Culture, carbon pricing and its impacts on CO_2 emissions and economic growth

by

Carlos Roberto Perez Alvarado

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Energy is one of the most relevant factors for economic growth, which is the main cause of CO_2 emissions. Currently, CO_2 accounts for 90% of emissions associated with human-induced climate change. Additionally, the potential economic impact of climate change could reduce annual global GDP between 5-20%, while the mitigation of climate change would cost only 1% of global GDP. In response, an increasing number of jurisdictions have implemented carbon-pricing mechanisms (i.e., carbon taxes and cap-and-trade systems) to reduce emissions, which covers 20% of the GHG global emissions. Under the Paris Agreement, 88 jurisdictions plan to use carbon-pricing mechanisms to achieve their 2030 target emissions reductions.

The gold standard for carbon pricing policymakers is to achieve the highest emissions reductions and to cause the least negative impacts on economic growth. Moreover, culture is deemed to play a critical role in shaping climate policies and enabling their successful implementation.

This study examined 49 jurisdictions at the national and the subnational level, using multiple regression analysis and moderation analysis to assess the impacts of carbon pricing on economic growth and carbon dioxide emissions, and the moderating effect of cultural distances on carbon prices. The study utilized the Hofstede's cultural dimensions framework to measure culture in the jurisdictions.

Results revealed that carbon prices and cultural dimensions were able to explain between 1.5% and 67.3% of the variance in the GDP growth rate, with uncertainty avoidance and the interaction between carbon prices and uncertainty avoidance as the

strongest significant predictors. With respect to the CO_2 emissions, carbon prices and cultural dimensions were able to explain between 5.5% and 29.2% of the variance in the carbon dioxide emissions growth rate, where individualism, masculinity, and uncertainty avoidance emerged as the strongest significant explanatory variables.

Consideration of culture as relevant factors in the development of carbon-pricing instruments is an important step in enhancing the chances of a successful implementation of climate change mitigation policies.

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I owe my deepest gratitude to my wife and my daughter for enjoying this experience with me.

Dedication

Dedicated to Anna Elisa, Elizabeth and to the memory of my friend Marlon.

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1. Introduction

1.1. Background

The Climate Change agreement reached in Paris in 2015 was a political achievement. Nevertheless, its environmental impacts are less clear. If the agreement is fully implemented, current Nationally Determined Contributions (NDCs) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat leaves the global emissions reductions targets as insufficient efforts to keep the world on track to limit temperature rise to 1.5 °C by 2030, the goal stated in the Accord (Dolphin, Pollitt, & Newbery, 2016). To meet the goals established in the Paris Agreement, jurisdictions need to increase their efforts to reduce emissions. None of the critical investments will be possible unless policies include incentives for change, by removing subsidies to fossil fuels, implementing carbon-pricing initiatives, increasing energy efficiency standards, developing auctions for lowest costs renewable energy (World Bank, Ecofys, & Vivid Economics, 2017), and considering the particular conditions and the social responses to climate change of the jurisdictions, such as cultural values.

In September 2014, more than 1,000 companies, including large oil and gas companies, signed the World Bank's *Put a Price on Carbon Statement*. Many firms, including ExxonMobil, Royal Dutch Shell, Total, and BP, have expressed a preference for carbon-pricing policies in lieu of regulatory approaches (Narassimhan, Gallagher, Koester, & Alejo, 2017).

At the present time, more than 30 billion metric tons of carbon dioxide per year are emitted globally from the combustion of fossil fuels(Newell, Pizer, & Raimi, 2013). Currently, the relationship between emissions and economic development is at the centre of debate on the appropriate policies for reducing greenhouse gas emissions. The need for urgent action regarding climate change is emphasized in the formulation of the UN's Sustainable Development Goals (SDGs), while the Paris Climate Conference (CoP21, December 2015) stressed the importance of expanding the geographic scope of action. By 2016, 195 developed and developing countries adopted the aforementioned Paris Agreement and established reduction targets for 2030, among them the United States of America (Fernández-Amador, Francois, Oberdabernig, & Tomberger, 2017).

In June 2017, the U.S. government and the Trump Administration decided to walk away from the Paris Accord, claiming that it will "undermine the country's economy" and that it "puts the U.S. at a permanent economic disadvantage" (Garden, 2017, para. 2).

The most relevant drivers that influence the growth rate of CO_2 emissions depends mainly on three factors: economic activity (derived from the use of fossil fuels), the carbon intensity of the economies, and the functioning of unexploited carbon sources and sinks on land and in the oceans (Canadell et al., 2007); the first two factors are those directly related to energy consumption. Currently, 90% of the CO_2 emissions originate from fossil-fuel combustion and are determined by the energy consumption or the level of energy-intensive activity (Le Quéré et al., 2013). However, changes in energy efficiency and in the fuel mix, especially from carbon-intensive sources such as coal to low-carbon ones or from fossil fuels to renewable energies, can cut the overall global emissions level (Bekhet, Matar, & Yasmin, 2017).

Climate change policies address these externalities' impact in one of three ways: a) require businesses and individuals to change behaviour towards technology adoption and emissions; b) subsidize businesses and individuals to invest in low-carbon services and goods; or c) put a price to externalities caused by greenhouse-gas emissions (Aldy & Stavins, 2011)

During the last ten years, carbon-pricing instruments, such as cap-and-trade systems and carbon tax have been widely implemented as effective financial instruments to reduce emissions in several jurisdictions. As of 2018, 45 national and 25 subnational jurisdictions are putting a price on carbon using these instruments. Carbon-pricing schemes implemented and scheduled for implementation would cover 11 gigatons of carbon dioxide equivalent ($GtCO_2e$), or about 20 percent of global GHG emissions, compared to 8 GtCO2e or about 15 percent in 2017. This increase is primarily due to the expected coverage of the China national Emission Trading System (World Bank & Ecofys, 2018).

The gold standard of climate change and carbon pricing policymakers is to achieve the highest emissions reductions and to cause the least negative impacts on economic growth. These two particular features of carbon-pricing instruments enhance substantially the political acceptability of climate policies. Moreover, policymaking is also affected by cultural values, which in turn, also improve policy acceptability and implementation. In this regard, authors claim that a better understanding of invisible cultural differences is one of the main contributions the social sciences can make to practical policymakers in governments, organizations and institutions, and to ordinary citizens (Disli, Ng, & Askari, 2016; Hofstede, 1980; Husted, 2005)

Developing resilience adapt to climate change is also about managing risks, either in reaction to or in anticipation of changes arising from changing weather and climate. Policy on mitigation has largely focused on the physical aspects of climate change, including risks to ecosystems and lives, the costs of decarbonizing economies, and the costs of impacts on various sectors of the economy. These are, for the most part, quantifiable and therefore conventionally included in policy analyses. No less important, however, are the cultural dimensions of climate change (Adger, Barnett, Brown, Marshall, & O'Brien, 2013).

These insights into how culture interacts with climate-related risks could radically alter understanding of social responses to climate change, and affect how mitigation and adaptation policies are designed. Most areas of public policy seek to promote societal goals through efficient policy mechanisms. Nevertheless, there is evidence that current climate change policies, overlooking culture, lead to undesired outcomes (Adger et al., 2013), which is one of the goals that this research seeks to explore. Therefore, this study's objective is to identify relevant cultural aspects that affect climate policies and explain the potential impacts of carbon-pricing instruments on economic indicators and emissions reductions by incorporating the cultural dimensions and its moderating influence on carbon prices to achieve effective emission reductions.

1.2. Problem statement

According to Vogel and Kun (1987), the public policy choices of a country are significantly influenced by culture. This influence of culture on a myriad of policy topics—education, wealth distribution, government oversight—is very well described in the literature, but the extent to which cultural values shape environmental and climate policy is not well documented (Waas, 2014). The literature that relates climate policy to culture is scarce, and non-existent in the case of carbon pricing, which is the gap that this study attempts to fill. Moreover, there is emerging evidence that climate policies, at least in specific cases, partly by neglecting cultural dimensions of climate change, have led to maladaptive results (Adger et al., 2013).

The relevance of culture in climate-change policymaking is essential, due to the fact that national culture is a total system of different values, beliefs, and perceptions among the countries (Hofstede, 1980). Thus, culture's influence may lead to the implementation of different environmental policies and affect countries' environmental performance.

On the other hand, over the past decade, the number of carbon-pricing initiatives has doubled, mainly in the form of carbon taxes and emission trading systems (ETS). During that same period, emissions covered have increased almost fourfold. The number of carbon-pricing initiatives will continue to grow, with several new initiatives under consideration and some of them planning to link jurisdictions, which increasingly requires taking into consideration cultural values.

The entry into force of the Paris Agreement in 2016, reaffirmed countries' commitment to reduce greenhouse-gas emissions, and several of them stated in their Nationally Determined Contributions (NDCs) that they are considering the use of carbon-pricing schemes (World Bank et al., 2017). In addition, as described before, two of the major concerns of policymakers during the development of carbon-pricing measures, are the potentially detrimental impacts on economic growth and the effectiveness of carbon-pricing schemes in reducing greenhouse gas emissions. The present study analyzed the aforementioned concerns by employing the Hofstede's cultural dimensions framework to assess the moderating effect of culture on carbon pricing and the influence of carbon pricing on economic growth and carbon dioxide emissions.

Due to the increasing relevance of carbon pricing as a financial instrument to reduce emissions, understanding how cultural values shape climate policies is essential to assure the successful implementation and adoption of carbon-pricing initiatives, both at the national and the subnational level.

1.3. Research question and objective

1.3.1. Research question

- What is the effect of culture and carbon pricing on economic growth and carbon dioxide emissions?

1.3.2. Objective

- To analyze the influence of culture and carbon-pricing initiatives on economic growth and CO_2 emissions in 49 jurisdictions, using Hofstede's cultural dimensions framework.

1.4. Contribution of research

Carbon pricing has been claimed as a cost-effective financial instrument to reduce greenhouse-gas emissions (Aldy & Stavins, 2011; Bowen, 2011; Hahn & Stavins, 2011; Mehling, Metcalf, & Stavins, 2018; Narassimhan et al., 2017; Newell et al., 2013; Schmalensee & Stavins, 2017; Tietenberg, 2013), which have become increasingly relevant following the Paris Agreement in 2015. Many countries have pledged emissions reductions targets through the use of carbon-pricing initiatives, which covers 20% of the global GHG emissions in 2018 (World Bank & Ecofys, 2018). In spite of this trend and the fact that several jurisdictions at the national and sub-national level have implemented carbon-pricing initiatives, there is little knowledge about the relationship between culture and the implementation of carbon-pricing instruments. This thesis contributes by addressing this gap, through the analysis of the influence that cultural values have on carbon pricing and its effects, to determine if culture intensifies or weakens carbon pricing's impacts on economic growth and CO_2 emissions. Thus, understanding the relationships between cultural values and carbon pricing could provide more information and highlight the importance of developing tailor-made strategies according to the culture of the jurisdictions, that enhance climate policy and carbon pricing implementation.

2. Literature review

This chapter has four sections. The first section describes the interactions between economic growth, energy, and CO_2 emissions and analyzes the Environmental Kuznets Curve hypothesis. The second section delineates the characteristics of climate change policies, the implementation of carbon-pricing instruments and their characteristics that include the Pigouvian taxes approach and the climate science that supports such policies. The third section explores in detail the impacts of carbon-pricing policies on economic growth and carbon dioxide emissions. Finally, the fourth section illustrates culture and describes in detail the Hofstede's cultural dimensions theory.

2.1. Economic growth, energy and CO_2 emissions

For a long time, economies have depended significantly on fossil fuels and electricity, although, the relationship between energy consumption and economic development has been dynamic and complex. Moreover, energy use has been shown to change with economic development stages, and although it presents some predictable regularity, a closer look reveals many national and subnational specificities that prevent any normative conclusions about desirable rates of energy consumption (Smil, 2000).

A remarkable correlation is discovered by comparing the global consumption of commercial energy with the best available reconstruction of the world’s gross domestic product (GDP) during the twentieth century. Growth rates of both variables coincide almost perfectly, indicating an approximately 16-fold increase in 100 years (Smil, 2000). Therefore, energy consumption is considered one of the most important vehicles for economic development. Economic growth needs too much energy for gearing its momentum in an efficient manner. However, this momentum produces a greater level of

CO_2 emissions, so policies should be formulated to regulate energy intensity and promote economic growth. In addition, emissions' increase and pollution are highly sensitive topics in developed nations that continue to rely heavily on fossil fuels to gear the pace of economic growth (Zaman & Moemen, 2017)

An estimation indicates that OECD countries' emissions will contribute around 13.8 billion metric tons of CO_2 by 2040 (Zaman & Moemen, 2017). Stern (2008) estimates that the economic impact of climate change could reduce annual global GDP by 5-20%, while greenhouse gases (GHG) mitigation would cost about 1% of the annual global GDP. Thus, the relationship between the CO_2 emissions and economic growth is an important connection between the economic and environmental policy (Marjanović, Milovančević, & Mladenović, 2016).

Renewable natural resources, and energy in particular, function as inputs into the production of goods and services. If the composition of output and the methods of that production were constant, then damage to the environment would be inseparably related to the scale of global economic activity. But substantial evidence indicates that development gives rise to a structural transformation in what an economy produces (Grafton & Knowles, 2004; Grossman & Krueger, 1995). Meaning that, the tendencies leading to change in the composition and techniques of production may be sufficiently strong to offset the negative effects of increased economic activity on the environment (Grossman & Krueger, 1995). In addition, Grossman and Krueger (1995) in their seminal study found little evidence that environmental quality deteriorates steadily with economic growth. Rather, they found for most indicators studied that economic growth brings an initial phase of deterioration of the environment followed by a successive phase of improvement.

On the other hand, many studies have found that energy intensity and economic scale change are the primary driving factors of CO_2 emissions (Zhu et al., 2014). The relationship between the economic growth and the environmental standards of a society is addressed by the Environmental Kuznets Curve (EKC).

2.1.1. Environmental Kuznets Curve

The environmental Kuznets curve is a hypothesis that relates various indicators of environmental degradation with income per capita (Jaunky, 2011). According to this hypothesis, during the early stages of economic growth, environmental degradation and pollution increase, but when certain level of income per capita is reached, the trend reverses, meaning that high-income levels of economic growth lead to environmental improvement. This implies that the environmental impact indicator is an inverted U-shaped function of income per capita (Stern, 2003). However, the EKC has never been shown to apply to all pollutants or environmental impacts (Dasgupta, Laplante, Wang, & Wheeler, 2002), and recent evidence challenges the notion of the EKC in general. For instance, the impact on individuals' well-being of environmental deterioration caused by the processes of economic growth in industrialized countries is evident (Antoci, 2009), although in developed countries, individuals have at their disposal many options of goods and services to protect themselves from environmental degradation. Additionally, Perman and Stern (2003) found that when statistics are considered and appropriate techniques are used, the EKC does not exist.

