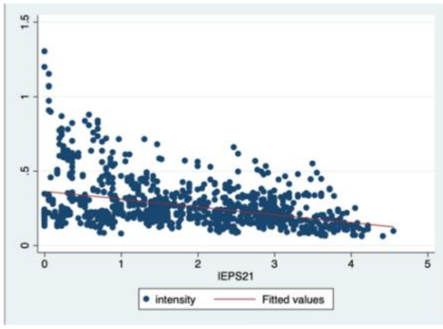
H_1: Policy stringency based on EPS Index explains variation in a countries emission intensity

Figure 3. Results from the initial regression

. reg intensity lEPS21

Source	SS	df	MS		
				Number of obs =	1,072
				F(1, 1070) =	183.84
Model	3.97754153	1	3.97754153	Prob > F =	0.0000
Residual	23.1501336	1,070	.021635639	R-squared =	0.1466
				Adj R-squared =	0.1458
Total	27.1276751	1,071	.025329295	Root MSE =	.14709

intensity	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lEPS21	-.0525859	.0038783	-13.56	0.000	-.0601959	-.0449759
_cons	.3642789	.0082622	44.09	0.000	.3480671	.3804908



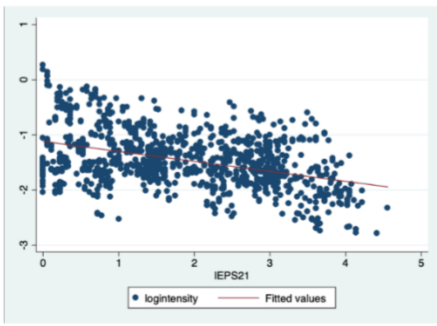
The results from the regression indicate that hypothesis H_1 can be accepted, thus the null-hypothesis is rejected. As one can derive from the figures, the correlation between the two variables depicts a negative slope (see negative coefficient). This implies that with a higher policy stringency, the emission intensity of a country decreases. Our results are statistically significant with a p-value of 0,000. In pursuance of improving the fit of the model further, we use a logarithm for the variable emission intensity as well as run a robust regression to increase the validity of our analysis. Statistical significance remains the same yet with a higher coefficient of determination R^2 of 17,38 %.

Figure 4. Results from the robust logarithm regression

. reg logintensity lEPS21

Source	SS	df	MS		
				Number of obs =	1,072
				F(1, 1070) =	225.09
Model	47.1083356	1	47.1083356	Prob > F =	0.0000
Residual	223.93841	1,070	.209288234	R-squared =	0.1738
				Adj R-squared =	0.1730
Total	271.046746	1,071	.253078194	Root MSE =	.45748

logintensity	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lEPS21	-.1809718	.0120624	-15.00	0.000	-.2046405	-.1573031
_cons	-1.119524	.0256969	-43.57	0.000	-1.169946	-1.069102



Moreover, we test our linear model for heteroskedasticity. We employ the Breusch-Pagan and Cook-Weisberg test to evaluate the robustness of the analysis. Since the p-value of the Chi-Square test is smaller than 0.05, thus showing the presence of heteroskedasticity, we run a robust regression to provide a more accurate measure of the true standard error of the regression coefficient.

Figure 5. Robustness check for heteroskedasticity

```
. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of logintensity

         chi2(1)      =    24.02
         Prob > chi2  =   0.0000
```

Nonetheless, our model based on an OLS regression is not taking into consideration time-invariant characteristics of each country that can affect the emission intensity over years. Thus, in order to improve the robustness of our model, we run a fixed-effect and random-effect model. We use the Hausman test to understand which type is more appropriate. According to this test, we find out that the random-effect model works better, thus run a new regression based on this finding (See Appendix 1 for more detailed results).

Figure 6. Results from the random-effect model

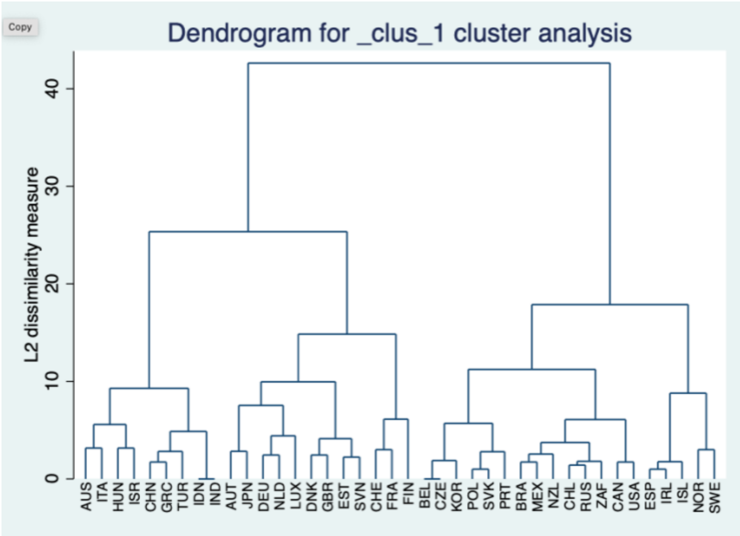
```
. xtreg logintensity lEPS21, re

Random-effects GLS regression                   Number of obs     =      1,072
Group variable: id                              Number of groups  =         38

R-sq:                                           Obs per group:
     within  = 0.6559                                         min =         22
     between = 0.0448                                         avg =       28.2
     overall = 0.1738                                         max =         29

                                                Wald chi2(1)      =    1969.89
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
logintensity |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lEPS21 |  -.2107821   .0047491   -44.38   0.000    -.2200902    -.201474
       _cons |  -1.062559   .0733792   -14.48   0.000     -1.20638   -.9187387
-------------+----------------------------------------------------------------
     sigma_u |  .44862465
     sigma_e |  .13663717
         rho |  .91511211   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store random
```

Our model and robustness checks suggest that the EPS index is a valid indicator to explain certain variation in emission intensities. As a result, we can use this index in our cluster analysis to group countries with a similar environmental policy mix and corresponding emissions to evaluate an ideal combination of policies.

4.2. Cluster Analysis

As previously indicated in Chapter 3.3, to determine whether there is a country with an ideal policy mix in our sample, based on emission intensity, a cluster analysis was conducted. Through Ward's linkage method, countries were clustered based on the 2018 EPS, composed of carbon-pricing instruments only.

Figure 7. Dendrogram of the cluster analysis



In order to find the optimal number of clusters, the Duda-Hart stopping rule was applied to understand the exact number of clusters needed (Milligan and Cooper 1985).

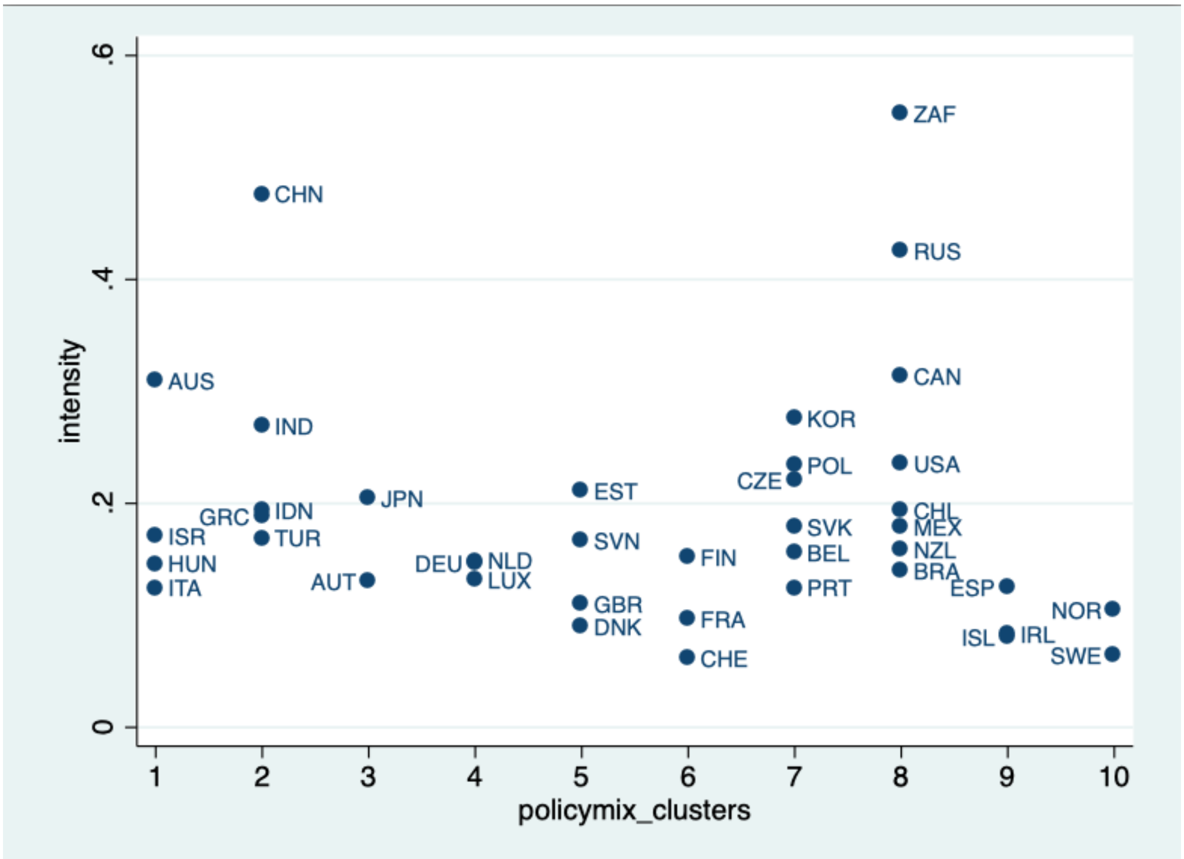
Figure 8. Results from Duda-Hart test

Number of clusters	Duda/Hart Je(2)/Je(1)	pseudo T-squared
1	0.7116	15.40
2	0.6439	10.51
3	0.5913	11.75
4	0.6181	6.18
5	0.5982	8.06
6	0.6082	4.51
7	0.5730	5.22
8	0.1958	12.32
9	0.4167	4.20
10	0.1985	4.04
11	0.5182	5.58
12	0.3556	7.25
13	0.4000	3.00
14	0.4040	4.42
15	0.2368	3.22