Grossman and Krueger (1995) consider that if there were no structural or technological changes in the economy; pure growth in the scale of the economy would result in a proportional growth in pollution and other negative impacts on the environment, called the scale effect (Stern, 2003). The conventional perspective that economic development and environmental performance are conflicting objectives reflects the scale effect alone (Stern, 2003). Therefore, incorporating other factors in the analysis is important to understand which structural changes have to be implemented to ensue the EKC.

The following proximate factors have to be considered for the EKC to happen:

- scale of production which consists of output mix, state of the technology, and input rations;
- output mix changes because different industries have different intensities of pollution over the course of economic development;
- changes in input mix, which imply the substitution of less/more environmentally damaging inputs;
- and improvements in state of technology, that involve production efficiency (use of less polluting units of input per unit of output) and emissions specific changes in process (less pollutants emitted per unit of input) (Stern, 2003).

On the other hand, Grossman and Krueger (1995) found that the environmental improvement in developed countries reflects an increased demand for environmental protection at higher levels of income, indicating that as jurisdictions experience greater prosperity, their citizens require that more attention be paid to the noneconomic aspects of their living conditions. The richer countries, which tend to have relatively cleaner air and relatively better environmental conditions, also have higher environmental standards and stricter legal environmental frameworks than in countries with lower incomes, many of which still face environmental problems (Grafton & Knowles, 2004). Selden and Song (1993) examined the EKC hypothesis in a panel of cross-sectional countries and found that air pollutants including suspended particulate matter, sulfur dioxide (SO_2), nitrogen oxides, and carbon monoxide rise their concentration along with the increase per capita income, while at the later stages of economic development, these pollutants considerably decline over time, thus the EKC hypothesis was confirmed for the four air pollutants. In addition, it is possible that environmental improvement might arise because, as countries develop, they stop to produce some pollution-intensive goods, and begin to buy these products from other countries with less restricting environmental protection laws. Perhaps this is the main explanation for the (eventual) inverse relationship between a country's income and pollution (Grossman & Krueger, 1995). Consequently, with respect to the inverted U-shaped relation to consumption, the Hecksher-Ohlin trade theory indicates that, under free trade, less developed countries would specialize in producing goods that are intensive in labor and natural resources. The developed countries would specialize in human capital and manufactured capital-intensive activities (Stern, 2003). The reduction in environmental degradation in the developed countries and increases in environmental degradation in middle to low income countries may partly reflect this specialization (Fredriksson & World Bank, 1999). Environmental regulation and stricter policies in industrialized countries might further encourage polluting activities to gravitate towards the developing countries (Suri & Chapman, 1998). Accordingly, increasing production and consumption in developing countries present challenges not only for emissions reduction targets but also in terms of fairness of effective policy instruments (Apergis, 2016).

Economic growth related to reduced pollution depends on several factors such as greater willingness to pay for environmental protection at higher levels of income. Nevertheless, the political factors driving a local EKC (such as voters demanding cleaner air and better environmental conditions) may not extend from local pollutants to global ones such as CO_2, since they show potential for externalization due to global mixing of GHGs and are seen as a necessary cost of economic growth (Fernández-Amador et al., 2017).

In summary, it appears that the EKC hypothesis only holds under specific circumstances and it may influence policy designs if taken into consideration. Aside from the EKC's practical application, it's clear that more wealthy countries have enough resources to address environmental issues more effectively than poorer countries, meaning that the levels of pollutants have declined in those countries over time with the implementation of increasingly stricter environmental laws and technical innovations. Nevertheless, studies supported by evidence showing that pollution is addressed and reduced in developing economies as well (Dasgupta et al., 2002).

2.2. Climate change policy and carbon pricing

Anthropogenic climate change is now beyond dispute, and the international climate negotiations that address targets for climate mitigation have intensified (Rockström et al., 2009). At the present time, more than 30 billion metric tons of CO_2 per year are emitted globally from fossil fuel combustion (Newell et al., 2013), considering that all productive activities that utilize fossil fuels as an energy source, produce greenhouse gas emissions, thus impact global climate. Higher levels of CO_2 that accumulate in the atmosphere will eventually result in higher global temperatures, greater climate variability, and increases in sea levels. These unwanted events are considered external costs and are referred to as the social cost of carbon (SCC), which is the basis for taxing or otherwise limiting carbon emissions, and is the focus of policy-oriented research on climate change (Pyndick, 2013). Climate change policies address these externalities impact in one of three ways: a) require businesses and individuals to change behaviour towards technology adoption and emissions; b) subsidize businesses and individuals to invest in low-carbon services and goods; or c) put a price to externalities caused by greenhouse-gas emissions (Aldy & Stavins, 2011).

Three decades ago, many environmental activists argued that government allocation of rights to emit pollution incorrectly legitimized environmental degradation, while others questioned the viability of such an approach (Mazmanian & Kraft, 2008), being at that time command-and-control the common approach employed. Today is increasingly acknowledged that because emission reductions vary greatly, aggregate abatement costs under command-and-control approaches can be than they need to be. Instead, by putting a price on emissions, carbon pricing tends to equate marginal abatement costs rather than emissions levels, and rates across sources. This means that in theory, market-based approaches can achieve aggregate pollution reduction targets at minimum cost (Schmalensee & Stavins, 2017). Additionally, in recent years, the number of carbon-pricing initiatives grows on a near yearly-basis (World Bank et al., 2017), and the importance of understanding the strengths and weaknesses of carbon-pricing policies as they emerge is enormous, in environmental, social, and economic terms (Schmalensee & Stavins, 2017).

By pricing CO_2 emissions (or the carbon content of the fossil fuels—coal, petroleum, and natural gas), governments encourage firms and individuals to find and exploit the lowest-cost goods and services to reduce emissions and invest in the implementation and development of innovative technologies, methods, and projects that could further mitigate emissions. A number of policy instruments can facilitate carbon pricing, including carbon taxes, cap-and-trade, emission reduction credits, clean energy standards, and fossil fuel subsidy reduction (Aldy & Stavins, 2011).

A key question for market-based policies concerns the degree to which they encourage long-term investment in new technologies rather than solely short-term fuel-switching and energy conservation. Early research into Europe's ETS indicates that such long-term investments may be limited (Leiter, Parolini, & Winner, 2011). Although, carbon-pricing instruments may be still too new to promote those long-term investments, studies indicate that renewable energy technologies are becoming economically competitive (Silva, Soares, & Pinho, 2012).

2.2.1. Climate change policy

Climate change, intensified by anthropogenic carbon dioxide emissions, presents an immediate and serious threat to both the ecological integrity of the World's ecosystems, and the economic and the social stability of its societies. Nevertheless, international climate change negotiations' outcomes have been mixed (Burch, Shaw, Dale, & Robinson, 2014).

Dealing with global warming requires a constant and global effort, because CO_2 emissions remain in the atmosphere for tens or hundreds of years. Moreover, carbon dioxide concentrations changes in any one year's emissions have an insignificant effect on current overall concentrations. Even substantial reductions in emissions made today will not be evident in atmospheric concentrations for decades (IPCC, 2014). Those factors directly affect climate policy design (Shogren & Toman, 2000) and shape much of the policy analysis, because it has strong implications for the permissible flow of emissions, and thus for emission reduction targets. The reduction targets, in turn, influence the pricing and technology policies. Therefore, understanding the risks associated to choosing different strategies is basic to an understanding of policy (Perman & Stern, 2003); especially, considering that research suggests that resistance to innovative environmental policy— whether by citizens, firms, NGOs, or politicians— may be driven by lack of knowledge about how it exactly functions and which impacts it generates (Baranzini et al., 2017). In that sense, it's relevant to mention that many policies for risk reduction work in terms of targets, usually expressed in terms of emission flows, stabilization levels, or average temperature increases (Stern, 2008). Consequently, one can think of a GHG abatement policy as a form of insurance: society would be paying for a guarantee that a low-probability catastrophe will not occur (or is less likely) (Pyndick, 2013).

The negative effects of climate change most likely will take decades or longer to become evident. Numerical estimates of physical impacts are few, and confidence intervals are even harder to obtain (Shogren & Toman, 2000). Undetermined physical risks are compounded by uncertain socioeconomic consequences. Cost estimates of potential impacts on market goods and services can be made with some confidence. But cost estimates for nonmarket goods such as human and ecosystem health give rise to serious debate (Shogren & Toman, 2000). In this regard, the social carbon cost presents a key point of discussion because of the uncertainty involved around the impacts of climate change and the incorporation of future costs due to the long-term permanence of CO_2 in the atmosphere (Pyndick, 2013). The physical analysis of climate change has been the main approach to climate debate, as opposed to the social or cultural aspects of it.

A pragmatic approach to the economic implications of putting a price on carbon is usually captured in terms of mitigation costs that result from comparing the policy scenario with a baseline that does not include climate change policy (Kriegler et al., 2015), which presents a problem in designing policy instruments that are efficient because they equate marginal social benefits with marginal social costs, assuming that the policymakers have adequate information on damages. And in the absence of such relevant information or the lack of political will to use it, another important problem remains for environmental economics—to design policies that achieve environmental targets at the lowest cost, known as the cost-effectiveness challenge (Hahn & Stavins, 2011). Carbon-pricing policies such as carbon taxes and cap and trade meet the principle of cost-effectiveness.

2.2.2. Carbon prices

Carbon prices are directly related to climate mitigation efforts because they measure the marginal cost of those emissions from sources covered by a jurisdiction's climate change policy (Baranzini et al., 2017). For these reasons, comparisons of the effective carbon prices, or the carbon abatement incentives, that different economic sectors face within and across jurisdictions are of great economic, environmental, and political interest. Effective carbon prices arise either via explicit carbon prices provided by carbon taxes or cap-and-trade systems, or implicitly, via the abatement incentives embedded in other policies that influence GHG emissions (OECD, 2013).

A comparison of carbon prices across jurisdictions shows the extent to which a jurisdiction is creating incentives for more or less expensive mitigation efforts in the sectors it regulates (World Bank et al., 2017). However, because jurisdictions implement domestic carbon-pricing instruments in their local currencies, the values of these different currencies may vary. Although market exchange rates are utilized in the context of competitiveness and traded goods, purchasing power parity exchange rates allow to compare carbon prices with respect to domestic goods and wages. Thus, a comprehensive evaluation would likely compare carbon prices using these rates (Narassimhan et al., 2017).

In addition to comparing different currencies, explicit carbon prices may not precisely reflect mitigation efforts. An explicit carbon price may be a limited measure of a jurisdiction's effort to reduce emissions. For instance, it may only cover a portion of a jurisdiction's emissions (e.g., only transportation), and it may fail to consider the impact of other, non-price policies that reduce GHG emissions (Aldy & Pizer, 2016). For example, regulations supporting energy efficiency regulations or renewable energies can achieve significant emissions reductions that are not reflected in the explicit carbon prices or energy prices influenced by carbon-pricing. There's also a risk that a policy may affect the effectiveness of the carbon price by subsidizing firms covered by the carbon tax or the emissions cap. Ultimately, the impact represented by carbon prices depends on both the price and the emissions reduced (Baranzini, Goldemberg, & Speck, 2000).

An alternative option to using explicit carbon prices are the implicit carbon prices, which estimate the average cost of abatement associated with a specific climate policy or a group of policies (OECD, 2016). Such implicit prices have the advantage of being applied more broadly, but the substantial disadvantage of not being directly observed, because they are usually derived from model simulations. To calculate implicit carbon prices, costs are divided by estimated abatement. Therefore, implicit carbon prices will be high for expensive policies and those that produce little net abatement. Additionally, in contrast to high explicit carbon prices, high implicit prices are not market signals, and they don't suggest that all less expensive mitigation options are being incentivized or taken, which makes them not as relevant for investment or trade decisions (Aldy & Pizer, 2016).

An equally significant aspect of carbon prices is that empirical evidence shows that carbon price changes do change behavior (Bowen, 2011) because the cost of emissions control and the price paid for the remaining emissions will be passed forward into the prices of final goods and services. Therefore, consumers will pay prices reflecting the emissions associated with the production of the goods or the services they buy (Goulder & Parry, 2008). As a result, for policymakers, setting a price on carbon that reflects the cost of carbon pollution can inform the objective and the ambition of climate change policies (Aldy, 2015). For example, the US government used an estimate of the social carbon cost (SCC) to assess standards for fuel economy, equipment efficiency and carbon emissions; where the social cost of carbon is defined as the present value of monetized damages associated with an incremental ton of CO_2 emissions (Aldy, 2015), in 2013 this cost was US$200 per ton of CO_2 (Pyndick, 2013). In other words, the SCC indicates the point where profit-maximizing firms will cut back on their emissions and the loss of profits from reducing emissions by a further unit (the marginal abatement cost) just starts to get bigger than the price it has to pay for continuing to emit that unit (Bowen, 2011). In some cases, laws require regulations to reflect a weighting of benefits and costs, the application of the SCC could determine the ambition of energy and climate policies; in other cases, pricing carbon is basically the instrument that underpins climate policies (Aldy, 2015). Moreover, researchers have demonstrated that carbon-price increases induce technological improvements, and small decreases in energy and oil demand (Bowen, 2011).

2.2.3. Emission trading systems and carbon taxes

Carbon-pricing policies to address climate change are relatively new. During the last four decades, conventional environmental policy approaches, namely, command-and-control approaches have dominated climate policy in many countries (Schmalensee & Stavins, 2017). Such command-and-control regulatory instruments have two approaches: technology-based standards and performance-based standards. Technology-based standards demand the use of specific equipment or processes. Performance-based standards specify allowable levels of pollutant emissions or allowable emission rates, but leave the specific procedures of achieving those levels up to regulated entities (Aldy & Stavins, 2011). These command-and-control instruments are not cost-effective, because of the variation of abatement costs across businesses

(Bowen, 2011). And the limitation of these standards beyond cost-effectiveness is that they don't incentivize firms to adopt superior and more efficient technologies; because once the policy's requirement has been met there is no motivation to adopt cleaner technologies (Hahn & Stavins, 2011). These crucial limitations of command-and-control regulations can be avoided through the use of market-based policy instruments because they tend to equate marginal abatement costs. Additionally, abatement costs would be 40-95 percent lower under carbon-pricing policies than under technology mandates (Tietenberg, 2013). This means that in theory, market-based approaches can achieve aggregate pollution control targets at minimum cost (Schmalensee & Stavins, 2017) through the implementation of carbon-pricing instruments (Newell et al., 2013).

Carbon pricing is a broad term that includes two policy approaches: emissions trading schemes and carbon taxes. Emissions trading systems place a cap on the total emissions level and leaves to the market the determination of the price, whereas carbon taxes set the price and allows the market to determine the total level of emissions reduced (Tietenberg, 2013).

Another relevant feature of the carbon-pricing initiatives is their ability to link jurisdictions at the regional, national, and subnational level, especially in the case of emission trading schemes. The last ten years have seen the organic growth of linkages between many of the world's cap-and-trade systems, implying that this proliferation of linkages indicate that for many nations the expected benefits outweigh expected costs (Ranson & Stavins, 2014). These benefits could potentially reduce the cost of achieving the emissions reductions specified in the initial NDCs under the Paris Agreement 32% by 2030 and 54% by 2050 (Mehling et al., 2018).

The decision to develop a link between two carbon-pricing systems depends on a variety of economic, political, and strategic factors; among them the less studied cultural ones. This growing network of decentralized, direct linkages among these systems may turn out to be a key part of a future hybrid climate policy architecture (Ranson & Stavins, 2014).

2.2.3.1. Emission trading systems

An ETS also known as a cap-and-trade system, may establish a limit either on total emissions or on emissions intensity, as measured by emissions per unit of gross domestic product. It may include emissions from all greenhouse gases or just one, such as carbon dioxide (Narassimhan et al., 2017).

An ETS limits the aggregate emissions of regulated sources by creating a determined number of allowances and requiring those sources to surrender allowances to cover their emissions (Stavins, 2008). Governments then provide allowances, either freely or through an auction, equal to the level of the cap (Aldy & Stavins, 2011). Facing the choice of surrendering a tradable emission allowance or reducing emissions themselves, firms put a price on an allowance that reflects the cost of the reduced emissions that can be avoided by surrendering an allowance (Aldy & Stavins, 2011). Moreover, firms with lower abatement costs will sell their allowances in secondary markets to firms with higher abatement costs, and overall, emissions reductions are achieved at least cost (Narassimhan et al., 2017). As a result, irrespective of the initial allowance distribution, trading leads allowances to be put to their highest valued use: covering those emissions that are the most expensive to reduce and providing the incentive to undertake the cheapest reductions (Hahn & Stavins, 2011).

Cap-and-trade is considered effective, because it sets an aggregate quantity, and through trading, yields a price on emissions, and is effectively the dual of a carbon tax that prices emissions and yields a quantity of emissions as firms respond to the tax's mitigation incentives (Aldy & Stavins, 2011). Furthermore, several key design considerations of an ETS include how many allowances to issue (i.e., the size or level of the emission cap); the scope of the cap's coverage: identify the types of greenhouse gas emissions and sectors covered by the cap; whether to regulate upstream (based on carbon content of fuels) or downstream (based on monitored emissions); carbon revenue management; monitoring, measurement, and verification of emissions and allowances; and impacts on international competitiveness (Narassimhan et al., 2017). Other policy design considerations include the flexibility to save allowances for future use (banking) or to bring a future period allowance forward for current use (borrowing) can promote cost-effective abatement, which makes sense in the case of climate change policies, because it is a function of cumulative emissions that remain in the atmosphere for long periods of time. In addition, levelling allowance prices over time through banking and borrowing reduces the certainty over emissions in any given year, but maintains certainty of aggregate emissions over a longer time period (Aldy & Stavins, 2011). These considerations are crucial in defining the ambition and effectiveness of climate change policies.

2.2.3.2. Carbon taxes

The easiest approach to carbon pricing would be through government imposition of a carbon tax (Metcalf, 2007), that internalizes the unaccounted public costs of increased pollution, ambient and global warming pollution, health and environmental effects, and other impacts of climate change resulting from greenhouse gas emissions (Narassimhan et al., 2017). The government could set a tax in terms of dollars per ton of carbon dioxide emissions or GHG emissions by sources and sectors covered by the tax; a tax on the carbon content of the fossil fuels (Aldy & Stavins, 2011); or on the amount of fuel produced/supplied. The latter two are a form of excise tax as different fuels emit different amounts of carbon dioxide (CO_2) in relation to the energy they produce, leading to a higher effective price for carbon-intensive fuels such as coal and lower price for less carbon-intensive fuels like natural gas (Metcalf, 2007). Additionally, important design considerations for a carbon tax system includes choosing the appropriate price to achieve cost-effectiveness, emissions coverage, the point of taxation (upstream or downstream), stringency (i.e., planned escalation of price over time), the flexibility of the price to change in light of new information on marginal cost of abatement, allocation of revenue generated from the tax towards general public spending or emissions-reducing activities, and harmonization across boundaries beyond the jurisdiction of the tax (Narassimhan et al., 2017).

In order to be efficient, the carbon price would be set equal to the marginal benefits of emission reduction, represented by estimates of the social cost of carbon. Furthermore, carbon tax could increase to reflect that the more GHG emissions accumulated in the atmosphere, the larger the incremental damage of one more ton of CO_2 (Aldy, Ley, & Parry, 2008). By the same token, focusing on the carbon content of fuels would enable the policy to capture a high percentage of CO_2 emissions as opposed to the millions of exhaust pipes that emit CO_2 after fossil fuel consumption (Aldy & Stavins, 2011).

As fuel suppliers face the emission tax, they will pass the cost of the fuels to the consumers, passing effectively the tax down through the energy system, and creating incentives for fuel-switching and investments in more energy-efficient technologies that reduce GHG emissions (Aldy & Pizer, 2016).

The impacts of a carbon tax on emissions and the economy will depend on the amount and management of the carbon revenue (Aldy & Stavins, 2011). It could be used to reduce the effects of existing distortionary taxes on labor and capital, thereby invigorating economic activity and offsetting some of a policy's social costs. Other relevant uses of revenue for social purposes include reduction of debt, and funding public programs, such as research and development of climate-friendly technology (Goulder & Parry, 2008).

2.3. Impacts of carbon pricing on economic growth and carbon dioxide emissions

Policymakers usually conduct two common assessments on carbon pricing to design climate policies, based on which conclusions of cost-effective or cost-efficient carbon-pricing policies are made: the impacts on economic growth and emissions reduction (Li, Wang, Zhang, & Kou, 2014).

The specific impacts of carbon pricing on economic growth include distributional impacts, effects on competitiveness, and economic benefits through carbon revenue management. And the impacts of carbon pricing on the level of CO_2 emissions encompass the carbon emissions leakage and the actual emissions reductions.

2.3.1. Impacts on economic growth

The projected impact of carbon-pricing policies on economic growth varies slightly across jurisdictions and studies, reflecting differences across studies with respect to the ambition of mitigation policies considered and to the level of CO_2 emissions in a business-as-usual scenario. Overall, several authors agree that the impact tends to be relatively small (Arlinghaus, 2015; Chateau & Saint-Martin, 2013; Lu, Tong, & Liu, 2010; Zhixin & Ya, 2011). In some cases, social welfare can be maximized under an efficiently implemented carbon-pricing instrument, and carbon revenues may theoretically be invested in a manner that maximizes overall welfare (Goulder & Parry, 2008). On the other hand, global warming can have considerable negative impacts on economic growth, and not having mitigation measures such as carbon pricing, could reduce annual global GDP by 5-20% (Stern, 2008).

Nonetheless, the introduction of a carbon price causes consumers and producers alike to experience both a private welfare loss. By design, pricing carbon will increase prices for carbon-intensive energy products and other intermediate and end-use products that involve carbon emissions during production or distribution (Jenkins, 2014). Accordingly, market forces will spontaneously work in a cost-effective way to reduce the quantity of emissions. Moreover, carbon pricing possesses two incentive effects. A ‘direct effect’, through price increases, promoting conservation measures, energy efficient investments, fuel and product switching, and economic changes in the production and consumption structures. An ‘indirect effect’, through the recycling of the collected fiscal revenues, reinforcing the previous effects, by changing investment and consumption patterns (Baranzini et al., 2000).

2.3.1.1. Competitiveness

Competitiveness is the ability of a country or a firm to create sustainable economic operations at micro and macro levels (Kleesma, Viiding, & Latosov, 2011). Therefore, the possibility that putting a price on carbon dioxide emissions in the form of a tax or an emissions trading scheme has adverse effects on a sector or a country's competitiveness is often a major concern for policymakers planning to introduce such instruments (Arlinghaus, 2015). When assessing the impacts on competitiveness, it's important to consider that the price signal of an ETS is not entirely equivalent to a carbon tax. Taxes are compulsory and one-way revenue-raising fiscal policy instruments. In contrast, the purchase of an emissions certificate in an ETS context is associated with the right to pollute (Arlinghaus, 2015).

The competitiveness effects of carbon pricing can result in negative economic and environmental outcomes, especially, for firms in energy intensive and trade exposed (EITE) sectors, such as iron and steel industries, forestry, and metal mining sectors. They may relocate facilities to countries without meaningful climate change policies, thereby increasing emissions in these new locations and offsetting some of the environmental benefits of the policy (Aldy & Pizer, 2016). These negative outcomes are often addressed in climate policies by protecting firms in EITE sectors through the implementation of measures, such as the establishment of border adjustments in the form of tariffs on goods imported from countries that do not price carbon and border rebates on exports (Gray & Metcalf, 2017). An alternative option is to provide additional support to domestic firms in EITE sectors in the form of exemptions or free-allowance allocations (Aldy & Stavins, 2011). Moreover, other factors are also relevant in evaluating the impacts on competitiveness inflicted by carbon-pricing instruments, such as feature exemptions, emission permits, and whether revenue recycling is considered or not.

Employment is another aspect at the center of the debate around climate policies since many policymakers deem carbon pricing a question of “jobs versus environment”, although it is not clear how changes in employment relate to competitiveness (Flues & Lutz, 2015). An expansion of employment could be a sign of an expansion of production, but a large workforce may also indicate less productivity. Additionally, carbon pricing might also induce a restructuring of employment between more and less polluting sectors, where the net effect on employment is not clear (OECD, 2011). For instance, Chateau and Saint-Martin (2013) found that net employment effects are small whereas there is a considerable shift of workers away from declining sectors, such as coal mining and other sectors that are producers or heavy users of fossil fuels, and toward industries producing clean energy and also goods and services whose products result in the least carbon emissions when produced and consumed.

2.3.1.2. Distributional effects

The evidence indicates that in the short-run the impact of carbon pricing on real incomes via consumer prices is regressive, meaning that lower-income groups take a proportionately larger hit. Lower-income groups in most nations tend to spend a larger proportion of their incomes on electricity, home heating fuels, gasoline, and other energy-intensive goods. Although this is not necessarily the case in poorer countries where the very poor have no access to fossil fuel energy (Bowen, 2011). Many low-income households may not be able to afford any increase in expenditures, and a carbon-pricing instruments should ensure that these households are not driven deeper into poverty. For households, higher energy prices imply reduced purchasing power, as well as a shift in purchasing behavior away from carbon-intensive goods and services (Kaufman & Krause, 2016). For instance, in the U.S. the effects of carbon prices on total household expenditures in energy, range from 2.1 percent for the poorest household grouping to 1.3 percent for the wealthiest grouping (Mathur & Morris, 2014).

In this sense, changes in energy prices depend on the carbon intensity of a household's energy use, meaning that the more carbon-intensive it is, the more a carbon price will change the energy prices that household pays. At the same time, the carbon intensity of household energy use depends on how electricity is produced in the region and how a given household uses energy (Mathur & Morris, 2014). Households that use energy predominantly for driving will have different carbon intensities compared to households that use energy predominately for heating or electricity, implying different distributional impacts (Kaufman & Krause, 2016). Additionally, how the proceeds from carbon pricing are distributed have decisive impacts on the ultimate distributional outcome (Rausch, Metcalf, & Reilly, 2011).

2.3.1.3. Carbon revenue management

In 2017, the total value of carbon-pricing instruments was US$52 billion (World Bank & Ecofys, 2018). More than US$28.3 billion in government carbon revenues are collected each year in 40 countries and another 16 subnational jurisdictions around the world (World Bank et al., 2017). Of those revenues, 27% (US$7.8 billion) are used to finance "green" spending in energy efficiency or renewable energy; 26% (US$7.4 billion) go towards state general funds; and 36% (US$10.1 billion) are returned to corporate or individual tax payers through paired tax cuts or direct rebates. As shown in Table 1, emission trading systems (US$6.57 billion in total public revenue) earmark a larger share of revenues for “green” spending (70%), while carbon tax schemes (US$21.7 billion) usually refund revenues or otherwise direct them toward government general funds (72% of revenues) (Carl & Fedor, 2016). The net carbon revenues are substantial, and the GDP and welfare impacts of carbon pricing depend significantly on how these revenues are recycled. There are also beneficial impacts to the economy from avoided climate change that are not frequently taken into account in many studies (Goulder & Hafstead, 2013). Revenues generated from auctioning allowances and carbon taxes could be used in climate change mitigation, reducing distortionary taxes, reducing budget deficits, addressing competitiveness concerns, augmenting government expenditure on public goods, or to increase the flow of climate finance from developed to developing countries (Narassimhan et al., 2017). Distributional effects can be alleviated in different ways. On one hand, financial compensations can be given to groups who would otherwise carry an uneven portion of the burden (Bowen, 2011). On the other hand, carbon taxes or ETSs can be complemented by other policy instruments to provide compensatory payments. Carbon revenues, for example, can be used to reduce payroll taxes that discourage labor force participation. If authorities are motivated into tackling these market and public policy failures by the threat of climate change, the costs of emissions reductions can be offset to some extent, while also accelerating the transition to a sustainable, low-carbon economy (Bowen, 2015). Finally, governments can use revenue to invest in infrastructure, complementary environmental policies, clean energy projects, R&D or climate change adaptation

(Narassimhan et al., 2017). Yet revenues could also be used to reduce outstanding public debt or spent on social objectives that have nothing to do with climate change. Reforming the tax-benefit system and public debt management are issues that arise irrespective of the need for carbon pricing and raise questions that are quite separate from the ones raised by the need to make growth green (Bowen, 2015), which in the end also affect economic growth. Additionally, some countries earmark the carbon revenue in an attempt to achieve a double dividend in emissions reductions, meaning that not only the emission reductions are attained, but also an improvement in the economic efficiency from the use of carbon revenues to reduce other taxes such as income taxes that distort labor supply and saving decisions (Carl & Fedor, 2016).

Table 1. Global cap-and-trade and carbon tax system revenues

Cap-and-trade and carbon tax systems	Annual revenue (millions)	Share of GDP	Green spending	General funds	Revenue recycling
European ETS	US$ 4640	0.03%	80%	20%	0%
California ETS	US$ 1034	0.05%	45%	4%	55%
Regional Greenhouse Gas Initiative (U.S.)	US$ 447	0.01%	49%	32%	12%
Chinese Provincial ETS pilots	US$ 250	0.02%	10%	90%	0%
Quebec Cap and Trade	US$ 100	0.03%	100%	0%	0%
Alberta Greenhouse Gas Reduction	US$ 92	0.03%	90%	10%	0%
Switzerland ETS	US$ 9	0.00%	0%	100%	0%
Australia carbon-pricing mechanism	US$ 8790	0.60%	15%	1%	53%
Sweden carbon dioxide tax	US$ 3680	0.67%	0%	50%	50%
Norway carbon dioxide tax	US$ 1580	0.31%	30%	40%	30%
United Kingdom carbon price floor	US$ 1530	0.05%	0%	85%	0%
British Columbia carbon tax	US$ 1100	0.49%	0%	0%	102%
Denmark carbon dioxide tax	US$ 1000	0.29%	8%	47%	45%
Switzerland carbon dioxide levy	US$ 875	0.13%	33%	0%	67%
Mexico special tax	US$ 870	0.06%	0%	100%	0%
Finland carbon dioxide tax	US$ 800	0.29%	0%	50%	50%
Ireland carbon tax	US$ 510	0.03%	13%	88%	0%
Japan tax for climate change	US$ 490	0.01%	100%	0%	0%
France carbon dioxide tax	US$ 452	0.02%	100%	0%	0%
Iceland carbon tax	US$ 30	0.22%	0%	100%	0%

Note. Adapted from *Tracking global carbon revenues: A survey of carbon taxes versus cap-and-trade in the real world* by Carl and Fedor (2016, p. 52-53).