As can be seen, the ideal number of clusters would be 13 (number of clusters with the lowest pseudo-T-squared), but this would result in several clusters with only one individual observation (country) in them, making the analysis non-significant. The opposite problem of having different individuals in the same cluster would occur by taking too few clusters. In order to solve this problem, only numbers of clusters between 6 and 10 were considered. Within this range, the result with a lower pseudo T squared (optimal number of clusters) is

10. The result of the cluster analysis is shown through a scatter plot (Figure 1.x), which shows the 10 different groups with within them the different countries indicated by their ISO, sorted from top to bottom in descending order by emission intensity.

Figure 9. Result from the cluster analysis (scatter plot)



To show the characteristics related to each group's policy mix, the average across countries within each cluster of each instrument's EPS score was taken. The Energy Support and Wind Support instruments were grouped into one category through an arithmetic average of the two. Table 1.x shows the different groups sorted from first to last in ascending order by emission intensity. All values considered to be of low or no stringency (0-1.9) are highlighted in red, those of medium stringency (2-3.9) in yellow, and those of high or maximum stringency (4-6) in green. It is clear from the table that overall low scores of stringency lead to higher emission intensities. Moreover, it can be observed that usually a high to medium stringency in market-based instruments, most notably the CO2 tax, results in lower emission intensity.

Table 2. Policy Mix Table

Group	Countries	ETS	CO2 Tax	Diesel Tax	Low-Carbon R&D	Wind&Energy Support
10	Norway, Sweden	2	6	4	4,5	0
9	Spain, Irland, Island	2	3,33	3,33	0,67	0
6	Finland, Switzerland, France	1,67	6	4,67	5,33	4,17
4	Germany, Luxembourg, Netherlands	2	0	3,67	3,67	4,83
5	Estonia, Slovenia, United Kingdom, Denmark	2,25	2,5	4	2,25	2,38
3	Japan, Austria	1,5	0,5	3,5	4	2,75
1	Australia, Israel, Italy, Hungary	1	0	4	1	2,75
7	Korea, Polonia, Czech Republic, Slovak Republic, Belgium, Portugal	2,17	0,33	3,5	2	0,33
2	China, India, Indonesia, Greece, Turkey	0,6	0	2,2	0,4	3,8
8	Brazil, Canada, Chile, Mexico, New Zeland, Russia, South Africa, United States	0,5	0,25	1,25	1,38	0,13

4.3. Ideal Policy Mix

Based on the results of our cluster analysis, Norway and Sweden have among the lowest figures for emission intensity in 2018, demonstrating high effectiveness of their decarbonization policy mix. This result is consolidated by the Climate Change Performance Index, which ranks these two countries among best performing ones (Burk et al. 2021). Consequently, we evaluate their policy mix more closely to understand what the ideal combination of instruments can look like according to our estimations. These successful achievements are in part derived from ambitious governments' decisions to introduce carbon neutrality about a decade earlier than other developed countries (DG Trésor 2021).

Norway and Sweden are global leaders in decarbonization (IEA 2021). Nordic countries have been experiencing climate change effects first-hand, due to the polar amplification effect, recording an increase of 10°C in the average annual temperature, since pre-industrial period (DG Trésor 2021). Therefore, they have been early pioneers in the elaboration of innovative decarbonization strategies, being among the first countries to introduce carbon tax during

1990's and targeted support measures to low-income households and industry (DG Trésor 2021).

In 2019, carbon emission intensity for Sweden was 108g CO2 per euro of GDP, more than 60% below the EU average (European Parliament 2021), while Norway CO2 Emissions intensity was 11.9440 tonnes of CO2-equivalents/ output in NOK million (Statistics Norway 2021). The policies and economic tools implemented in these countries include record high carbon tax (DG Trésor 2021). However, despite being crucial to the impressive achievements of Sweden and Norway, carbon tax is not the only policy instrument in place. Accompanying support measures like targeted subsidies and income tax deductions for low-income households have been central to ensure a sustainable and just green transition (DG Trésor 2021). Moreover, renewable energy has a significant role in the climate change mitigation strategy of these countries.

Sweden

In Sweden carbon tax was introduced in 1991 at a rate of 250 SEK (25 EUR) per tonne of CO2 emitted and it has been constantly increased during the years up to 1200 SEK (129, 89 $) per tonne, in 2022 (Ministry of Finance 2022). Sweden levies among the highest CO2 tax per ton of carbon emissions (Tax foundation 2022). In the energy and power field, Sweden long term goal is a national energy system fully reliant on renewables (Bird 2017). Renewable sources like biofuels and hydropower already fulfil more than 50% of total energy consumption needs, thanks to a functioning market-based electricity certification framework implemented in 2003 and which requires energy producers to generate a portion of their energy production from renewable and clean sources (Bird 2017). A great portion of Sweden's electricity supply comes from hydro and nuclear, combined with a growing contribution from wind. Heating is supplied mainly through bioenergy-based district heating and heat pumps (IEA 2021). Additionally, effective financial incentives and subsidizing schemes are used to encourage climate-friendly investments.

Norway

Norway launched its carbon tax for the first time in 1991, and since then, it has been used as the main climate change mitigation tool (Ji 2014). Nominal Carbon tax rate in Norway is among the highest in Europe and it covers 80% of emissions on the national territory (OECD 2022). The overall country policy for emission reduction objective has a long-term perspective on carbon pricing (OECD 2022) and, indeed, Norway's national climate action plan for 2021-2030 presents great potential for increasing the carbon tax from NOK 590 (69 $) per tonne to NOK 2000 (233 $) by 2030. Besides the CO2 tax, Norway's cut-edging environmental policy strategy includes an additional energy taxation scheme targeting mineral products like oil and gas, and petroleum derived vehicle fuels to secure verified emission decrease. Furthermore, the Norwegian government has implemented, since 2008, the International Climate and forest initiative, aiming at curbing GHG emissions from deforestation and forest degradation not only within the national territory, but also globally (UN 2020). In 2021, Norway has strengthened its commitment to enhance its 2030 targets to a reduction of emissions of at least 55% below 1990 levels, rated by Climate action tracker as compatible with Paris agreement 1.5C temperature goal (Climate Action Tracker 2022).

Norway and Sweden lead the way in the reduction of CO2 emissions because they have some of the most ambitious climate change mitigation agendas (Government offices of Sweden 2022), based on substantial emission reductions goals, technology development and innovative energy infrastructures (Prime Minister's Office 2022).

5. Limitations

The analysis presented in this paper has some noteworthy limitations. To start with, this research is based on the OECD Environmental Policy Stringency Index, which bears several limitations in itself. First and foremost, many policies are outside of its coverage (Kruse 2022), including for example international agreements-based initiatives (e.g. EU ETS) and policies regulating emissions from agricultural activities (Kruse 2022). Additionally, pilot projects are not considered by the EPS index, as well as forestry related policies. Another weakness of the index is that data are only available until 2020. Although it accounts for developments related to the outbreak of Covid 19, it does not allow to define the implications of the recent war in Ukraine and consequent gas crisis. Moreover, some of the policy instruments accounted for in the EPS index have been purposefully excluded in this study, given its focus on implicit and explicit carbon pricing.

The main limitation underlying the methodology of the paper is that the analysis is only able to establish a strong correlation, but not causation between the examined variables. The first relationship between emission intensity and the EPS index shows only a correlation, despite strong statistical significance and statistical tests confirming its validity. Although some controls are already included in the "intensity" variable, many others that could influence emissions, such as geographic characteristics, level of technology, energy efficiency, are not being taken into account. This limitation recurs in the cluster analysis, which is based only on the EPS without including other control variables.

Finally, by looking at emissions in a specific year and not reductions in emissions over a period, the final analysis is static and unrepresentative of efforts to combat climate change in recent years. However, this approach is problematic because taking the difference in emissions along a period makes it difficult to isolate the effect of a single year's policy mix. In an attempt to address this problem, it was decided to take the policy mix of one year earlier than the emissions. This ensures that policies implemented in the following year will not affect environmental performance. However, even this approach has limited explanatory power since one cannot know the longer-term effects of the chosen policy mix, and one cannot isolate the effect on emissions of previous policies with a long-term effect.