2.3.1.4. Expected impacts on GDP's growth rate

Carbon pricing entails impacts for the entire economy of a jurisdiction. In a competitive market, carbon prices can be passed through to energy prices for downstream industries and it's expected to generate cost-efficient CO_2 emissions reductions (Li et al., 2014). In the short-run, carbon prices will rise proportionally the prices of related goods and services, increase the costs of the enterprises, reduce the competitiveness of energy-intensive and trade-exposed industries, and inflict adverse impacts on economic growth (Lin & Li, 2011). Some authors argue that the adverse economic impacts of carbon pricing on the economy are minimal to non-existent depending on how carbon revenues are employed, which has a relevant effect on the projected GDP loss. They emphasize that the potential GDP losses could be reduced considerably by using the carbon revenues to reduce existing taxes that discourage economic activity. For instance, the projections of the average annual carbon tax revenues raised in the United States from 2000 to 2020 to achieve a 20% reduction of CO_2 emissions range from US$65 billion to US$ 300 billion (Gaskins & Weyant, 1993). Thus, it's hypothesized:

Hypothesis 1 The higher the carbon price the lower the short-term GDP growth rate.

2.3.2. Impacts on CO_2 emissions

The main objective of carbon-pricing instruments is to reduce carbon emissions, most existing carbon policies have no specific requirements to assess policy effectiveness in reducing emissions, although some attempted to evaluate their impacts (Lin & Li, 2011). Identifying the overall impacts of carbon-pricing instruments can be challenging because many factors affect the carbon emissions, including economic growth and other programs designed to address environmental impacts (Sumner, Bird, & Smith, 2009). Jurisdictions have used different metrics to determine the emission benefits of carbon pricing. One of the most common metrics for assessing carbon pricing effectiveness is overall reductions in CO_2 emissions that can be tracked using GHG emissions inventories at the national or subnational level (Aldy & Pizer, 2016). This metric is somewhat flawed because it reflects not only the carbon pricing effects but also the effects of other carbon reduction polices and variables such as the level of economic growth. While these metrics lack precision, jurisdictions can use it to evaluate their overall GHG reduction goals and to determine whether policies, including carbon pricing, are effective (Sumner et al., 2009).

Baranzini et al. (2000) indicate that the final impact on emissions depends, among other factors, on the emissions covered, meaning what is exactly taxed or capped, and the level of carbon prices (i.e. how much to pay). Indeed, if the carbon price is set at a relatively low level (compared to marginal abatement costs), or if energy demand is relatively insensitive to price changes, then emissions will not decrease sufficiently to attain a given abatement objective (Baranzini et al., 2000). Both factors, the level of carbon prices and the coverage of emissions reflect the ambition of the carbon-pricing policy (Narassimhan et al., 2017).

2.3.2.1. Ambition of carbon-pricing instruments

Ambition in this context captures the extent to which a carbon-pricing instrument contributes to global climate mitigation efforts. The product of coverage and stringency, defined as the “coverage adjusted carbon price”, indicates the level of ambition of an

ETS system and a carbon tax (Pyndick, 2013). The Regional Greenhouse Gas Initiative (RGGI) located in the West Coast of the U.S., for example, stands out as one of the most well-planned and well-executed ETS markets with full auctioning of allowances and efficient use of carbon revenues, but could be considered the least ambitious ETS program with a coverage adjusted price of $0.53 per ton of GHG emissions even though its emissions fell 57% between 2005 and 2016, perhaps induced by other complementary policies (Narassimhan et al., 2017). Carbon prices adjusted for sectoral coverage and exemptions are significantly lower than they would be without such exemptions in most of the carbon-pricing schemes. For instance, Ireland and Norway exempt certain EITE sectors and cover most of their respective economies with either a carbon tax or the EU ETS, but their effective carbon prices are less than US$10 per ton of CO_2 emissions (Narassimhan et al., 2017).

2.3.2.2. Carbon leakage

Another important issue with respect to the impacts of carbon pricing on emissions is carbon leakage, where increases in carbon emissions outside of a particular jurisdiction offset the reductions achieved within the jurisdiction. Carbon leakage occur in at least two ways. First, new regulations within one jurisdiction can increase production costs, causing emitting firms to move to another jurisdiction. Second, new regulations implemented by one jurisdiction can shift consumer demands away from goods and services produced within that jurisdiction, leading to increased demands and emissions elsewhere (Goulder & Parry, 2008). However, the extent of carbon leakage is controversial and there is considerable debate over the design of the correct policy mix to reduce it (Antimiani, Costantini, Martini, Salvatici, & Tommasino, 2013), being the major concern with respect to carbon leakage that carbon reductions would not contribute to global emission reductions and the effectiveness of the climate strategies might be undermined (Dröge, 2009).

A popular option to tackle carbon leakage is border adjustment for imports, which usually implies requiring importers to pay a tax according to the emissions associated with their product's production, at the same price as faced by domestic producers (Fischer & Fox, 2012).

Another important consideration to prevent carbon leakage is the potential for policy linkages across jurisdictions, which is easier to implement for cap-and-trade schemes. Generally, linkages are likely when jurisdictions have similar environmental goals, economic conditions, a history of productive engagement on other issues and familiarity with each other's regulatory and political systems (Ranson & Stavins, 2014). Additionally, in case that political constraints induce policies to be made by authorities whose jurisdictions are less efficient, the situation can be improved through linkages across regional programs (Fischer & Fox, 2012).

2.3.2.3. Expected impacts on the CO2 emissions' growth rate

As described before, the primary motivation for implementing carbon-pricing initiatives is their ability to attain environmental goals, in particular, the reduction of GHG emissions, while simultaneously increasing economic efficiency. Consequently, a reduction in carbon dioxide emissions closely associated with a decrease in fossil fuel consumption improves air quality, and through carbon revenue recycling may promote technological innovation. Additionally, compared to the benefits of climate change mitigation and prevention, which are global and long-term, the benefits resulting from the reduction of local environmental problems, such as air quality in big cities, would mainly accrue in the short term and at the local level. (Baranzini et al., 2000).

According to (Siegmeier, Mattauch, & Edenhofer, 2018), carbon pricing is the key to decarbonizing the economy. As one of the CO_2 mitigation methods, carbon pricing can also reduce energy use, regulate emission flows, improve energy efficiency and simultaneously promote the development of renewable energy. This emissions-reduction impact, among other factors, comes mainly from the level of carbon prices. For example, the carbon tax rates in Sweden (US$ 45/tonCO_2 in 1991) are generally higher than those in other countries, which is one of the main reasons why the absolute decrement of CO_2 emissions per capita in Sweden (13% emissions reduction between 1990 and 2008) is much larger than it in other countries (Lin & Li, 2011). Thus, it's expected:

Hypothesis 2 The higher the carbon prices, the lower the short-term growth rate of CO_2 emissions.

2.4. Culture

UNESCO (2012, p. 5) in their Post-2015 Agenda recognizes the relevance of culture as a "driver and enabler of environmental sustainability", and the lessons learned during the implementation of the Millennium Development Goals (MDGs) emphasize that "leaving out the cultural context has been blamed for the failure of well-intentioned development programs and the gaps in achieving the MDGs", revealing the "inadequacy of universal policies and approaches to development."

Universal environmental policies play a crucial role in climate change mitigation. Examples of these policies and instruments are laws, taxes, tradable permits, distribution of information, and subsidies. Nevertheless, the cost-effectiveness of a policy is a key decision parameter in a world with scarce resources (Gupta et al., 2007), and considering specific cultural contexts where those universal policies are applied improve their chances of a successful implementation, thus their cost-effectiveness. On the other hand, the negative impacts of energy consumption and anthropocentric emissions on climatic conditions may be diminished or intensified by cultural factors, which are embedded in all societies (Disli et al., 2016).

Culture defines the behavior of individuals and groups in their relation to authority, self-conception, and the ways of dealing with conflicts (Disli et al., 2016). Similar to social capital, cultural capital (i.e., the knowledge of informal institutions) not only defines guidelines or constraints for economic behavior, but also serves as self-enforcement mechanism (Disli et al., 2016). The notion that *social/human capital,* the social bonds, norms, and values in a society, are important to environmental sustainability is because they, in part, determine the nature of the society's relationship to its *natural capital.* In this regard, researchers have investigated the relationship between connectedness among people and the environmental condition in a society (Park, Russell, & Lee, 2007). This clarifies why cultural factors are increasingly recognized as being important in dealing with environmental issues (Disli et al., 2016). Moreover, cultural values tend to be quite stable over time and thus do not offer instruments that can be manipulated in order to achieve specific policy goals (Hofstede, 1980). This contributes to support the notion that if culture is not considered during the development of policies, initiatives may no be implemented successfully.

Another relevant aspect is that in addition to the development of culturally congruent programs, understanding the influence of culture helps policymakers to know whether environmental practices used in one jurisdiction can be transferred effectively to another (Husted, 2005), which is critical in the elaboration of climate change policies that are commonly designed globally.

2.4.1. Hofstede's framework

Culture has been described in different ways. Hofstede's shorthand definition is: "Culture is the collective programming of the mind that distinguishes the members of one group or category of people from others" (Hofstede, Hofstede, & Minkov, 2010, p. 6). Moreover, culture has been used in many fields, anthropology, sociology, management, political science, occupational, organizational, among many others to explain distinctive traits of people in one group from others (Hofstede, 2011). On the other hand, changing the level of aggregation studied changes the nature of the concept of 'culture'. Societal, national and gender cultures, which people adopt from an early age, are much deeper rooted in the human mind than occupational cultures acquired at school, or than organizational cultures acquired on the job. For example an organizational culture can be changed as people take new jobs, as opposed to societal culture, which is not easily exchangeable (Hofstede, 2001).

During the second half of the twentieth century, authors speculated about the nature of the basic problems of societies that would present distinct dimensions of culture. And the most commonly used dimension to order societies is their degree of economic evolution and modernity. Economic evolution is reflected in people's collective mental programming, but there are other cultural varieties unrelated to economic evolution many authors have also studied in an attempt to apply these dimensions to different levels of aggregation (Hofstede, 2001). In 1969 Inkeles and Levinson distilled three standard analytic issues that were the precursors of Hofstede's framework: relation to authority, conception of self (masculinity), and primary dilemmas or conflicts (Hofstede, 1997).

In 1970 Geert Hofstede had access to a database about values and sentiments of people in 50 countries around the world. These people worked in the local subsidiaries of IBM. The relevant characteristic about this database was that initial analyses of the database at the level of individual respondents were confusing, but the data revealed an interesting correlation when they were analyzed at the level of countries (Hofstede, 1980). One of the strengths of this study is that, in terms of culture, Hofstede was able to establish a clear difference between the societal level and the individual level. Hofstede continued his study and he identified that the mean scores by country correlated significantly with the country scores obtained from the IBM database.

Apparently, IBM employees' profiles, with presence in countries all over the world could be useful to identify differences in *national* value systems. The reason being that from one country to another they represented almost perfectly matched samples: they were similar in all aspects except nationality, which made the effect of national differences in their answers stand out clearly, encouraging him to conduct a country-level analysis factor (Hofstede, 2011). Factor analyzing revealed common problems that IBM employees were dealing with in all these societies. The following problems were identified: dependence on superiors; a need for rules and predictability; the balance between individual goals and dependence on the company; the balance between ego values and social values. These results were similar to Inkeles and Levinson's standard analytic issues and were empirically supported by the IBM data, which gave origin to the dimensions of national culture; where a dimension is an aspect of a culture that can be measured relative to other cultures. (Hofstede, 1997). The six cultural dimensions are labelled: *Power Distance*, related to the problem of human inequality; *Uncertainty Avoidance*, related to the level of stress in a society or individuals in the face of ambiguity; *Individualism* versus *Collectivism*, related to the integration of individuals into primary groups; *Masculinity* versus *Femininity*, related to the division of emotional roles between women and men; *Long Term* versus *Short Term Orientation*, related to the choice of focus for people's efforts according to its temporality; and *Indulgence* versus *Restraint*, related to the gratification versus self-control of basic human desires (Hofstede, 2001).

In Hofstede's approach, each country has been positioned relative to other countries through a score on each dimension. The dimensions are statistically distinct and do occur in all possible combinations, although some combinations are more frequent than others (Hofstede, 2001). Nevertheless, researchers have shown that there is plenty of within-country variation on cultural values (Hofstede, 1980).

Research that uses a wide array of frameworks has shown that cultural dimensions are related to behaviors and attitudes in organizational environments; and perhaps the most influential cultural classifications is that of Geert Hofstede (Kirkman, Lowe, & Gibson, 2006). Hofstede's cultural distances have been applied in thousands of empirical studies and researchers have used Hofstede's framework successfully to select countries that are culturally different in order to increase variance, and most country differences predicted by Hofstede were supported. Therefore, Hofstede's values are clearly relevant for cross-cultural research. For instance, many studies that used Hofstede's cultural values as moderators at the country level have shown important effects on micro and macro level (Kirkman et al., 2006).

Despite the unquestionable acceptance of the cultural dimensions, some critical voices of Hofstede's work indicate that the limited characterization of his work, its confinement within the territory of states, and its methodological weaknesses mean that it is not an enhancer of understanding particularities. It is also mentioned that if the aim is understanding culture then it's necessary to know more about the richness and diversity of national practices and institutions – rather than merely assuming their 'uniformity' (McSweeney, 2002).

Another critique indicates several contention points to Hofstede's work: cultures do not equate to nations, pointing out that many cultures have been identified in one country; the transparency with which Hofstede related the cultural dimensions with other studies of country or national differences for the purposes of making international comparisons, indicating that cultural distances are more correlated with socio-economic national indicators than culture itself. For example, power distance shows a close relationship to educational and occupational class indices; and that ascribing numerate indices to cultural attributes generates methodological issues, because of the dynamic and adaptive nature of the balance between such attributes (Baskerville, 2003).

Although the criticism of Hofstede's work, several researchers have attempted to measure culture and cultural differences, and as Taras, Kirkman, and Steel (2010, p. 406) state: ‘‘virtually all later models of culture include Hofstede’s dimensions and have conformed to his approach’’. The researchers include the following: concepts developed by Schwartz and Bilsky (1987) and Trompenaars (1993); and the GLOBE model (House, Hanges, Javidan, Dorfman, & Gupta, 2004). Among these studies, the culture scores developed by Hofstede have been the most widely applied (Shi & Wang, 2011).