6. Framework for Political Feasibility

While reducing CO2 emissions and achieving carbon neutrality in the foreseeable future is technically and economically possible, most countries are currently still failing to implement the necessary environmental policies due to political barriers (Peng et al. 2021). As Rawls described it in the early 2000, a "realistic utopia" which a net-zero economy could be described as from an environmentalist point of view, depends not only on "desirable social arrangements" but also on the "realistic achievability" of those arrangements (Rawls 2001). Accordingly, while stringent carbon pricing instruments might be desirable, the necessary social transformation to meet the decarbonization targets would require rapid economic, social, and political changes and the (realistic) achievability or political feasibility of these changes is often questionable (Patterson et al. 2018).

Political feasibility in this context describes the collective belief within a society and government about the extent and speed of carbon abatement initiatives that are considered to be desirable and realistic. The feasibility of different carbon pricing instruments can vary over time and is influenced by the characteristics of each country, such as wealth, the industry and geography. Additionally, technical and economic feasibility and policy innovation shape political feasibility and most importantly, the support (or opposition) of influential members of society such as politicians, private sector agents or the media (Patterson 2018). Policymakers should consider political feasibility when proposing policies, as policies with a lack of political support are generally more difficult to implement. (Peng et al. 2021). When a policy faces strong opposition from the public, from interest groups or when institutional capacity is low, governments are unlikely to implement initiatives successfully, even when the policy has substantial technical or economic potential (Patterson et al. 2018). Similarly, policies tend to be implemented faster when they are politically feasible and cause less disruption to the domestic political environment (Peng et al. 2021).

6.1. The Political Assessment of Clean and Environmental Policies Tool

To reach the climate targets set internationally, for instance in the Paris agreement, a policy mix with stringent instruments is needed. However, political feasibility must be considered in order to introduce these kinds of instruments successfully, to protect the more vulnerable members of society from the consequences of climate change and to move towards an equal net-0 society and economy (Kruse et al. 2022). Nonetheless, the dimension is often not represented in the most used decision-support tools, which usually focus on factors such as costs or emission abatement rates. After identifying the most ideal policy mix in the previous chapter, in the following the political feasibility of implementing the respective policy instruments in different environments will be analyzed. For that, a decision-support tool targeted at measuring feasibility along different dimensions was developed, based on the Political Assessment of Clean air and Environmental Policies (PACE-Tool) (Peng et al. 2021). Utilizing the tool, a political-feasibility score is assigned for each policy on the basis of seven key metrics that are most relevant according to political economy literature. The seven metrics can be divided into Public Opinion, Market Structure and Government Capacity. These three different economic considerations have found relevant for the following reasons:

1. Public opinion: as identified before, in order to implement a policy successfully, the support of the public is necessary. In the tool, the metric considered to measure public

opinion is the direct cost to the public that the respective policy would cause (Benes et al. 2015)

2. Market structure: the more compatible the proposed policy is with the current market structure, the easier its implementation will be. Therefore, the tool measures the expected benefits and costs for the market, the degree of market concentration, and the presence of organized interests (Busby and Shidore 2017; Mitchell 2008)
3. Government capacity: a stronger capacity of the respective governmental is also an important determinant for implementation outcomes; to determine the score, three different metrics are considered, measuring government concentrations, institutional capacity and government willingness (Galston 2009; Benes et al 2015)

Dependent on the country's performance across each metric and how favorable each dimension is for political feasibility considerations, a score from -1, 0 or 1 is assigned. The scoring and interpretation logic in detail can be found in the appendix (see annex 1-2). After obtaining a score for each policy initiative, the results can be compared in order to determine the highest scoring initiative(s) that appear to entail the highest political feasibility and therefore the highest chances of a successful and timely implementation (Peng et al 2021). In order to generate scores that can be easily compared and to avoid negative scores, the final scores where adjusted by adding 6. The insights will then be utilized to inform the policy recommendations for the respective country.

Individual Part

Country Analysis: Mexico - Elisabeth Tyszkiewicz

A Feasible Emission Mitigation Strategy for Mexico

10.1. Introducing Mexico

Mexico ranks amongst the most vulnerable countries to climate change around the globe. Given its location between two seas, its latitude and topography, the country is particularly prone to extreme hydrometeorological events. Likely consequences of climate change in Mexico include a rise in the frequency and severity of tropical cyclones, rain, and droughts. Combined with severe wealth inequality, climate change in Mexico will not only threaten food and water security but also exacerbate the already high inequalities in health and employment, possibly fueling popular discontent and upheaval (USAID 2017).

While being the world's 11^{th} largest emitter of carbon dioxide, Mexico is also a pioneer among developing economies in the transition to a competitive, low-carbon economy (Climate Policy Watcher 2022). To lower its vulnerability and safeguard the livelihoods of Mexican citizens, the government was one of the first worldwide to commit to decreasing emissions and funding the necessary mitigation and adaption measures under the legislative framework of the 2012 "General Climate Change Law" (GLCC) (Climate Change Knowledge Portal 2021).

The present energy and climate change policy framework in Mexico aims to improve sustainability, competitiveness, and supply security. However, Mexico is also facing many of the same issues as other emerging economies, with a political and social environment that favors measures promoting economic development and growth. As a result, Mexico's legal system establishes a clear requirement to choose the least expensive mitigation measures while fostering and maintaining the competitiveness of the key economic sectors (México Gobierno de la República 2015).

Since President Andrés Manuel López Obrador (AMLO) took office in December 2018, Mexico's decarbonization policies have stagnated. Under the guise of energy security and republican austerity, the administration encourages the use of fossil fuels while deprioritizing the prevention of climate change, resulting in a continuous distancing from the 1.5°C Paris Agreement goal (CAT 2022).

Against this backdrop, the aim of this individual report is to define a politically feasible emission mitigation strategy for Mexico. For this purpose, this work will discuss the country's policy package, position Mexico on its roadmap to decarbonization and apply the previously outlined political feasibility model. Finally, the insight gained from the analysis will be used to give informed and implementable policy recommendations compiled into a roadmap for Mexico's decarbonization.

10.2. A Trajectory of Mexico's Policy Mix

An overview of Mexico's Environmental Policy Stringency (EPS) including six different carbon pricing policies from 1990-2020 is depicted in below (Figure 1). The index is based on national policies and excludes pilot policy projects. On a first glance, it becomes clear that Mexico's stringency has overall been low, with the diesel tax marking an exception between 1994-2003. Since 2013 a slowly increasing commitment to climate mitigation policies can be observed.

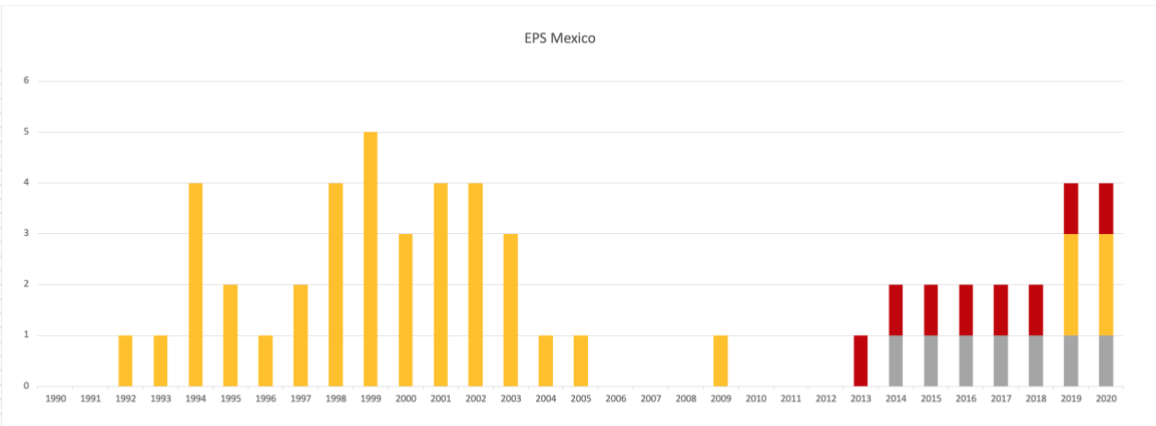


Figure 1: Mexico's Environmental Policy Stringency (EPS) calculated based on OECD's dataset

To gain a more in-depth understanding of Mexico's carbon policies beyond the EPS scores, a policy stocktaking of Mexico's decarbonization policies was conducted based on a profound analysis of government documents, academic research and climate reports. In the following, the trajectory of Mexico's climate change mitigation measures over the years will be synthesized and contextualized.

10.3. Foundations of the Mexican Climate Policy

The "General Climate Change Law" (GLCC), adopted in 2012, serves as the cornerstone of Mexican climate policy. The GLCC specifies Mexico's commitment under the Copenhagen Accord to reduce GHG by 30% below Business as Usual (BAU) by 2020, and a reduction of 50% by 2050 compared to 2000 levels (General Law on Climate Change Mexico 2012). While the legislation provides the institutional framework for policy action, strategies and plans to achieve climate targets, it does not mandate the use of specific policy instruments. Mexico was the first developing country to introduce a law of this kind, and the country was also one of the global pioneers. Detailed guidelines for the GLCC's implementation are outlined in the National Strategy on Climate Change, the Special Programme on Climate Change (PECC), and the Special Programme on the Use of Renewable Energy.