Despite the relevance of culture in shaping human behavior, only a limited number of studies have specifically addressed the role of culture in environmental sustainability. For instance, using Hofstede's cultural dimensions, Husted (2005) demonstrated that there is a relationship between a jurisdiction's cultural values (power distance, individualism, and masculinity) and its social and institutional capacity for environmental sustainability. In a cross-country study, Park et al. (2007) examined the influence of the cultural dimensions on the environmental performance. They found that both power distance and masculinity are negatively related to environmental sustainability, and demonstrated that the applicability of the Environmental Kuznets Curve hypothesis is limited when cultural values are included in their model. Peng and Lin (2009) found that national cultural dimensions, particularly power distance and masculinity are significantly related to environmental performance. Onel and Mukherjee (2014) described that individualism and uncertainty avoidance have a positive relationship with environmental health. Disli et al. (2016) determined that in countries with more power distance, masculinity, and indulgence; the EKC shifts upward in early economic development stages. Lahuerta-Otero and González-Bravo (2017) found that a country’s cultural factors influence its environmental performance, indicating that power distance, masculinity, and long-term orientation explains air quality with an inverse relationship.

From different perspectives (Disli et al., 2016; Husted, 2005; Lahuerta-Otero & González-Bravo, 2017; Onel & Mukherjee, 2014; Park et al., 2007; Peng & Lin, 2009) agree that including culture in the development of policies and promoting a culture of shared responsibility, results in strengthened institutional capacities that can effectively combat environmental degradation. Because of the influence of culture as well as different levels of income and development, it's preferable to develop strategies that allow jurisdictions to set their own environmental policy objectives and goals instead of adopting common targets for all jurisdictions (Disli et al., 2016). For this reason, it's imperative for policymakers to recognize cultural diversity. In other words, global targets and especially their subnational implementation should incorporate local cultural factors (Disli et al., 2016), because societies may not be able to make any material changes required to achieve environmental sustainability if they fail to reach beneath physical challenges and confront problems at a much deeper level in their culture and consciousness (Elgin, 1994). Namely, it is not only in the external physical environment, but just as much in our cultures, (i.e., in our heads), that change has to take place, if we are to have a world that is sustainable for the human race in the future (Packalén, 2010).

Culture functions as a guidance for individual behavior and norms for group interactions and collaborations. Cultural values entail beliefs, and standards, serving as a strong informal institution that shapes human interactions (Hofstede, 2001). Given the importance of culture, in this study it's examined how the cultural values of a country influence its climate policies and instruments through carbon pricing, and the effect these carbon prices have on economic growth and carbon dioxide emissions levels.

2.4.2. Cultural dimensions

Power distance. This cultural dimension how the less powerful members of a society are willing to accept the unequal distribution of power. High power distance societies are hierarchical, and they accept their role within them. These societies have a great deal of respect for those in authority (Keegan & Green, 2015).

In low power distance societies, individuals are part of the decision-making processes (Hollesen & Arteaga, 2010), so they feel more involved in global issues, such as climate change. By contrast, societies with high levels of power distance will display a larger gap between the minority groups in power and the majority groups who assume their role. This frequently leads societies to become passive with respect to social initiatives and debates over issues affecting the environment. As a result, a system characterized by a high score in power distance will be less able to debate and participate actively in social issues, including environmental and climate change problems (Husted, 2005). Based on these arguments it is expected that societies with high power distance have high inequality and less economic growth (Papamarcos & Watson, 2006). Thus, it's hypothesized:

Hypothesis 3_A The lower the level of power distance in a jurisdiction, the higher the GDP's growth rate.

Hypothesis 4_A The higher the level of power distance in a jurisdiction, the higher the CO_2 emissions' growth rate.

Individualism. Hofstede (1997) describes individualistic cultures as those in which individuals are independent from others and take care of themselves and their immediate families. They will focus to reach their own objectives first, rather than collective ones (Hollesen & Arteaga, 2010). Conversely, collectivistic societies care about the members of the group in exchange of unquestionable loyalty, meaning that common values prevail over individual opinions. Some researchers believe that in collectivistic cultures, individuals are expected to collaborate toward society's interests and maintain harmony, as they are committed to future well-being. Consequently, collectivists will participate actively in environmental actions and policies (Parboteeah, Addae, & Cullen, 2012) as they pursue a future quality of life that implies present commitment and effort, where opinions and votes are predetermined in-group (Park et al., 2007). On the other hand, a different group of authors argue that individualists are more prone to protect the environment, considering that individualistic cultures potentiate and value personal initiatives, where tasks such as engaging in environmental debates prevail over relationships (Cox, Friedman, & Tribunella, 2011). Accordingly, individualistic cultures will be in a better position to respond to climate change issues, as individual environmental initiatives reinforced by pressure groups (Husted, 2005) will be easier to implement. In this sense, individualists, with their concerns and resourcefulness, are expected to create more consciousness in which individuals accept responsibilities (Onel & Mukherjee, 2014) that translate into environmental policies and initiatives to address these climate change concerns. Therefore, environmental interest-groups activities appear to be much more widespread and diverse in individualistic cultures than in collectivistic cultures (Husted, 2005).

Considering the different perspectives presented in the literature, it is reasonable to expect that there are more chances that pro environmental initiatives emerge in individualistic societies than in collectivistic ones. And based on their resourcefulness and independent nature, individualistic societies require strong economies to flourish in self-sufficient environments. Thus, it's expected:

Hypothesis 3_B_ The more individualistic a jurisdiction, the higher the GDP's growth rate.

Hypothesis 4_B_ The more individualistic a jurisdiction, the lower the CO_2 emissions' growth rate.

Masculinity. This dimension has two elements, gender egalitarianism and achievement orientation (Taras, Steel, & Kirkman, 2012); it refers, among other things, to a focus on "material success", as opposed to a concern with the "quality of life" (Hofstede, 1997). Hofstede's (2001) discussion directly links masculinity to the preference for material wealth and argues that masculinity creates a preference for economic growth over environmental conservation. An analysis of this cultural dimension indicates that women's cultural values differ less among societies than men's cultural values (Hofstede, 2011), highlighting that the pursuit of economic growth, typical of masculine cultures, will lead to a slower adoption of costlier environmental friendly technologies and reduce their responsiveness to climate problems. Masculine cultures, oriented to the achievement of goals and targets, tend to have less perception of future risks. They therefore tend to ignore environmental risks, as climate change is not sufficiently important to them (Park et al., 2007). Conversely, low-masculinity societies pay more attention to social dynamics, and females traditionally take more responsibility for social needs. Moreover, females tend to be more conscious about environmental issues and ecological balancing (Eisler, Eisler, & Yoshida, 2003). Thus, it's hypothesized:

Hypothesis 3C The greater the masculinity of a jurisdiction, the higher the GDP's growth rate.

Hypothesis 4C The greater the masculinity of a jurisdiction, the higher the CO_2 emissions' growth rate.

Uncertainty avoidance. This dimension represents the degree to which people feel averse to ambiguity. Some authors (Disli et al., 2016; Lahuerta-Otero & González-Bravo, 2017; Park et al., 2007; Peng & Lin, 2009) utilize uncertainty avoidance as synonym of risk avoidance, but Hofstede (2011, p. 10) expresses explicitly that "uncertainty avoidance is not the same as risk avoidance." The use of risk avoidance as an interchangeable term with uncertainty avoidance, might lead to misinterpretations and inconsistency in the results associated to this cultural dimension. Uncertainty avoidance, in essence, indicates to what extent a culture programs its members to deal with unstructured situations. Unstructured situations are new, unfamiliar, unexpected, and different from usual (Hofstede, 1997). Uncertainty avoiding cultures try to minimize the possibility of such situations by strict behavioral codes, laws and rules, disapproval of deviant opinions. Countries with high levels of uncertainty avoidance seek to make decisions that affect negatively citizen empowerment, which is essential for a country's environmental sustainability (Husted, 2005). Studies have also demonstrated that people in high uncertainty avoiding societies are more emotional and motivated by inner nervous energy. Conversely, uncertainty accepting cultures, are more tolerant of opinions different from what they are used to; they try to have fewer rules, and on the

philosophical level they are empiricists, relativists and allow different currents to flow side by side (Hofstede, 2001). With respect to economic growth, high uncertainty countries have countless legislations,
regulations and laws in order to lower uncertainty and control everything (Hancıoğlu, Doğan, & Yıldırım, 2014), which can be restrictive for innovation, entering new markets, creating new jobs, and increasing competition; whereas low uncertainty avoidance countries tend to have a greater willingness to take risks, to dissent, and to live
with as few rules as possible (Papamarcos & Watson, 2006). Therefore, it is reasonable to expect that restrictive regulations with low incentives for innovation in high uncertainty avoiding societies are economically developing slower and having lower rates of entrepreneurship and technological innovation. Furthermore, environmental challenges require societies with a higher degree of tolerance toward new ideas, different opinions, and discussion forums that enable the environmental debate and solutions beyond the status quo. Thus, it's expected:

Hypothesis 3$_D$ The lower the uncertainty avoidance, the higher the GDP's growth rate.

Hypothesis 4$_D$ The lower the uncertainty avoidance, the lower the CO_2 emissions' growth rate.

Long-term orientation. This dimension reflects the degree to which members of a jurisdiction orient their thinking toward the more distant future. Values associated with long-term orientation are thrift, perseverance, and having a sense of shame; whereas values associated with short-term orientation are respect for tradition, reciprocating social obligations, and personal steadiness and stability (Hofstede, 2001). From a costbenefit perspective, societies concerned with the short-term will prioritize present costs over future benefits, so they will not engage in environmental long-run initiatives unless present benefits are higher than the costs. On the other hand, long-term-oriented jurisdictions can estimate the future benefits of present actions. Once they upgrade the benefits, they will be willing to face the present costs (Lahuerta-Otero & González-Bravo, 2017). According to the aforementioned analysis and considering that the global economy is still heavily dependent on relatively inexpensive fossil fuels, a transition towards renewable sources will likely cause more present-day economic pain for short-term oriented cultures (Disli et al., 2016). Thus, it is reasonable to expect that long-term-oriented societies value the safety that economic expansion and favorable environmental conditions provide to assure the welfare of the communities. Therefore, it's proposed the following:

Hypothesis 3$_E$ A higher level of long-term orientation will produce a higher growth rate of the GDP.

Hypothesis 4$_E$ A higher level of long-term orientation will produce a lower growth rate of CO_2 emissions.

Indulgence. This dimension refers to jurisdictions that allow free gratification of basic and natural human desires related to enjoying life and having fun. Restraint refers to a society that controls gratification of needs and regulates it by means of strict social norms (Hofstede, 2011). Indulgent jurisdictions are tolerant towards individuals' desires to enjoy themselves and spend money. Restrained societies regulate and curb such gratification. Even though this dimension has not been widely tested, indulgent societies characterize themselves by a more wasteful and extravagant lifestyle, which, may cause environmental pollution. On the other hand, stricter regulations and moderate behavior, which describe restrained jurisdictions, may reduce pollution (Disli et al., 2016). According to the literature, indulgent societies have a hedonistic and permissive approach towards pollution and resources in general, which promotes short-term perspectives to acquire instant satisfaction. Thus, it's hypothesized:

Hypothesis 3$_F$ A higher level of indulgence will decrease the growth rate of GDP

Hypothesis 4$_F$ A higher level of indulgence will increase the growth rate of CO_2 emissions.

2.4.3. Interactions between carbon prices and cultural dimensions on GDP and CO_2

Hofstede (1997, 2001), acknowledges that the level of economic development influences cultural variables in different ways and according to the EKC hypothesis, depending on the economic development stage of the countries, they will tend to pay more attention to environmental concerns or not. However, with rising income levels, nations are able to impose more drastic environmental policies such as higher carbon prices (Disli et al., 2016). Rich countries tend to be lower in power distance and high in individualism. Low scores of Power Distance relate "to high levels of education and high status occupations among those surveyed" (Hofstede, 1980, p. 105), and 58% of the variance in Power Distance can be predicted from national wealth, population size and latitude (Hofstede, 1980). Individualism, on the other hand, reflects in measures of social mobility, sectorial inequality, press freedom, and organization size (Hofstede, 1980), but it also "relates Gross National Product per capita" (Hofstede, 1980, p. 231).

As with Power Distance, Individualism may be predicted from the basis of national wealth (Baskerville, 2003), which causes a relatively high correlation between these cultural dimensions.

In wealthy countries the issues related to basic needs have been resolved for the majority of the population. Resources to care for the environment clearly exist. In rich societies, where strong pluralism and lively debate predominates, environmental issues can come more easily to the attention of the public because the ability of the climate change issues to enter the political agenda depends in part on cultural values of power distance and individualism, both of which influence political pluralism and debate. However, rich countries with high power distance and collectivism, deter pluralism and debate, environmental issues are likely to enter the national policy agenda more slowly (Husted, 2005). In general terms, high-power distance countries are more pollution-intensive compared to low-power distance countries (Disli et al., 2016). That is not the case of poor countries, where even societies characterized by pluralistic politics and lively political debates will be forced to focus on more basic needs (Vogel & Kun, 1987). In this sense, one would expect that rich countries that implement initiatives with higher carbon prices are more prone to be influenced by cultural dimensions, having low power distance and high individualism. Thus, it is hypothesized:

Power distance X Carbon prices

Hypothesis 5$_A$ Lower levels of power distance strengthen the negative relationship between carbon prices and the GDP growth rate.

Hypothesis 6_A The higher the level of power distance, the weaker the negative relationship between carbon prices and the CO_2 emissions growth rate.

Individualism X Carbon prices

Hypothesis 5_B The higher the level of individualism, the stronger the positive relationship between carbon prices and the GDP growth rate.

Hypothesis 6_B The higher the level of individualism, the stronger the inverse relationship between carbon prices and the CO_2 growth rate.

Masculinity X Carbon prices

Rich countries have more resources to finance developing policies, incentives, subsidies, and strategies that help deter environmental degradation such as higher carbon prices (Grossman & Krueger, 1995). Due to the scarcity of resources in poorer countries, it's expected that developing countries would have less resources to invest regardless of cultural values like femininity, which would tend to support environmental sustainability. Since rich countries have more resources that can be invested to address environmental degradation and impose stricter penalties to environmental externalities, they should be more sensitive to the cultural preferences of their societies in terms of material wealth (masculinity) or environmental care (femininity) (Husted, 2005). Thus, it is expected:

Hypothesis 5_C The higher the level of masculinity, the weaker the negative relationship between carbon prices and the GDP growth rate.

Hypothesis 6C The lower the level of masculinity, the stronger the inverse relationship between carbon prices and the CO_2 growth rate.