With regards to the institutional structures under the GLCC, the National Institute of Ecology was turned into the National Institute of Ecology and Climate Change (INECC). The INECC was given the responsibility of creating the National Emissions Inventory, a collaborative institution charged with supporting the development of strategies, plans, programs, instruments, and actions pertaining to sustainable development, as well as assisting in the evaluation and analysis of national climate change policy. Furthermore, the GLCC declared the inter-ministerial Commission on Climate Change (IMCC), which was first established by presidential decree in 2005, officially as the organization tasked with coordinating governmental responses to climate change as well as developing and carrying out national adaptation and mitigation policies (General Law on Climate Change Mexico 2012).

Given Mexico's vulnerability to the effects of climate change, the law places high priority on adaptation measures. The overarching aim is to minimize social and environmental vulnerability. One of the tools designed to strengthen resilience is the “Risk Atlas”, informing on existing and potential future vulnerability scenarios. The GLCC also established a climate change fund to channel public, private, national, and international financing support toward actions that simultaneously contribute to adaptation and mitigation, including research and innovation projects and technological development (General Law on Climate Change Mexico 2012).

In the course of the Paris Agreement of 2015, Mexico defined its National Determined Contribution (NDC) to limit the global temperature increase below 2°C compared to pre-industrial levels. Mexico set an unconditional target of decreasing its GHGs and short-lived climate pollutants (SLCP) by 25% below BAU until 2030. This suggests a peak in net emissions beginning in 2026 and a drop in emissions intensity per unit of GDP of about 40% from 2013 to 2030. Furthermore, the nation set a conditional goal of reducing its emissions by up to 40%, subject to a global treaty addressing carbon equality topics such as international carbon pricing, carbon border adjustments, technical cooperation, access to affordable financial resources, and technology transfer (IEA 2022a). Finally, Mexico established several adaptation components by 2030, which overlap with the GLCC. Priority areas include the protection of local communities against the negative effects of climate change, as well as the improvement of critical infrastructure's resilience and ecosystems' capacity to support national biodiversity (IEA 2022a). In 2020, Mexico submitted an updated NDC, whereby both conditional and unconditional targets remained the same. However, its projected emissions under BAU continued to rise, lowering the nations mitigation ambition in terms of absolute levels. Moreover, the updated version is considered less transparent and measurable (CAT 2022).

10.4. Mexico's Carbon Pricing Instruments

10.4.1. Explicit Carbon Pricing in Mexico

In 2014, Mexico introduced its carbon tax and integrated it into the 1980 Special Tax Law on Production and Services, *Impuesto especial sobre produccion y servicios (IEPS),* through an amendment (Climate Laws 2022). At the time it was set at around US$3,5 per excess ton of CO2, varying depending on the type of fuel (SEMARNAT 2014). The tax, which is levied on fossil fuel suppliers and importers of fossil fuels, is applied to fuels that emit more carbon dioxide than natural gas does. Conversely, this means the tax does not apply to natural gas, and some of the emissions from other fuels are also excluded (Black et al. 2021). According to an OECD country note, in recent years, the carbon tax has slowly increased. In 2021, 58.1% of CO2 emissions originating from energy use are priced, representing an increase of 2.6% since 2018 (OECD 2021). In late 2017, a regulation that established the guidelines for the usage of emission reduction credits for compliance under the Mexico carbon price went into effect. The rule permits the use of Certified Emission Reductions (CERs) from Clean Development Mechanism (CDM) projects in Mexico and CERs that are also compliant with the EU ETS as payment means under the carbon tax (World Bank Group & Ecofys 2018). While the carbon tax has generated considerable governmental revenue (US$263 million in 2019), the impact on emission reduction is not clear. Despite relatively high coverage, the low rate makes a significant reduction improbable (CAT 2022).

In 2017, Mexico launched a voluntary Emissions Trading Scheme simulation. Preliminary Mexican ETS regulations were released in October 2019, and the pilot phase began in January 2020 (CAT 2022). The current year, 2022, is designated as transitional period between the pilot and operational stage. The pilot ETS includes around 300 major corporations in the electricity and industrial sectors with yearly emissions above 100,000 tons of CO2, which together account for about 40% of Mexico's GHG emissions. It is applied downstream at the point of fuel combustion. Several hundred enterprises are anticipated to join in the final phase ETS in 2023 after the trial period that developed the infrastructure for executing the program and monitoring emissions. The policy stipulates the yearly emissions cap to be determined based on reports of historical emissions and Mexico’s NDC. In 2021, the emission cap was set at 273 million tons of carbon dioxide emissions. Although a shift to allowance auctions is being publicly discussed, emission allowances are currently distributed freely. Corporations can achieve up to 10% of their requirements by purchasing emission offsets (for mitigation initiatives in sectors outside the ETS) rather than buying permits, albeit they cannot bank allowances across phases. Future emissions limitations that are legally binding have not yet been created (Gabbatiss 2022; Black et al. 2021).

10.4.2. Implicit Carbon Pricing in Mexico

Implicit pricing policies are not extensively developed. Regarding energy taxes, the government introduced an excise tax for automotive gasoline, diesel and liquified petroleum gas in 2000 as an amendment to the Special Tax on Product and Services (IEPS) (OECD 2019). All fuels and energy services offered to non-commercial consumers are subject to VAT, while transportation fuels are liable to said excise tax. However, the excise tax rate is adapted monthly by the government, depending on the international energy prices, in order to control national prices. The IEPS applies a floating rate that fluctuates in accordance with a formula that is based on global benchmark prices for gasoline and diesel. The rate of IEPS turns negative when this benchmark price is high, causing local prices to drop below the opportunity cost of gasoline and diesel. In contrast, a decline in the international pricing results in an increase in the IEPS rate, raising the government’s tax revenues. Additionally, agriculture and fishing industries, commercial boats, passenger, and cargo transportation are eligible for specific fuel-tax credits, however the credits only apply when the IEPS rate is positive. Given the persisted rise in international pricing for oil and its derivatives, the Mexican government has set pre-tax prices well below the cost of imports in recent years, with the government paying PEMEX, the state-owned monopoly importer, the difference (OECD 2011).

In 2012, the government set up the Climate Change Fund as part of the GLCC, aiming to direct and organize government revenues and other financial resources toward supporting climate change mitigation efforts. Priority issues include RE development and energy efficiency initiatives (Climate Laws 2022). While there are several policies and laws stipulating the promotion of renewable technologies and research, such as the Energy Transition Law of 2015, the Energy Reform of 2013 or the Transition Strategy to Promote the Use of Cleaner Technologies and Fuels of 2016, the Mexican government continues to direct more support to the supply of fossil fuels than of renewables (Climate Laws 2022; CAT 2022).

After Mexico made significant progress on abolishing a significant part of its fossil fuel subsidies and transitioning towards open energy market since its 2013 Energy Reform, in recent years there have been setbacks in this regard (Sánchez et al. 2018). Between 2017 and 2019, the government more than tripled its support for fossil fuels, mostly through producer subsidies. PEMEX received direct transfers from the López Obrador administration, to pay off debt and pension obligations and develop new infrastructure, notably a refinery in the state of Tabasco. Also taking into account extra tax deductions, OECD estimations assume Mexico's total fossil fuel assistance in 2019 at USD 17.1 billion (Climate and Energy Joint Ministerial Meeting 2021).

Subsidies for fossil fuels continue until today, mostly in the form of electricity subsidies. Residential electricity use is subsidized at 20%, with over 60% of electricity generation being sourced from fossil fuels (Black et al. 2022; IEA 2022b). At the same time, government spending for renewable energy sources has declined in recent years. Up until 2017, the Fund of Energy Transition and Sustainable Energy Use financed several renewable energy projects with 23% of its budget, amounting to approximately 3.7 million USD (IEA 2019). Since AMLO took office, expenditures were reduced and redirected to fossil fuel related projects. Moreover, several policies were introduced which further complicated renewable energy development. Amongst others, this included the 2020-2024 Energy Sector Program which redirected more funds from RE to fossil fuel development or a resolution by Mexico's National Energy Control Center, which defined wind and solar plants as unreliable energy sources and discontinuing pre-operative tests (Salgado 2021).

While there is no feed-in tariff in place in Mexico, there were plans for creating long-term renewable energy auctions. Between 2015 and 2018, three pilot rounds of auctions produced 65 new wind and solar power projects, leading to record-low generating prices for renewables (SENER 2018). In line with the 2015 Energy Transition Law, the auction was supposed to allocate contracts for the trade of electricity, cumulative electric energy, and clean energy certificates from 2021 onwards (CAT 2022). However, President López Obrador suspended the program in early 2019 shortly after taking office and the government continuously postponed the integration of RET into the national power system since then, citing economic hardships such as those related to Covid-19 as the reason (Government of Mexico 2020).

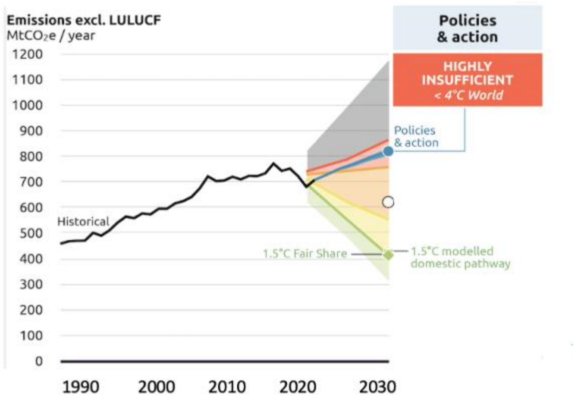
10.4.3. Recent developments

While Mexico was initially praised for its pioneering commitment to combating climate change, the incumbent president reversed many of the previously set policies. As established above, among the presidents first actions was the discontinuation of the REAs and the approval and financing of an oil refinery in Tabasco, which is expected to cause 2.1 MtCo2 emissions every year (CAT 2022; Gracia 2020). With the spread of Covid-19 came additional policies harming green energy advancements. A fast-tracked energy bill that the government released in 2020 halted private investment in renewable energy and gave priority to the government's own aging fossil-fuel power facilities (Government of Mexico 2020). Later that year, the Climate Change Fund was discontinued, one of the main sources of national funding for climate change mitigation and adaptation (CAT 2022). In 2021, around 70% of the federal funding designated for "climate change mitigation and adaptation impacts" was used to transport fossil fuel natural gas (Secretaría de Hacienda y Crédito Público 2021). At the end of the same year the government announced to dissolve INECC (Secretaría de Medio Ambiente y Recursos Naturales 2021).

Overall, the foregoing document analysis made clear that while Mexico has an extensive legislative framework, its policy action lacks in its intensity and commitment to decarbonization. Economic growth is clearly prioritized by incumbent AMLO at the expense of the environment. The political framework for the carbon tax is in place and has relatively high coverage, however the current carbon price is too low to have the needed impact for complying with the 1.5°C target. Given the fact that Mexico's ETS is only completing its pilot phase, its effectiveness is not yet clear. While the establishment of a political framework for ETS is a promising step towards industrial carbon reduction, critics are concerned that calculating the ETS cap based on historical emissions instead of ambitious climate targets may considerably limit its impact (CAT 2022). Regarding implicit pricing, there are some legislations in place, however there are currently insufficient support structures for renewable energy systems, and still too much government subsidies and price adjustments encouraging fossil fuel use.

10.5.Mexico's Carbon Emissions

With a GDP of 27,1 Trillion USD (2021) Mexico is considered an upper middle-income country and represents the second-largest economy in Latin America. As such, the country is amongst highest emitting nations worldwide (World Bank 2021). Greenhouse gas emissions in Mexico have been constantly on the rise since the 90s. The power sector (electricity and heat) accounts for largest share of emissions (30%), closely followed by industry and transport, accounting for 26 and 24 percent of emissions respectively (KPMG International 2021). Over half of energy related emissions are caused by oil (53%), 36% are natural gas related and 11% related to coal (Black et al. 2021). Disregarding LULUCF (land use, land use change and forestry), Mexico emitted more than 700 Mt/CO2 in 2021. Currently, the Climate Action Tracker considers Mexico's policies and action as highly insufficient, as they will lead to continuously rising emissions and are not in line with the 1.5°C limit set in the Paris Agreement. If all nations adopted Mexico's strategy, global warming would likely even exceed 3°C (CAT 2022). According to a Climate Analytics report, Mexico would have to put in place a new, more ambitious NDC with a target reduction of emissions of at least 38% below 2015 levels, excluding LULUCF to be in line with the global 1.5 °C pathway by 2030. This would entail an emission reduction to 418 Mt/CO2 by 2030, compared to the current conditional NDC of 638 MtCO2 (Climate Analytics 2022).



Source: Climate Action Tracker Mexico, 2022

Figure 2: Emission pathways for Mexico based on modelled domestic pathways. The black line shows Mexico's historical emission trajectory measures in MtCO2 per year. The blue line shows the modelled emission pathway based on current policies and actions and compares it to the ideal 1.5°C pathway in green.

10.6. Political Feasibility Analysis

Overall, it becomes clear that Mexico has a long way to go to decarbonize its economy, particularly considering the retreating commitment to climate change mitigation under President López Obrador. To advance the countries mitigation measures, the present section will assess the political feasibility of four carbon pricing policies. Guided by the ideal policy mix identified in the common report and informed by the analysis on Mexico's historical policy trajectory and its legislative framework, the following policy options were chosen to be assessed: (EX-1) Increase price and coverage of the Carbon Tax, (EX-2) Reduce the ETS cap and fully auctioning allowances, (IMP-1) Phasing out Fossil Fuel Subsidies, and (IMP-2) Reinstate Renewable Energy Auctions.

10.6.1. Policy Options

The analysis made clear that raising and expanding Mexico's carbon tax in coverage would be an effective way to advance its progress towards a low-carbon economy (EX-1). While the coverage is already relatively wide, exempting natural gas from the carbon tax limits its effectiveness. Similarly, the low prices are unlikely to have a significant effect on emissions. The second explicit pricing option EX-2, reducing the ETS cap and transitioning to a full auctioning of allowances was chosen to maximize the effectiveness of the ETS. Being still in its pilot phase, Mexico is so far only freely allocating allowances based on historic emissions (the so-called grandfathering approach). This has the benefit of safeguarding the competitiveness of domestic companies but potentially limits the cost-effectiveness of the ETS. Allocating allowances through government auctions bears benefits such as being easy to implement and monitor, the generation of government revenues, the avoidance of potentially challenging political processes and efficient emission abatement through transparent price signals (Healy, Graichen and Cludius 2018).

The third policy option, IMP-1, aims to continuously move Mexico's economy away from fossil fuels and towards renewable energy sources by phasing out fossil fuel subsidies, including those for electricity produced with fossil fuels. The market for RE is directly affected by the governmental electricity subsidies, making many renewable energy producing methods less profitable and affordable than fossil-fuel based power (Sánchez et al. 2018). Finally, long-term renewable energy auctions could be reinstated to further aid RE development and in turn promote RE usage (IMP-2). Since the pilot RE have already been successful in the past and there are operative frameworks in place, it was chosen to focus on REA instead of FiT.

10.6.2. Political Feasibility Analysis

As outlined in the common part, each of the policy options was assessed based on the political feasibility framework adapted by Peng et al. (2021). It includes scoring for three political economy considerations: public opinion, market structure and government capacity, each measured by up to three sub-metrics. For a more detailed explanation of the framework see Chapter 6 in the common report. Appendix 1 provides a thorough justification for each numerical score awarded to each of the four policy options. An overview of the feasibility ranking is summarized in the table below.

Policy	Public Opinion	Market			Government			Aggregate score (rescaled from 1-13)
	Public opposition	Market benefit/cost	Market concentration	Organized interests	Government concentration	Institutional capacity	Government Willingness	
EX-1	Direct cost -1	Market Cost -1	Moderately concentrated 0	Organized losers -1	Concentrated +1	High capacity +1	Low willingness -1	4
EX-2	Direct cost -1	Market Cost -1	Not concentrated -1	Organized losers -1	Concentrated +1	Middle 0	Low willingness -1	2
IM-1	Direct cost -1	Market Cost -1	Moderately concentrated 0	Organized losers -1	Concentrated +1	Low capacity -1	Low willingness -1	2
IM-2	No direct cost +1	Market benefit +1	Not concentrated -1	No organized winners 0	Concentrated +1	Middle 0	Low willingness -1	7

Table 1: Darker shades of blue or yellow indicate a higher political feasibility score. A score of 1, -1 or 0 was given if a dimension was favorable, unfavorable or neither, respectively, for policy implementation in terms of political feasibility.

Overall, the political feasibility analysis reveals a relatively low political feasibility for all four proposed carbon pricing policies. As the document analysis already suggested, Mexico scores particularly low on the metrics of government willingness. Additionally, organized interests as well as expected costs to market players and the public hamper the feasibility of carbon pricing policies. Mexico generally scores high in government concentration, showing the potential of the legislative and executive system for climate policies. However, institutional, and administrative capacities are lacking in areas including CO2 trading schemes and alternatives to fossil fuel subsidies. Phasing out fossil fuel subsidies (IM-1) and reducing the ETS cap and transitioning to an auctioning system (EX-2) were found to have the lowest political feasibility. This can mostly be traced back to the government's focus on fossil fuels for national economic growth and the associated support of this sector. Renewable energy auctions (IM-2) scored the highest in terms of political feasibility, underlining the possibility of short-term reinstatement, especially if institutional capacities were to be strengthened.

10.7.Roadmap for transitioning to a low-carbon economy

In this section, insights from the political feasibility analysis as well as the document analysis will be used to give short- to long-term recommendations for Mexico's decarbonization.

10.7.1. Short-term recommendations

R1: A more ambitious NDC

A new, more ambitious, and transparent NDC should be in line with the 1.5°C target, implying emission abatement of a minimum of 38% below 2015 emissions. After retreating commitment under the latest updated NDC, a more ambitious commitment could create momentum and frame Mexico's future decarbonization policymaking.

R2: Communication Campaign

Following extensive dialogue with all stakeholders affected by the different carbon policies, the government should launch an educational communication campaign. It should explain the policy's rationale, present evidence in favor of implicit and explicit carbon pricing and clarify any potential misunderstandings. A public campaign could not only increase public support but could also create a focal point for mobilization in favor of the reform (Lucatello 2022).