<u>*Uncertainty avoidance X Carbon prices*</u>

Hofstede (2001, p. 116), defines uncertainty avoidance as “the extent to which members of a culture feel threatened by uncertainty and unknown situations.” It reflects the degree to which a culture tolerates ambiguity and constitutes a response to anxiety about the future. From an ecological perspective, some authors consider that coping with an unknown environmental challenge imposes a high degree of uncertainty to societies, and argue that societies with high uncertainty avoidance react to that ambiguity by promoting environmental measures that minimize those challenges (Park et al., 2007). On the other hand, Hofstede (2011) refers to uncertainty avoidance as a dimension that indicates to what extent a culture programs its members to feel either uncomfortable or comfortable in unstructured situations. In high uncertainty avoiding cultures there are characteristics like: “intolerance of deviant persons and ideas: what is different is dangerous”; “in politics, citizens feel and are seen as incompetent towards authorities”; and “the uncertainty inherent in life is felt as a continuous threat that must be fought” (Hofstede, 2011, p. 10). So, in Hofstede’s perspective, uncertainty avoidance goes beyond preventing an undesired event; it reflects a constant attitude against unstructured circumstances, and to some extent toward change. In that sense, it’s reasonable to expect that uncertainty avoiding societies are less receptive to put high prices on carbon emissions, which may hurt economic growth and create ambiguous economic outcomes that have been achieved through the implementation of well-structured and fine-tuned policies. Thus, it’s hypothesized:

Hypothesis 5_D The lower the level of uncertainty avoidance, the stronger the negative relationship between carbon prices and the GDP growth rate.

Hypothesis 6_D The higher the level of uncertainty avoidance, the weaker the inverse relationship between carbon prices and the CO_2 growth rate

Long-term orientation X Carbon prices

In long-term oriented societies, actions are driven by long-term objectives, rather than short-term outcomes. Short-term oriented cultures may give too little importance to the future effects of their current decisions, whereas long-term oriented cultures may prefer to sacrifice present benefits for future ones (Laibson, 1997). A transition to energy-efficient technologies, renewable energies, and carbon-pricing instruments will likely cause economic pain for short-termed societies, which may be reluctant to put high prices on carbon emissions. Thus, its expected:

Hypothesis 5_E The higher the level of long-term orientation, the weaker the relationship between carbon prices and the GDP growth rate.

Hypothesis 6_E Lower levels of long-term orientation weakens the negative relationship between carbon prices and the CO_2 growth rate.

Indulgence X Carbon prices

Indulgent societies have a more hedonistic and permissive approach toward pollution and natural resources exploitation, whereas restrained societies handle carefully their resources with stricter norms and can reduce pollution (Disli et al., 2016), meaning that indulgent societies may perceive carbon taxes as a constraint to their lifestyle. Indulgent societies wouldn't adopt high carbon prices easily because the use of natural resources is intended for the betterment of their lifestyle. Thus, it's expected:

Hypothesis 5_F A high level of indulgence weakens an inverse relationship between carbon prices and the GDP growth rate.

Hypothesis 6_F A low level of indulgence strengthens a negative relationship between carbon prices and the CO_2 growth rate.

2.4.4. Turning point shifts in cultural dimensions

The hypotheses proposed reflect broad tendencies that relate cultural variables to the carbon-pricing instruments for the economic growth and the carbon dioxide levels. Nevertheless, at any specific moment, the political leaders of a given jurisdiction might make decisions contrary to these broad tendencies as in the case of the decision of the U.S. government to leave the Paris Agreement. The United States has the highest scores in terms of individualism, but this decision may be seen as a contradiction with respect to the relationship expected in the hypothesis. These cultural arguments do not imply that jurisdictions with certain cultural profiles move effortlessly towards environmental sustainability and emission reduction targets, only that in the long run certain cultural variables should support the carbon-pricing initiatives for environmental sustainability more than others (Husted, 2005). For example, although it is expected that jurisdictions with high power distance would prioritize economic growth over environmental performance, it is possible that, with higher income levels, high-power-distance societies can impose environmental standards that more democratic cultures would not. This suggests that the relationship between culture, carbon pricing, carbon dioxide emissions, and economic growth might be more complex than previously thought (Disli et al., 2016).

3. Methods

The following chapter covers the methodology of this study. The objective of this research is to:

Analyze the influence of culture and carbon-pricing initiatives on economic growth and CO_2 emissions in 49 jurisdictions, using Hofstede's cultural dimensions framework.

A quasi-experimental pretest-posttest design was used for the construction of the dependent variables: 1) economic growth and 2) carbon dioxide emissions. The independent variable is the level of carbon prices and control variables are type of mechanism and type of jurisdiction. Culture was included as a moderator variable.

The chapter begins by describing the research design, the sample, and the measures employed. Multivariate hierarchical regressions were conducted using SPSS to test the relationships and the moderating variables. Afterwards, a detailed description of the statistical methods, their validity and reliability, and the limitations were discussed.

3.1. Quantitative Research Design

A quantitative methods approach was employed, which includes the analysis of cross-sectional data derived from official statistics, regulations, policies, and the cultural dimensions framework. Theory indicates that carbon-pricing initiatives are broadly adopted financial instruments to reduce emissions. Therefore, a detailed analysis of the jurisdictions' climate policies was conducted, which goes hand in hand with the carbon-pricing instruments.

The Hofstede's cultural dimensions framework was used to analyze the moderating effect of culture on carbon-pricing initiatives, and consequently, its impact on carbon dioxide emissions and economic growth. By analyzing the moderating effect described above, it is possible to make relevant inferences that explain how culture affects climate-change policies and the potential impacts described before. Thus, the reason for applying quantitative methods in this study is because determining the cultural dimensions' influence on carbon prices (independent variable) and its impact on gross domestic product and CO_2 emissions (dependent variables) implies causal relationships. A quantitative approach is suitable for causality analysis, correlations, and hypothesis testing.

A quasi-experimental one group pretest-posttest design was employed in the construction of the growth rates of economic growth and CO_2 as dependent variables. Subsequently, a multivariate hierarchical regression was conducted, where the national scores for the Hofstede's cultural dimensions framework were utilized as moderators: power distance, individualism, uncertainty avoidance, indulgence, long-term orientation, and masculinity. Finally, the type of mechanism and type of jurisdiction were used as control variables to evaluate the relationship between culture, carbon price, economic growth, and CO_2 emissions in the model.

3.2. Sample

The hypotheses were tested using data from 30 jurisdictions at the national level and 19 jurisdictions at the sub-national level, consisting of 48 different jurisdictions, with the exception of Switzerland, which was considered twice because it has implemented both types of mechanisms studied, carbon tax and emissions trading scheme. In total 49 jurisdictions were included in the study (Appendix A). Thirty-two emission trading systems were analyzed and 17 carbon tax schemes, where 16 of the jurisdictions at the national level have implemented carbon taxes, and 14 of them have implemented emissions trading schemes. Only British Columbia as a sub-national jurisdiction has implemented a carbon tax. All the countries of which the sub-national jurisdictions were studied, weren't included as countries. The majority of the jurisdictions studied belong to the Organization of Economic Cooperation and Development (OECD). All of the jurisdictions included in the study have implemented carbon-pricing instruments, and the decision of whether or not to include a jurisdiction was anchored to data availability.

3.3. Measures

3.3.1. Dependent variables

The two dependent variables analyzed in this study, carbon dioxide emissions and economic growth, are constructed as growth rates, because they are useful to know how fast an indicator has risen (or declined) over a certain period. Additionally, growth rates allow for better comparisons across jurisdictions (Federal Reserve Bank of Dallas, 2018). In a sense, calculating growth rates levels the playing field between the jurisdictions. In this study, the reason for using growth rates in the construction of the dependent variables is to compare economic growth and CO_2 emissions levels before and after carbon pricing implementation. The formula used to construct the growth-rate variables is

$$g_t = \left[\left(\frac{X_t}{X_{t-n}}\right) - 1\right] * 100$$

where g_t is the growth rate in period *t, X* is the variable being examined (economic growth and CO_2 emissions) and *n* is the time period of interest.

3.3.1.1. Growth rate of CO2 emissions

The effectiveness of carbon-pricing instruments at relatively lower costs it's measured by its capacity to reduce emissions (Baranzini et al., 2000). Bearing in mind the previous affirmation, this study employed the growth rate of CO_2 emissions between the previous year and the subsequent year of carbon pricing implementation as a dependent variable, considering that reduction in CO_2 emissions is closely associated with a decrease in fossil fuels consumption, which is the main purpose for implementing carbon-pricing instruments. Additionally, the reason for selecting CO_2 among other greenhouse gases as a dependent variable was not only because it reflects the link between economic activities and fossil fuel consumption but also because it's the largest human contributor to human-induced climate change (Canadell et al., 2007). Furthermore, it is relevant to highlight that the total CO_2 emissions data for the jurisdictions analyzed in this research, doesn't include the land use land use change and forestry sector (LULUCF).

All the units for carbon dioxide emissions are in metric tons. The data for the carbon dioxide emissions at the national level originates from the Emissions Database for Global Atmospheric Research (EDGAR v4.3.2) (Janssens-Maenhout et al., 2017). At the subnational level for the jurisdictions in Canada, the CO_2 data derives from the Environment and Climate Change Canada Data website; for the subnational jurisdictions in the United States of America the data originates from the World Resources Institute's Climate Analysis Indicators Tool (WRI/CAIT 2014); and the data for the subnational jurisdictions in China was taken from journal article: China CO_2 emission accounts 1997-2015 written by Shan et al. (2018).

3.3.1.2 Growth rate of Real GDP

The growth rate of real GDP between the year before and after carbon pricing implementation was used as a dependent variable to identify the potential impacts of carbon pricing on economic growth. Real GDP was employed to avoid the inflationary effects on the value of all goods and services in the economies studied and because it provides a more accurate figure of economic growth. In addition, economic growth is a major concern for policymakers, GDP loss is frequently used to decide whether a climate policy can be finally implemented or not (Li, Wang, Zhang, & Kou, 2014).

All the units for GDP are in U.S. dollars. The data for the real gross domestic product at the national level comes from the United Nations website at 2010 constant prices in U.S. dollars. At the subnational level for jurisdictions in Canada, the real GDP data derives from the Statistics Canada website at 2007 constant prices in Canadian dollars converted to U.S. dollars; for the subnational jurisdictions in the United States of America, the data originates from the Department of Numbers website at 2009 constant prices in U.S. dollars; and the data for the subnational jurisdictions in China originates from the National Bureau of Statistics of China website at constant prices in yuan converted to U.S. dollars.

3.3.2. Independent variable

3.3.2.1 Carbon price

The level of carbon prices is the predictor variable that represents the price that climate policies put to externalities (Aldy & Stavins, 2011). Policymakers pursue a level of carbon prices that are effective in reducing carbon emissions, but that does not cause regressive impacts on economic growth. In order to attain those characteristics, policymakers restrict carbon prices' coverage to specific sectors, usually associated with energy generation and consumption. The share of emissions covered by carbon prices implemented in the jurisdictions studied was considered in the construction of this variable. The carbon prices utilized in this study are the prices at the moment of implementation of the carbon-pricing instruments and were converted to U.S. dollars with the exchange rate at the implementation moment of the initiatives. The data of the carbon prices were taken from official websites of the initiatives, journal articles, and different versions of the State and Trends of Carbon Pricing and Carbon Market reports developed by the World Bank (2018). All the units of carbon prices are in U.S. dollars.

3.3.3. Control variables

3.3.3.1 Type of mechanism

Two types of mechanisms were included in the study, carbon taxes and emissions trading schemes. This categorical variable was included in the regression model as a dummy variable to represent group membership and determine if the type of mechanism studied influence the dependent variables. The "dummy coding" assigned 0 to carbon taxes and 1 to emissions trading schemes.

Some authors have conducted contrasting studies between the types of carbon-pricing mechanisms and identifies important differences that relevant in its functions as a control variable according to their ability to: reduce administrative costs, tackle uncertainties about damages from emissions and costs abatement, control volatility of prices, avoid "emissions leakage",, achieve budget discipline, achieve useful linkages across jurisdictions, achieve broad sector coverage, and gain political support (Goulder & Schein, 2013).

3.3.3.2 Type of jurisdiction

Two types of jurisdictions were included in the study, jurisdictions at the sub-national level (provinces, states, etc.) and country level jurisdictions. This categorical variable was included in the regression model as a dummy variable to represent group membership and determine if the type of jurisdiction influence the response variables. The “dummy coding” assigned 0 to national jurisdictions and 1 to sub-national jurisdictions.

Several studies indicated that climate policy development at the national level, and resulting negotiations amongst them, has produced mixed results. Moreover, power is shifting away from the central state to a diverse array of subnational and regional actors. On the other hand, increasing subnational governance of environmental issues, with a particular focus on climate change as an issue that requires ‘integrated action at multiple levels of government’ has become relevant for the implementation of carbon-pricing instruments. In this regard, the relevance in considering the type of jurisdiction as a control variable consists in the differences between the national and the subnational levels with respect to: changes at multiple sociotechnical levels, loci of innovation, institutional barriers to change, and the challenges faced in attempting to govern or steer shifts toward more sustainable pathways (Burch et al., 2014).

3.3.4. Moderating variables

3.3.4.1 Cultural dimensions

A number of authors (Cox et al., 2011; Disli et al., 2016; Halkos & Tzeremes, 2013; Husted, 2005; Lahuerta-Otero & González-Bravo, 2017; Onel & Mukherjee, 2014; Park et al., 2007; Pelau & Pop, 2018; Peng & Lin, 2009; Ringov & Zollo, 2007; Tata &

Prasad, 2015; Vachon, 2010) have used the Hofstede's cultural dimensions framework as moderators or mediators to study relationships between culture and a broad diversity of environmental issues.

The Hofstede's cultural dimension variables of power distance, individualism, masculinity, long-term orientation, indulgence, and uncertainty avoidance were applied to all the jurisdictions at the national level, and they were measured using data published in the website Hofstede Insights (www.hofstede-insights.com) for all the jurisdictions, using information at the country level. Hofstede Insights was created in 2017 from a merger between Itim International and The Hofstede Centre. The Hofstede measures of culture are widely cited and used by many scholars. The Hofstede's cultural dimensions country scores are expressed as between 0 and 100 (Onel & Mukherjee, 2014).

One problem with the use of Hofstede's measures is that he measures cultural differences at the national level (Husted, 2005) and not all nations are culturally homogeneous (Enz, 1986). Significant differences may exist between regions in sub-national jurisdictions and also between the people who participate in the processes of climate policymaking. In addition, the Hofstede's data assumes that culture is very stable and changes very slowly. Hofstede (2001, p. 36) predicted that relative national cultural scores would not change substantially "until at least 2100". Although that assumption is plausible, it is disputed by some authors (McSweeney, 2002).

Despite these limitations, Hofstede's cultural dimensions are used in order to apply a well-known and validated framework for analyzing culture that will assist in the accumulation of knowledge (Enz, 1986). Additionally, a comprehensive review based on

Hofstede's work found that the cultural dimensions have largely been supported by evidence in replications and extensions (Søndergaard, 1994).

3.4. *Data Analysis*

This study employed SPSS to conduct statistical analyses, addressing the influence of culture on carbon prices and its effects on economic growth and carbon dioxide emissions. The data analysis consisted of an ordinary least squares (OLS) analysis with a hierarchical regression method to explain the relationships and the moderation effects.