R3: Reinstate renewable energy auctions (IM-2)

The reinstatement of REAs not only is politically feasible as evidenced above, but also Mexico's political and geographical landscape offers large renewable energy potential (IRENA, 2015). However, there are some deficiencies in terms of institutional capacities for REA's complicating the project development of auction winners (Viscidi 2018). Thus, capacity building and administrative reform are needed to secure the successful renewable energy development. Particularly, the process for granting construction permits should be revised for the timely realization of RE projects (del Río 2019).

10.7.2. Medium- and long-term recommendations

In medium- to long run, it is recommended to increase price and coverage of the carbon tax (EX-1), reduce the ETS cap and fully auction allowances (EX-2) and to phase out fossil fuel subsidies (IM-1). The following recommendations aim at increasing the political feasibility of the carbon pricing policies.

R4: Political legislation and communication

The long-term trajectory of CO2 taxes, fossil fuel subsidies and emission trading/caps should be unambiguously set by law and clearly communicated to give consumers and producers the needed assurance to effectively adapt to the new conditions. This would considerably lower transaction costs and provide the necessary incentives for energy-intensive industries to comply and adjust.

R5: Support schemes

Much of the economic opposition to the ETS, carbon tax and fossil fuel subsidy removal stems from their cost on market players and the public. For these policies to be politically viable, the

Mexican government should redistribute part of the revenue to support affected economic sectors in their transition and compensate displaced workers and to offset regressive distributional impacts. For example, fossil fuel reliant industries affected by carbon pricing could receive temporary financial compensation, aiding them in their transition. Similarly, laid-off workers could receive re-employment guarantees and training for working in the renewable energy sector. To secure popular support for carbon pricing policies, it is indispensable that the burden on low-income households is lifted especially considering the high wealth disparity in the country (Chancel et al. 2022). Research by the OECD on attitudes towards climate policies has shown that including targeted cash transfers to part of the population significantly increases popular support for the carbon pricing policies in Mexico (Dechezleprêtre et al. 2022). Without such schemes, Mexico runs risk of sparking civil unrest as a response to rising prices, as it has been the case in early 2017 when the liberalization of gas and oil prices lead to drastic gasoline hikes (Grass & Echeverria, 2017). Relief could for example come through cash transfers to vulnerable households, or reductions in income taxes (Dechezleprêtre et al. 2022). To support the implementation of these schemes, social assistance delivery mechanisms must be developed to secure the timely distribution of support measures.

R6: Capacity building for ETS

Since the ETS is still in its pilot phase, the instrument needs further development to become fully operational. Most importantly, capacities for a rigorous emissions monitoring, reporting, and verification system need to be strengthened as well as the technical expertise to establish the right emission cap for producers. The trading activity seen during the pilot program can provide the necessary experience to refine the ETS design and correct possible biases. At the same time, it would be beneficial for Mexican officials to request international assistance for building financial, administrative, and technical capacities.

If implemented successfully, these complementary measures could increase the aggregate political feasibility by up to four points per policy by increasing public support, minimizing market costs, fostering the organization of groups in favor of the proposed policies, and increasing institutional capacities (see Appendix 3). However, a significant barrier to realizing any climate policies is the lacking willingness of the López Obrador administration. Before the government commits to decarbonization, it is highly unlikely that there will be progress in carbon pricing policy.

10.8. Conclusion

The purpose of this report was to create an evidence-based, politically feasible carbon pricing strategy for Mexico's decarbonization. To reach this objective, first the national carbon policy framework was discussed, with a focus on the different pricing instruments in place. The document analysis made it evident that although Mexico has a comprehensive legal system, its policy implementation lacks the fervor and dedication needed to achieve decarbonization. While Mexico has been considered a pioneer of climate legislation in the past, under the current president, the environment has clearly been taking a backseat to economic growth. This has also been found to be evident in Mexico's emission pathway, which is far from complying to the Paris Agreement. Based on the analysis of Mexico's policy trajectory and legislative framework and the ideal policy mix identified in the common part, four policies aiming to advance the country's decarbonization were chosen to be assessed in terms of political feasibility. The analysis showed a relatively low political feasibility for all four proposed carbon pricing policies. Low government willingness, organized interests opposed to pricing policies and expected costs to market players and the public were found to be the main factors impeding political feasibility. To increase the political feasibility of the proposed policies and advance the decarbonization of Mexico's economy, six recommendations were given, mainly focused on political communication and legislation, capacity building and the implementation of support schemes. While the recommended measures could significantly increase the political feasibility of the proposed policy options, lacking political will remains a major inhibitor to progress. This also represents one of the main limitations of this work, as it restricts the applicability of the proposed recommendations. A second limitation lies in the nature of the political feasibility analysis, since the awarding of numerical values inherently bears the risk of subjectivity. Finally, this work does not provide detailed, instrument-specific recommendations for implementation. Future research could build up on this report and elaborate further on the necessary steps to take for the proposed policy options to be realized.

Group Part

7. Final Remarks and Conclusion

The objective of this work was to answer the research question whether an ideal policy mix that is most effective in the abatement of emissions exists. Moreover, five in-depth country-specific analyses were conducted to understand how selected countries could realistically improve their respective environmental policy mixes further.

Based on our assumptions and hypothesis in the bivariate regression and cluster analysis, it is possible to answer the first part of the research question in the affirmative. Our findings suggest that when different clusters of countries with similar environmental policy stringencies and corresponding emission intensities are developed, it is evident that, generally, states with overall high stringencies in their policy mix showcase lower intensities of emissions. Analyzing the best-performing clusters (10, 9 and 6), we show that a common characteristic are high stringency values for market-based instruments such as carbon- and diesel tax. Although Group 9 (Spain, Ireland, Island) depict slightly lower values, clusters 10 (Norway, Sweden) and 6 (Finland, Switzerland, France) both indicate a strong focus on explicit instruments such as the CO2 tax, leading them to lower emission intensities in comparison to other country groups. In particular, Sweden and Norway have strongly relied on high rates for their carbon taxes, while committing to have their energy systems almost exclusively based on renewables. Thus, in line with the majority of economic studies on explicit carbon pricing instruments, we draw the conclusion that **market-based policy tools are of utmost importance in any policy mix and can substantially bring countries closer to reach their climate objectives.** With this finding, our working project contributes to the body of research on environmental policy mixes by evaluating the emission abatement effect a broader spectrum of carbon pricing policies, rather than just focusing on one instrument.

Nonetheless, when interpreting the findings of our analysis, several limitations must be considered. First and foremost, one must note that the bivariate regression does not prove causality between the EPS index and emission intensity, yet only shows a strong, statistically significant correlation. The results should therefore be utilized as a basis for additional research on this subject to confirm the findings. In addition, the ideal policy mix our results have identified is in place in two highly developed countries - Norway and Sweden. However, applying this policy mix in other contexts may not lead to similar emission reduction, because Norway and Sweden are characterized by very high levels of economic and social development, as well as very strong democratic institutions. Replication of the Scandinavian policy approaches in other countries, without accounting for country-specific characteristics, may lead to different results, thus bearing the potential for misinterpretation. Additionally, one must acknowledge the ongoing dispute between the developing and developed countries regarding the responsibilities of emission mitigation given the historic pollution behavior of the industrialized states during their economic growth in the last centuries. Lastly, the report on hand is exclusively examining the effectiveness of carbon pricing instruments. In practice however, countries can choose from a more diverse set of instruments and must consider other harmful GHG emissions such as Methane in their policy making as well.

We complement our theoretical results from the cluster analysis by introducing political economy considerations based on Peng et al. which are crucial when implementing policy instruments. **We highlight that, although focusing on market-based instruments can lead to high abatement of emissions as our theoretical findings suggest, in practice, country specificity must be taken into consideration.** The country analysis revealed distinct challenges and differences in the political feasibilities of policies which must be addressed with custom and specified solutions to bring these economies closer to climate neutrality instead of a “one-size-fits all” approach. In **Mexico**, the political feasibility of carbon pricing was found to be generally low, which is why the implementation of complementary measures such as support schemes were recommended.

Similar to the interpretations from the cluster analysis, the political feasibility tool selected for formulating the country-specific policy options and recommendations also presents some limitations. The numerical scale from -1 to 1 does not capture the slight variety of circumstances that may affect certain outcomes in the countries under review. Additionally, the implementation of the tool through the scoring process might be subject to biases which this study is not controlling for. Future research could examine political feasibility of different emission reduction policy options, by formulating evaluations and scoring based on a more varied numerical scale, accounting for the several shades of political and social scenarios in the countries analyzed.

Finally, we emphasize the **importance of addressing distributional aspects** when implementing environmental instruments. Complementary policies that support, for instance, low-income households in the transition to low-carbon economies are non-negligible to reach climate objectives and avoid anti-climate movements as seen in France with the “yellow vest” demonstrations. Policies must be designed with complementary measures that make the green transition fair and feasible in order to ensure public support for climate related activities.