A quasi-experimental single-group pretest-posttest design with a within-participants approach (Shadish, Cook, & Campbell, 2002) was used for the construction of the dependent variables, meaning that the data collected for the economic growth and CO_2 emissions growth rates considers one year before the carbon pricing implementation (i.e., the pretest) and one year after the carbon pricing implementation (i.e., the posttest). The measures used in the pretest and the posttest are the same, and changes in the dependent variables from pretest to posttest are interpreted to reflect the effectiveness of the carbon pricing implementation (independent variable).

A single-group pretest–posttest design does not have control or comparison groups. The logical basis of the pretest–posttest indicates that if Y (a change in the dependent variable) regularly follows X (an independent variable), then X is sufficient for Y to happen and could be a cause of Y (i.e., if X, then Y) (Frey, 2018).

Although this design allows researchers to examine some outcome of interest prior to some treatment, it does not eliminate the possibility that the observed changes might have occurred regardless of the treatment (Salkind, 2010). Including a pretest measure is an improvement over the posttest-only research design; however, this design is still relatively weak in terms of internal validity. As a result, a causal inference between a change in the dependent and independent variables would be subject to rival explanations in the design. In other words, the internal validity of the pretest–posttest design is subject to threats (Marsden & Torgerson, 2012). Also, the longer the time lapse between the pretest and posttest, the harder it is to rule out alternative explanations for any observed differences, which is the main reason to have included only the previous and the subsequent year to carbon pricing implementation in the study (Salkind, 2010). Additionally, it's a cost-effective way to determine the effectiveness of an intervention (Frey, 2018).

The most important threat to internal validity for the design employed in this study is history. History could be responsible for any observed difference between the pretest and posttest. The threat of history consists of a situation where many events in addition to the intervention may occur between administration of the pretest and the posttest and may account for some or even all of the observed changes (Frey, 2018). These events might occur either within or outside the context of intervention, which could be the case of the GDP's growth rate, where many factors may affect the economic growth of a jurisdiction; such as economic crises, population changes, technology improvements or regulations and laws toward economic activity. A similar situation experiences the carbon dioxide's growth rate, which in the absence of climate policies, has a positive relationship with economic growth (Jaunky, 2011), meaning that a rise in energy consumption to produce the additional output leads to a greater generation of emissions.

To rule out a potential influence of history as a threat, it was verified that measures for both dependent variables consistently changed in the predicted direction according to the literature, denoting that economic growth is not significantly impacted and CO_2 emissions are effectively reduced as shown in Figure 3 (Baranzini et al., 2000). Additionally, since the outcome variables are continuous, the data obtained from the one-group pretest-posttest design were analyzed with the dependent-means t-test (paired-difference t-test) (Appendix B), which indicated that the difference between groups (pretest and posttest) for both dependent variables is statistically significant (Salkind, 2010).

Many theoretical frameworks in the social sciences focus on causal models. These models specify the effects of one or more independent variables on one or more dependent variables or outcome variables. On the basis of the literature review and hypothesis construction, the framework employed in this research is a moderated causal relationship (illustrated in Figure 2).

A moderated causal relationship, as shown in Figure 1, is one in which the relationship between *X* and *Y* is moderated by a third variable, *Z*. In other words, the nature of the relationship between *X* and *Y* varies, depending on the value of *Z.* Moderated relationships often are called interaction effects, although precise conceptualizations of interaction effects vary across statistical models (Jaccard & Turrisi, 2003a).

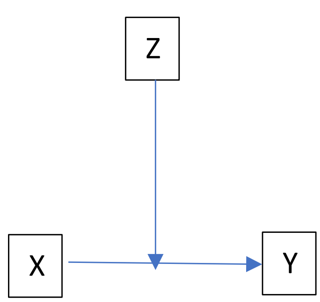

Figure 1. Moderated causal relationship. Adapted from "Interaction effects in multiple regression" by J. Jaccard and R. Turrisi, 2003, California, CA. Copyright 2003, by SAGE Publications, Inc.

This study explores the moderating effect of the cultural variables on carbon prices and determines its influence on economic growth and carbon dioxide emissions as response variables. In order to test hypotheses associated with the moderating effect described before, interaction terms were created, by multiplying the cultural variables by the level of carbon prices (Baron & Kenny, 1986). The interaction terms were relatively highly correlated, high levels of multicollinearity were detected. Multicollinearity causes that the estimates of the coefficients of the independent variables become sensitive to the data used (Baron & Kenny, 1986). To correct this problem, the centering procedure proposed by Russo and Fouts (1997) was applied. This method involves "de-meaning" or "centering" the variables by subtracting their means from the variable's value for each observation. This method helps to reduce the problem of multicollinearity with the interaction variables.

Accordingly, after the moderating variables were defined, a multivariate hierarchical regression with an enter regression method was used in testing the hypotheses, considering that is relevant knowing if adding one or more predictor variables to an existing regression equation will significantly increase the predictability of the criterion (Jaccard & Turrisi, 2003b). The amount of incremental explained variance is typically evaluated by subtracting the squared multiple correlation in the original equation from the squared multiple correlation in the expanded equations, as the models operationalized in this research. The difference in the squared multiple correlations is the amount of incremental explained variance due to the additional predictors (Jaccard & Turrisi, 2003a).

Following the methodology indicated in the literature, first, the variables were tested on the effects to control for type of mechanism and type of jurisdiction, followed by adding the main effect of the level of carbon prices on economic growth and CO_2 emissions, and the effects of contingency moderators such as the cultural dimensions. The product terms of the level of carbon prices with the cultural dimension variables, were added afterward to the model to determine whether there was a significant increase in the predictability of the criterion variable (Jaccard & Turrisi, 2003b).This allowed the study to examine the contribution of the cultural dimensions.

The following regressions were run in stages:

Model 1. [$\Delta GDP/\Delta CO_2$] = f (type of mechanism, type of jurisdiction)

Model 2. [$\Delta GDP/\Delta CO_2$] = f (type of mechanism, type of jurisdiction, level of carbon prices, cultural dimensions)

Model 3. [$\Delta GDP/\Delta CO_2$] = f (cultural dimensions, type of mechanism, type of jurisdiction, level of carbon prices, interactions between carbon prices and cultural dimensions).

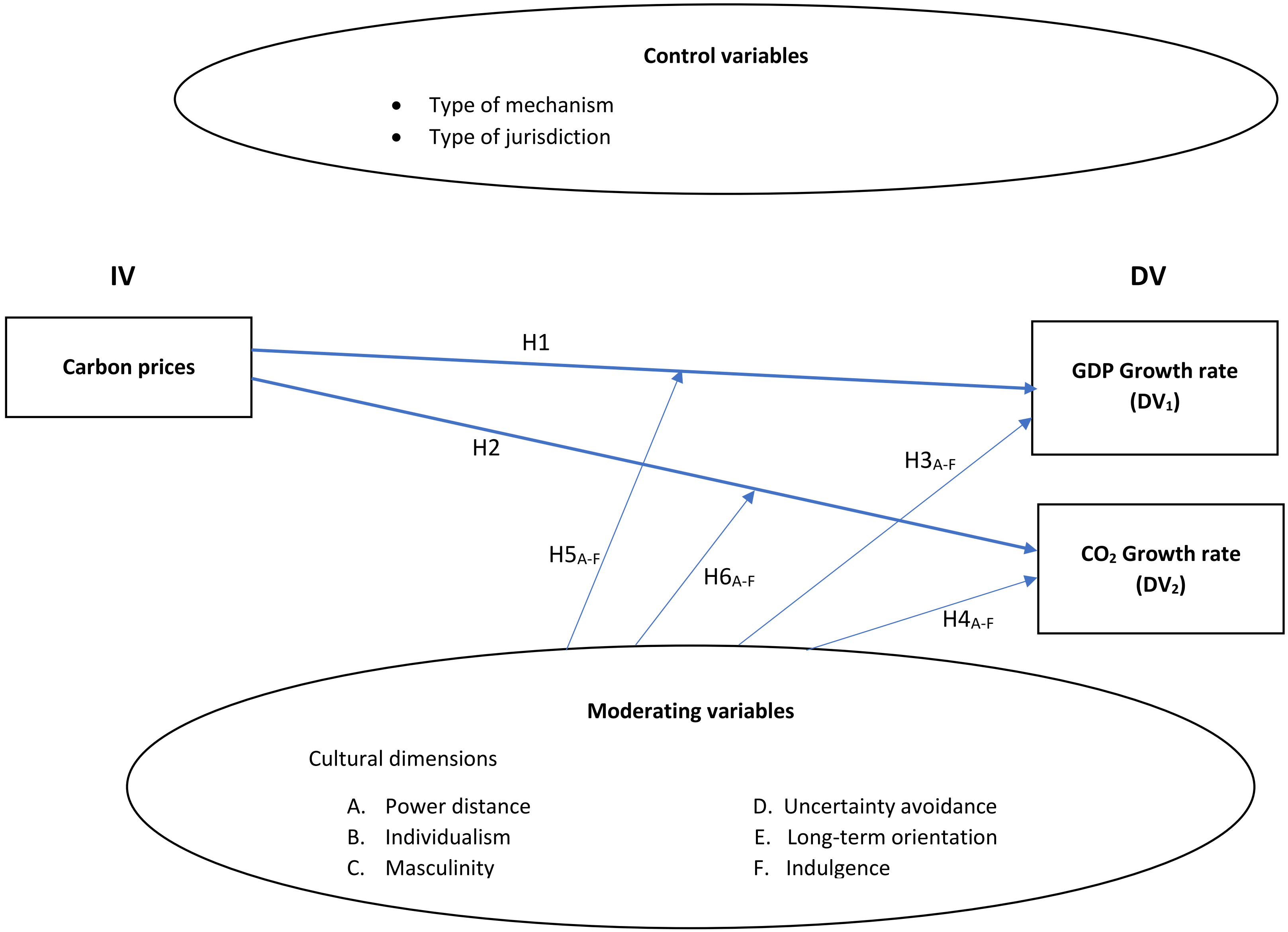

Figure 2. Model of direct and moderator effects

3.5. Validity and reliability

Several tests were conducted to examine the validity and reliability of the data and results in the study. According to Joppe's 2000 study (as cited in Golafshani, 2003), validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are; and defines reliability as the extent to which results are consistent over time, represent accurately the total population under study, and if they can be reproduced under a similar methodology. According to these concepts, data were screened to detect outliers and missing values, then tested for normality, multicollinearity, and homoskedasticity (Appendix C).

Outliers can mislead the regression results. When an outlier is involved in the study, it pulls the regression line towards itself. This can result in a solution that is more precise for the outlier, but less precise for all of the other cases in the data set (Kannan & Manoj, 2015). To avoid this effect on the results, a combination of three multivariate outlier detection methods of distance measures was employed: Mahalanobis distance (MD_i), Cook's distance (D_i), and Leverage point (h_i). The criterion applied to outlier detection with the combined methods' approach, indicates that observations detected by two or more methods as highly deviated from the rest of the data are considered outliers (Kannan & Manoj, 2015). No outliers were detected and no missing values were found using SPSS tools.

The Shapiro-Wilk (SW) test was used to examine normality in the data. The SW test is the most well-known regression test and is considered to have good power properties over a wide range of asymmetric distributions. As stated by Yap and Sim (2011, p. 2153), "if the researcher suspects that the distribution is asymmetric (i.e. skewed) then the SW test is the best test"; the SW is a solid option for normality testing. The variables analyzed with the SW test are a little kurtotic and skewed, but they show non-significant p-values ($p>.05$), meaning that the data is in general terms normally distributed. Multicollinearity was analyzed by the variable inflation factor test (VIF) and the Pearson's correlation matrix. According to the literature, VIF values between 4 and 10 reflect a significant correlation (O'brien, 2007). Items with VIF values higher than 10 are considered multilinear and the corresponding variables are removed (or combined together by taking the value of the mean) (O'brien, 2007). A cut-off value of 0.8 was used for the correlation matrix (Table 2) to determine the multicollinearity. No multicollinearity was identified among the variables studied.

Heteroskedasticity accounts for the loss in efficiency in using ordinary least squares (OLS), which may be substantial and, more importantly, the biases in estimated standard errors may lead to invalid inferences (Breusch & Pagan, 1979). The data were examined for heteroskedasticity using the Breusch-Pagan and the Koenker tests. The results of both tests failed to reject the null hypotheses (H0: homoskedasticity), showing non-significant p-values ($p>.05$), and indicating that there are no heteroskedastic disturbances in the data.

3.6. Limitations

The study analyzed 49 jurisdictions at the national and the sub-national level. An important limitation was the unavailability of cultural distances' scores for the sub-national jurisdictions. With the exception of Quebec, the rest of the sub-national jurisdictions utilized national scores. Another aspect is that the majority of the jurisdictions included in this research belong to the OECD, implying that the findings of the study may not be generalizable to other jurisdictions.

Jurisdictions that have implemented carbon-pricing initiatives and were initially considered for this study, weren’t included, because critical data weren’t available for those particular jurisdictions, such as carbon prices or cultural dimensions scores. Another reason is that some carbon-pricing initiatives have been recently implemented and the data that reflect the effects of carbon prices on economic growth and CO_2 emissions are not available yet. Only jurisdictions that have implemented carbon-pricing schemes were considered for this research.

4. Results

This chapter presents the findings of the study. First, it begins with an overall description of the effects of carbon-pricing instruments on economic growth and carbon dioxide emissions, depicting its respective overall trends. Second, the results of the hierarchical regression analyses are presented, beginning with the results of the regression of carbon prices and cultural dimensions on the gross domestic product growth rate and the interactions between the cultural variables and the levels of the carbon prices. Third, the chapter finalizes with the results of the hierarchical regression of the independent variables and the moderating variables on the carbon dioxide's growth rate, including its respective interactions.

4.1. GDP and CO_2 growth rate's trends

The wealth of jurisdictions is a factor in explaining their amounts of GHG emissions and will also impact their ability to afford various emissions reduction strategies. There is a general trend of increasing emissions with gross domestic product (GDP), although with substantial variability, depending on the implementation of climate policies (Kennedy, Ibrahim, & Hoornweg, 2014). The average trend of the 49 jurisdictions included in the study depicts the impact of the carbon-pricing policies' implementation, showing that the CO_2 emissions decrease, while the GDP increases after the implementation of carbon-pricing instruments, as it's shown in figure 3. The CO_2 and GDP average trends presented in Figure 3 show the overall tendencies in the 49 jurisdictions analyzed, and in general terms represents the influence of carbon-pricing instruments on the aggregated-data curves of GDP and CO_2 emissions.