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9. Appendix

Common Report

Appendix 1: Further Statistics of the Quantitative Analysis

Figure 1. Regression with a Fixed Effect Model

```
. xtreg logintensity lEPS21, fe

Fixed-effects (within) regression               Number of obs     =      1,072
Group variable: id                              Number of groups  =         38

R-sq:                                           Obs per group:
     within  = 0.6559                                         min =         22
     between = 0.0448                                         avg =       28.2
     overall = 0.1738                                         max =         29

                                                F(1,1033)         =    1968.63
corr(u_i, Xb)  = -0.0793                        Prob > F          =     0.0000

------------------------------------------------------------------------------
logintensity |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lEPS21 |  -.2109925   .0047554   -44.37   0.000    -.2203238   -.2016612
       _cons |  -1.065851   .0094711  -112.54   0.000    -1.084435   -1.047266
-------------+----------------------------------------------------------------
     sigma_u |  .44817506
     sigma_e |  .13663717
         rho |  .91495621   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(37, 1033) = 296.26                  Prob > F = 0.0000

. estimates store fixed
```

Figure 2. Hausman Test: Determines that the random effect model is more suitable for the analysis

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
      lEPS21 |   -.2109925    -.2107821       -.0002104        .0002439
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        0.74
                Prob>chi2 =      0.3883
```

Figure 3. Panel Data Scatterplot

Appendix 2: Political Assessment of Clean air and Environmental Policies Tool

Table 1. Seven metrics on political feasibility

Political Economy Considerations	Metrics	Interpretation	Relevant Political Economy Literature
Public Opinion	Popular opposition	When the costs of implementing a policy are directly borne by the public, the policy is more likely to face a strong popular resistance.	Benes et al (2015); Cheon et al (2013); Overland (2010)
Market Structure	Market benefit/cost	When the affected industry expects benefits (costs) from the policy implementation, the policy is more (less) likely to be supported by the industry.	Benes et al (2015); Busby and Shidore (2017); Busby et al (2018)
	Market concentration	When the affected industry is characterized by a small number of producers and product lines, emissions mitigation will be more feasible from a collective action perspective.	Busby and Shidore (2017); Busby et al (2018); Olson (1965); Mitchell (2008)
	Organized interests	A presence of an organized interest group representing the affected industry will make implementing a policy easier (more difficult) when the industry expects benefits (costs).	Benes et al (2015); Bernhagen (2012); Grossman and Helpman (2001)
Government Capacity	Government concentration	When the authority over rulemaking and policy implementation activities are fully centralized, the degree of government concentration is high, which is often beneficial for effective policy making and implementation. When they are under control of state governments with (without) a coordination with the central government, government concentration is medium (low).	Busby and Shidore (2017); Busby et al (2018); Tsebelis (2002)
	Institutional capacity	Stronger institutional capacity improves the feasibility of implementing a policy.	Benes et al (2015)
	Government Willingness	A stronger Interest of those in power in the implementation of a policy improves political feasibility	Galston (2009) Political Feasibility: Interest and Power

Table 2. Meaning of –1, 0, +1 scores

Political Economy Considerations	Metrics	Interpretation of the scores		
		-1 (Unfavorable)	0 (Neither favorable nor unfavorable)	+1 (Favorable)
Public Opinion	Popular opposition	The public directly bears the costs of policy implementation.	N/A	The public does not bear the costs of policy implementation.
Market Structure	Market benefit/cost	An affected industry expects costs from policy implementation.	An affected industry expects neither benefits nor costs from policy implementation.	An affected industry expects benefits from policy implementation.
	Market concentration	The affected sector is *not* concentrated (i.e., characterized by a large number of producers and product lines that contribute to emissions.)	N/A	The affected sector is concentrated (i.e. characterized by a small number of producers and product lines that contribute to emissions.)
	Organized interests	The industry expects costs and is represented by organized interest groups, or The industry expects benefits but is *not* represented by organized interest groups.	The industry neither expects benefits nor costs.	The industry expects benefits and is represented by organized interest groups, or The industry expects costs but is *not* represented by organized interest groups.
Government Capacity	Government concentration	The government is not concentrated.	The level of government concentration is moderate.	The government is concentrated.
	Institutional capacity	The government has low institutional capacity (i.e., administrative apparatus for implementing a given policy).	The government has a medium level of institutional capacity (i.e. administrative apparatus for implementing a given policy).	The government has high institutional capacity (i.e., administrative apparatus for implementing a given policy).
	Government Willingness	The government has no interest in implementing the respective policy	The government is indifferent about the policy	It is in the governments interest to implement the respective policy

Individual Report – Mexico

Appendix 1: Rationale for awarded numbers

EX-1: Increase price and coverage of the Carbon Tax

Metric	Explanation
Popular opposition (-1)	Research on the distributional impacts of carbon taxes have shown that citizens **bear the costs** of this policy in three ways: Directly through the cost increase of electricity and fossil fuel derivatives, and indirectly since the increase in production cost caused can lead to higher prices of carbon-intensive goods and services as well as to decreased income from work. (Dorband et al., 2019; Haug et al., 2018; Wang et al., 2016). Distributional concerns are particularly relevant in Mexico, since it is considered one of the most unequal nations in the world (Chancel et al., 2021).
Market benefits/costs (-1)	In Mexico, the carbon tax is levied on suppliers and importers of fossil fuel, meaning there is a **direct cost** on the industry if the tax was to be increased (SEMARNAT, 2014).

Market concentration (0)	The oil and gas industry in Mexico is **moderately fragmented**. Petroleos Mexicanos (Pemex), Royal Dutch Shell PLC, TC Energy Corporation, ExxonMobil Corporation, and BP PLC are amongst the major competitors in the sector (Mordor Intelligence, 2022a). Since President López Obrador came into office the government has taken efforts to further strengthen the state-owned company PEMEX, while limiting and controlling private sector activity. While PEMEX is not a monopoly anymore since the 2013 Energy Reform, it maintains clear market dominance among the few main players (International Trade Administration, 2021).
Organized interests (-1)	PEMEX would expect clear costs from the expansion of the Carbon Tax. Being a state-owned enterprise and thus closely tied to the government, there is an organized interest against raising the tax. Moreover, the initial formulation of the carbon tax policy intended the inclusion of natural gas in the tax, however this was contested by private interests working with natural gas (Belausteguigoitia et al., 2022). The fact that natural gas was ultimately exempted from the tax demonstrates the **powerful political influence of this pressure group**.
Government concentration (+1)	The authority over rulemaking is **concentrated** since carbon tax regulations are implemented and enforced on a national level. Hydrocarbon activities are centrally overseen by the Energy Ministry and its sub-institutions including The National Hydrocarbon Commission (CNH), the main regulator for exploration and production of oil and gas and the Energy Regulatory Commission (CRE) (Serra & Escobedo, 2020).
Institutional capacity (+1):	The institutional capacity is **high**. Since 2013, Mexico has successfully implemented its current carbon tax and the central government has shown to be effective in ensuring compliance. The implementation of Measurement, Verification and Control (MRV) systems in jurisdictions achieved the successful tracking of taxpayer compliance (Garcia et al., 2021).
Government willingness (-1):	The current administration has **no interest** in expanding the carbon tax framework. Instead, the president continuously increases the state's support for fossil fuel use as it is thoroughly explained in the main text.

EX-2: Reduce the ETS cap and transition into full auctioning of allowances

Metric	Explanation
Popular opposition (-1)	Just as with carbon taxes, ETS **negatively affects the public.** Due to rising production costs for businesses caused by a lower ETS cap, households may pay more for carbon-intensive consumer products and services, and their income from employment and investments may also decline (Haug et al., 2018).
Market benefits/costs	Compared to the current free allowance allocation system, transitioning to full auctioning with an ambitious cap will come at a benefit in the long run. Experience from other nations has shown that a

(-1)	comprehensive auctioning system is the best way to achieve cost-effective emission abatement (Lucatello, 2022). However, **initially there will be significant additional costs** for transforming industrial processes (Belausteguigoitia et al., 2022). Since affected markets will presumably be against the proposed policy despite the long-term benefit, the market benefit/cost metrics was rated as -1.
Market concentration (-1)	The ETS affects both the energy sector and the industry sector. As elaborated above, the energy sector is only moderately fragmented. When it comes to the industrial sector, however, there are numerous sub-markets included: Automotive, cement, chemical, foods and beverages, glass, steel, metallurgical, petrochemical and paper (Gutierrez Gonzáles, 2022). Thus, the market is **fragmented.**
Organized interests (-1)	Like with the carbon tax, it is highly **likely that there will be resistance** from private interests with political power from the affected industries if the ETS cap were to be reduced and there was a binding auctioning allocation of allowances. For this reason, experts highlight the importance of complementing this policy option with compensation schemes for affected industries to render it politically feasible (Belausteguigoitia et al., 2022).
Government concentration (+1)	The authority over rulemaking is **concentrated**. SEMARNAT is responsible for coordinating the ETS process, of registering, reporting and compiling emissions using data collected by RENE. Moreover, there is an accrediting body auditing verification reports of the firms required to participate in ETS (Gutierrez González, 2022).
Institutional capacity (0):	The institutional capacity for the Mexican ETS is **moderate**. While the pilot program already set up a system for ETS, to transition to an effective full auctioning of allowances administrative and technical capacity must be expanded. The pilot phase can be considered as a "work in progress" stage, since institutional capacities still have to be built. It is an important initial step to gain experiences, however for an effective operational phase of a cost-effective auctioning system, regulations for monitoring, reporting and verification are indispensable. Mexico might require international assistance in building technical, financial and administrative capacities (Gutierrez González, 2022).
Government willingness (-1):	The government's willingness to invest in the ETS, develop the program and lower the cap is **low**. López Obrador's predecessor Enrique Peña Nieto facilitated the ETS project. The current administration's agenda relies mainly on fossil fuels, prioritizes boosting economic competitiveness and maintaining low fuel prices (Stevens, 2022).

IMP-1: Phasing out fossil fuel subsidies

Metric	Explanation
Popular opposition (-1)	A removal of fossil fuel subsidies is perceived to have a **negative effect** on public welfare through increased electricity, oil and gas prices. In

	reality, fossil fuel subsidies in Mexico are highly regressive and clearly benefit high income groups, who consume the most energy. Nevertheless, the general public is not fully aware of the regressive character of the subsidies, despite several thorough studies and significant public discussion in mainstream media. A common, often politically charged, myth is that fossil fuel subsidies help the poor. To the contrary of this belief, price increases resulting from the removal of subsidies only have a minimally negative effect on vulnerable households (OECD & IEA, 2016).
Market benefits/costs (-1)	The fossil fuel sector would bear a **cost** on energy-intensive sectors as they do not receive the subsidy anymore. According to an assessment by the World Bank, even if there is an initial compensation program for these sectors there will be long-term losses in profit, both with sudden and gradual removal of subsidies (World Bank, 2013).
Market concentration (0)	As explained below under EX-1, the fossil fuel industry in Mexico is **moderately fragmented**.
Organized interests (-1)	As in most other countries where fossil fuel subsidies are present, in Mexico there are **influential interest groups** and lobbies benefiting from the governmental support exerting pressure to maintain the subsidies. According to a report by the OECD and the IEA (2016), there are several organized interest groups leveraging against a phasing out of fossil fuel subsidies from energy-intensive sectors. An example of such a pressure grouping are agricultural groups in the north of Mexico which use electrical pumping systems for irrigation have strong ties to powerful regional politicians.
Government concentration (+1)	Rulemaking with regards to fossil fuel subsidies is **relatively concentrated** and on mostly on national level. With the Energy Reform of 2013 the coordination and concentration of government responsibility over fossil fuel subsidies were strengthened. The Secretariat of Energy (SENER) remained the main responsible entity for energy policy, while the National Hydrocarbons Commission (CNH) and the Energy Regulatory Commission (CRE) were charged as independent regulators. Electricity tariffs are determined by CRE. Yet, there are some excepted sectors with tariffs set by federal executives. Regarding fuels, the Secretariat of Finance and Public Credit (SHCP) has the price-setting responsibility (IEA & OECD, 2016). While the energy reform foresaw a complete liberalization of fuel prices, to this date national prices are still being adjusted based on the international energy market (OECD, 2011). The Energy Sector Coordination Council coordinates activities of the energy sector. It is headed by the Secretary of Energy and comprising the Undersecretaries of Planning, Electricity, and Hydrocarbons, the President-Commissioners of CRE and CNH, and the heads of the gas and electricity network operators, CENACE and CENAGAS. The council may request other pertinent organizations,

	such as the finance, economics, and environment ministries, to attend its sessions. Additionally, another entity is tasked with "analyzing specific circumstances that may influence the Federal Executive's formulation of energy policy and proposing coordination actions (IEA & OECD, 2016).
Institutional capacity (-1):	Institutional capacity for phasing out fossil fuel subsidies is **low**. It is impeding reform, mainly because there are limited capacities for applying alternative delivery mechanisms that could replace fossil fuel subsidies, such as targeted transfers or other forms of social assistance (IEA & OECD, 2016).
Government willingness (-1):	As already explained in the report, the government is **unwilling** to change its fossil fuel expenditures. Reforms of the fossil fuel and electricity subsidies is further complicated by the current administrations' pledge of maintaining low electricity prices (IEA & OECD, 2016).

IMP-2: Reinstate long-term REA

Metric	Explanation
Popular opposition (+1)	The public would **benefit** from the reemployment of long-term renewable energy auctions. It offers them the opportunity to consume clean energy at low prices. Moreover, the expansion of the renewable energy sector leads to local employment opportunities for both skilled and unskilled workers. However, when reinstating REA, community participation in the planning of RE development projects is pivotal. In the previous auctions, many of the project sites were located within indigenous land, leading to socioeconomic tensions (IRENA, 2019).
Market benefits/costs (+1)	Renewable energy auctions clearly **benefit** the domestic and international renewable energy sector. Since Mexico's long-term renewable energy auctions offer 15-year contracts, they facilitate financing for project developers as the design minimizes investment risk (Hochberg & Poudineh, 2018)
Market concentration (-1)	The RE market in Mexico is **not concentrated** and characterized by a large number of competitors. The main market players include Acciona, Enel, Canadian Solar, Siemens Gamesa Renewable Energy, and Electricite de France (Modor Intelligence, 2022b).
Organized interests (0)	The renewable energy sector can expect benefits from reinstating renewable energy auctions, there are **no organized interest groups** with political power.
	Rulemaking over REAs is **centralized.** The in 2013 established control center, Centro Nacional de Control de Energía (CENACE), is responsible for yearly establishing the bidding guidelines, which later need to be approved and published by the Ministry of Energy (SENER).

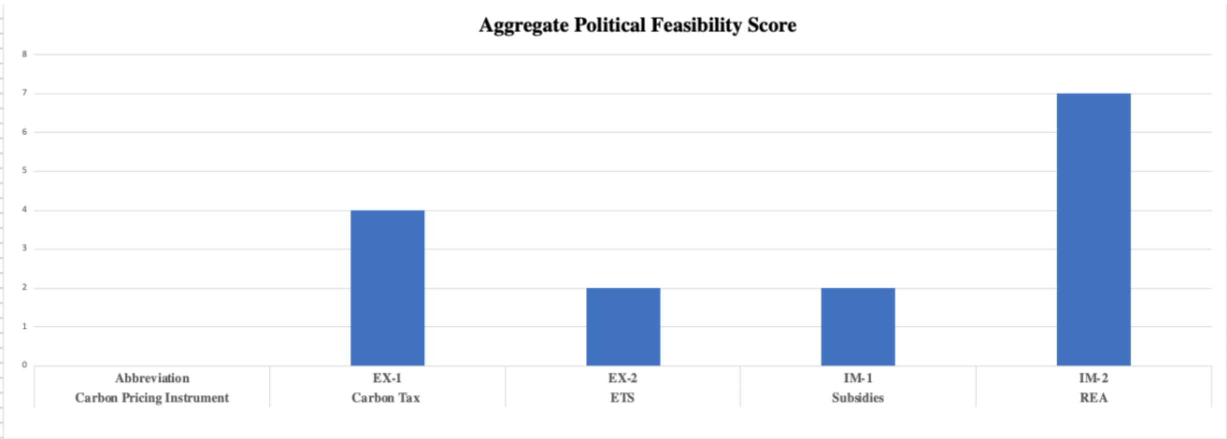
Government concentration (+1)	CENACE also operates as the entity organizing the auctions on a national level (del Río, 2019).
Institutional capacity (0):	While previous auctions helped to establish a foundation for operational REA's, the institutional capacity is **moderate**. While the process of the auction itself has worked well, the auction winners' projects were often delayed, or not even implemented at all, due to delayed construction permits (del Río, 2019). Guadarrama Gándara (2018) argues that the difficulty in acquiring building licenses in Mexico is causing PPA delays and underbuilding and is now the major barrier to the deployment of renewable projects in Mexico. According to Viscidi (2018), it is extremely difficult for project developers in Mexico to secure land rights and the approval of the surrounding communities in order to construct power plants and transmission lines. Thus, some legislative and administrative adaptations are required for the successful implementation of renewable energy projects.
Government willingness (-1):	The current governments' interest in reinstating the long-term energy auction is **low**. In April 2019 the National Energy Control Center (CENACE) published a resolution stating that wind and solar power plants were limiting the efficiency, quality, and reliability of national energy provision. Subsequently, the government mandated an end to the pre-operational development of wind and solar power facilities which were previously initiated by the REA as well as any future auctions. In Februrary 2021 López Obrador presented an order to update the Electric Industry Law, reducing the legal support for renewable energy auctions among the private market, which was later approved by Congress. Since several companies took legal action against this decree, the law is currently suspended. Yet, these events showcase the governments unwillingness to reinstate auctions.

Appendix 2: Feasibility Scores

Section A. Political feasibility scores

-1: Unfavorable for policy implementation; 0: Neutral; +1: Favorable; For more instructions, please see the sheet on"Info on political scoring".

			Public Opinion	Market			Government			Score	
Carbon Pricing Instrument	**Abbreviation**	**Explanation**	**Direct Cost to Public**	**Market benefit/cost**	**Market concentration**	**Organized interests**	**Government concentration**	**Institutional capacity**	**Government Willingness**	**Raw**	**Adjusted**
Carbon Tax	*EX-1*	*Increase Price and Coverage of Carbon Tax*	-1	-1	0	-1	1	1	-1	-2	4
ETS	*EX-2*	*Reduce the ETS cap and transition to full auctioning of allowances*	-1	-1	-1	-1	1	0	-1	-4	2
Subsidies	*IM-1*	*Phase out fossil fuel subsidies incl. electricity*	-1	-1	0	-1	1	-1	-1	-4	2
REA	*IM-2*	*Reinstate long-term Renewable Energy Auctions*	1	1	-1	0	1	0	-1	1	7



Appendix 3: Adjusted aggregate feasibility score

The graph below illustrates the added political feasibility points (orange) to the original feasibility score (blue) in case of an ideal implementation of the proposed recommendations.