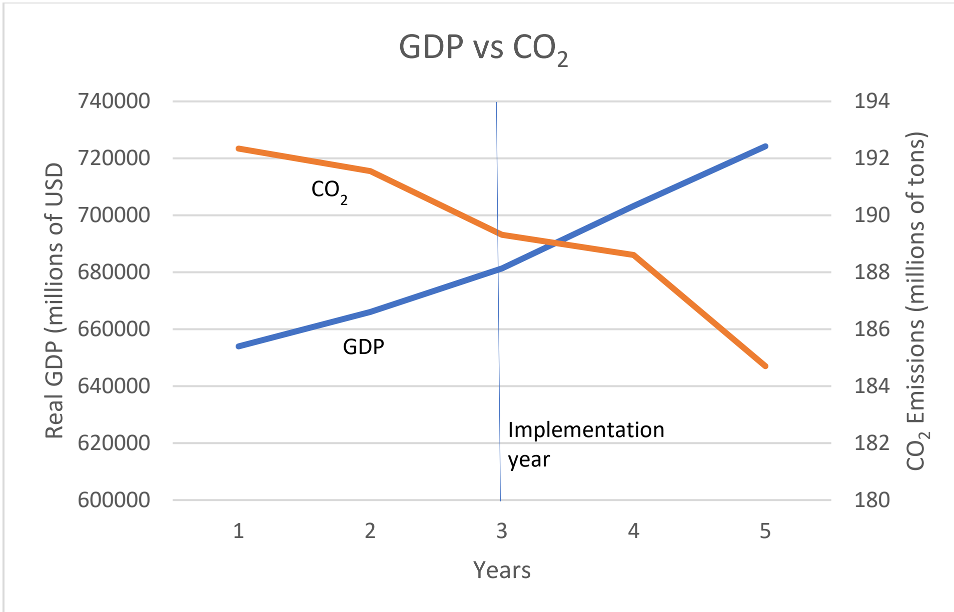

Figure 3. Average trends of GDP and CO_2 emissions growth rates in the jurisdictions studied, before and after the implementation of carbon pricing

Conversely, countries lacking of strategies to reduce emissions, such as carbon pricing, show a positive relationship between economic growth and CO_2 emissions (Bekhet et al., 2017; Jaunky, 2011; Narayan & Narayan, 2010).

Nonetheless, when the jurisdictions' growth rates, before and after carbon pricing implementation, are analyzed individually, 7 of them present a small decrease in the GDP rate: Connecticut, Finland, Iceland, Maine, Poland, Rhode Island, and Sweden; and 14 jurisdictions show an increasing rate of CO_2 emissions: Alberta, Chongqing, Czech Republic, Finland, Greece, Japan, Latvia, Luxemburg, Portugal, Korea, Rhode Island, Slovenia, Spain, and Ukraine. The purpose of Figure 3 is to provide an overview of a 5-year trend (two years before and after carbon pricing implementation) for economic growth and carbon dioxide emissions in the jurisdictions studied, demonstrating that carbon-pricing policies have the expected impacts on both dependent variables, whereas explicit carbon prices might not reflect entirely these impacts. Furthermore, this section introduces the Results Chapter, which encompasses the results of the hierarchical regressions analyses for both dependent variables.

4.2. Results of hierarchical regression analyses

Table 2 shows the descriptive statistics and correlation matrix for the variables. The correlation matrix suggests a moderate level of collinearity between power distance and individualism. But such moderate levels should not be damaging to the assumptions of OLS regression (Hanushek & Jackson, 1977; O'brien, 2007), the variance inflation factors (VIFs) indicate that they are in acceptable ranges, below 10 (Akinwande, Dikko, & Samson, 2015; O'brien, 2007), which are presented in Tables 3 and 4 along with the regression results. The relatively high correlation between power distance and individualism is acknowledged by Hofstede (1997), and is caused because Power distance and Individualism can be explained from the basis of national wealth (Baskerville, 2003). Hofstede (1997) notes that this relation disappears when economic growth is held constant. In this study the correlation values between power distance and individualism are below the cut-off point of 0.8.

An examination of the Mahalanobis distance, Cook's distance, and Leverage point indicated no multivariate outliers in the data (Kannan & Manoj, 2015). A Shapiro-Wilk test indicated that the data in general terms are normally distributed (Yap & Sim, 2011). And finally, the Breusch-Pagan and Koenker tests showed that the data are not affected by heteroskedasticity disturbances (Breusch & Pagan, 1979). The results of these tests indicated that the data were suitable to run the regression analyses (Appendix D).

Table 2. Descriptive statistics and correlations (N=49)

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.Growth rate CO_2	-.0305	.07975																
2.Growth rate GDP	.083	.114	.368**															
3.Carbon price	14.124	12.934	.237	-.042														
4. Power distance	48.939	19.304	.148	.507**	-.314*													
5. Individualism	62.347	25.329	-.419**	-.588**	.040	-.742**												
6. Masculinity	51.796	21.012	-.368**	.073	-.157	.131	.018											
7. Uncertainty avoidance	57.612	21.854	.192	-.266	.117	.253	-.216	-.066										
8. Long term orientation	51.674	24.387	.322*	.618**	.173	.446**	-.617**	.112	.070									
9. Indulgence	52.592	20.517	-.284*	-.599**	.137	-.604**	.651**	.047	-.192	-.691**								
10. Type of jurisdiction	.39	.492	-.286*	.209	-.487**	.180	.131	.364*	-.578**	-.159	.059							
11. Type of mechanism	.63	.487	-.245	.203	.022	.035	.154	.489**	-.280	.083	.043	.520**						
12. CP*PD	-.288	.808	-.275	-.146	-.193	-.178	.453**	.123	-.016	-.202	.127	.247	.361*					
13. CP*IND	.040	.835	.431**	.386**	.144	.471**	-.575**	-.165	.086	.430**	-.365**	-.286*	-.312*	-.636**				
14. CP*MAS	-.145	1.083	.055	.202	-.188	.105	-.122	.180	.317*	.088	-.362*	-.094	-.001	.064	.002			
15. CP*UNA	.116	1.0372	-.078	.308*	.226	-.011	.069	.356*	-.074	.158	-.051	.257	.653**	.508**	-.408**	.217		
16. CP*LTO	.171	.838	-.374**	-.453**	.041	-.184	.419**	.138	.186	-.298*	.392**	.109	.239	.237	-.403**	.014	.156	
17. CP*IVR	.133	.957	.302*	.264	.045	.115	-.313*	-.419**	-.054	.350*	-.395**	-.229	-.428**	-.506**	.503**	-.078	-.447**	-.548**

*. Correlation is significant at the 0.05 level (2-tailed) **. Correlation is significant at the 0.01 level (2-tailed)
PD: power distance; IND: individualism; MAS: masculinity; UNA: uncertainty avoidance; LTO: long-term orientation; IVR: indulgence
The interactions are between the carbon price and the cultural dimensions, which are centered.

4.2.1. Results of hierarchical regression analysis including interaction effects with cultural dimensions on GDP's growth rate

In order to determine the influence of carbon prices on GDP and the moderating effects of the six cultural dimensions, Table 3 presents the results of regressing the GDP's growth rate on the carbon prices and the six cultural dimensions in the second model. The regression starts by controlling for the type of jurisdiction, and the type of mechanism in the first model. Finally, the third model of the hierarchical regression included the interactions between the carbon prices and the six cultural dimensions.

Model 1 in Table 3 shows that there are not significant relationships between the GDP's growth rate and the control variables, type of jurisdiction and type of mechanism. The model's adjusted coefficient of determination (adjusted R^2) is 0.015 and the F-statistic is not significant ($p>0.05$).

In Model 2 the control variables remain insignificant. In this model, carbon price was included as independent variable along with the six cultural dimensions. The relationship between carbon prices and the GDP's growth rate was not significant and its sign is opposite the expected direction. This indicates that Hypothesis 1 is not supported, which proposed that carbon prices would negatively influence the economic growth rate of a jurisdiction in the short run. Furthermore, a significant and negative relationship between Uncertainty Avoidance and the GDP's growth rate was identified ($\beta = -.415$, $t\ (39) = -2.906$, $p<0.01$), supporting Hypothesis 3_D, which indicates that low uncertainty avoiding jurisdictions have higher economic growth rates. Long-term Orientation and Indulgence are in the expected direction, but not significantly related

Table 3. Hierarchical regression including interactions with cultural dimensions on GDP

	GDP growth rate (DV_1)		
Variable	Model 1	Model 2	Model 3
Type of jurisdiction	.142 (1.370)	-.013 (3.816)	.025 (4.463)
Type of mechanism	.130 (1.370)	.139 (2.013)	.012 (2.768)
Carbon price		.065 (1.797)	-.032 (2.766)
Power distance		.186 (3.963)	.257 (6.028)
Individualism		-.265 (3.590)	-.134 (5.276)
Masculinity		-.035 (1.573)	-.136 (2.081)
Uncertainty Avoidance		-.415** (2.368)	-.388* (3.451)
Long-term orientation		.189 (3.009)	.248 (3.765)
Indulgence		-.277 (2.897)	-.034 (4.272)
Carbon price x power distance			-.054 (3.380)
Carbon price x individualism			.135 (3.579)
Carbon price x masculinity			.197 (1.999)
Carbon price x uncertainty avoidance			.367* (3.794)
Carbon price x long term orientation			-.154 (2.229)
Carbon price x indulgence			.026 (3.166)
Adjusted R^2	.015	.586	.673
ΔR^2		.607	.112
F-test for ΔR^2		8.544**	7.587**

N=49. Standardized coefficients are reported. Variance inflation factors are in parentheses. Significance levels are based on two-tailed tests.

*p<0.05

**p<0.01

with the GDP's growth rate. Power distance, Individualism, and Masculinity are not significant and its sign is opposite the expected direction. The introduction of these variables explains additional significance variance compared to the base model (ΔR^2=.607) and the significant F-statistic (F (9,39) = 8.544, p<.001).

Model 3 adds the interactions between carbon prices and the six cultural dimensions. The control variables remain insignificant. The relationship between Uncertainty Avoidance and the GDP's growth rate continues being significant and negative in this model (β = -.388, t (33) = -2.534, p=0.02). Additionally, there is a positive significant interaction between Uncertainty Avoidance and carbon prices (β = .367, t (33) = 2.284, p=0.03). Hence, Hypothesis 5_D is supported, which indicates that a lower level of Uncertainty Avoidance strengthens the negative relationship between carbon prices and the GDP's growth rate. The introduction of these interactions explains the increasing significance variance compared to Model 2 in Table 3 (ΔR^2=.112), and the significant F-statistic (F (15,33) = 7.587, p<.001).

The interpretation of the signs for the interaction terms is counterintuitive. In this case, the sign of the interaction between Uncertainty Avoidance and the carbon prices is positive, but since the interpretation of the interaction effects is complicated at best, these interaction effects were examined graphically, using the simple slopes procedure described by Aken and West (1991). The simple slopes method requires to plot values one standard deviation above the mean and one standard deviation below the mean. Figure 4 shows the relationship of centered carbon prices values at low, average, and high levels of Uncertainty Avoidance, depicting that low levels of Uncertainty avoidance strengthen a negative relationship between carbon prices and the GDP growth rate, as indicated in the Hypothesis 5_D, which presents the largest slope. At average levels of Uncertainty avoidance, the interaction depicts a slightly negative slope; and at higher levels of uncertainty avoidance, the relationship between carbon prices and the GDP growth rate becomes positive. On the one hand the positive sign of the interaction term indicates that the negative relationship between carbon prices and GDP increases at lower levels of Uncertainty Avoidance (larger slope), but on the other hand a positive relationship between carbon prices and GDP increases at higher levels of Uncertainty Avoidance (smaller slope). This result suggests that there are two significant regions of the interaction, one at high levels of Uncertainty Avoidance and the other one at lower levels of Uncertainty Avoidance. In other words, an increasing or decreasing growth rate of GDP at high or low carbon prices depends on the levels of Uncertainty Avoidance.

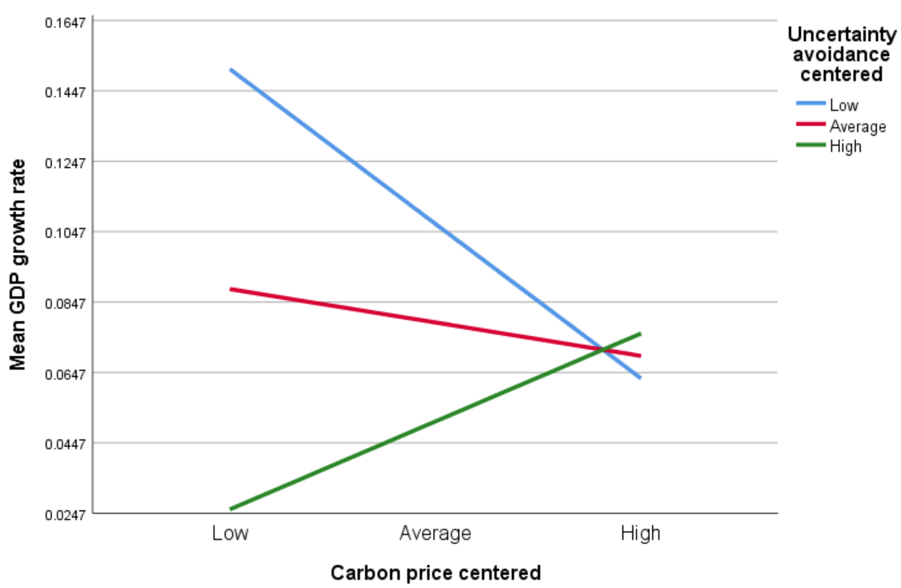

Figure 4. Interaction effects between Uncertainty Avoidance and carbon prices on GDP's growth rate.

This still supports Hypothesis 5_D, but also a region of the interaction where high levels of Uncertainty Avoidance and low carbon prices increase GDP. However, considering the region with a larger slope. Nonetheless, it's safe to say that as carbon prices increase the GDP's growth rate decreases more rapidly for those jurisdictions with lower levels of Uncertainty Avoidance compared to those with higher levels of Uncertainty Avoidance.

4.2.2. Results of hierarchical regression analysis including interaction effects with cultural dimensions on CO_2 emissions' growth rate

In order to explain the influence of carbon prices on CO_2 emissions and the moderating effects of the six cultural dimensions, Table 4 presents the results of regressing the CO_2 emissions' growth rate on the carbon prices and the six cultural dimensions and controlling for type of jurisdiction and type of mechanism. Lastly, the third stage of the hierarchical regression included the interactions between the carbon prices and the six cultural dimensions.

Model 1 in Table 4 shows that there are no significant relationships between the CO_2 emissions' growth rate and the control variables, type of jurisdiction and type of mechanism. The direction of both relationships is negative. The model's adjusted coefficient of determination (adjusted R^2) is 0.055 and the F-statistic is not significant ($p>.05$).

In Model 2 the control variables remain insignificant. In this model, carbon price was included as independent variable together with the six cultural dimensions. The relationship between carbon prices and CO_2 emissions' growth rate was not significant, and its sign is opposite the expected direction. This indicates that Hypothesis 2 is not supported, which proposed that carbon prices would negatively influence the CO_2 emissions' growth rate of a jurisdiction.

Table 4. Hierarchical regression including interactions with cultural dimensions on CO_2

Variable	CO_2 emissions growth rate (DV2)		
	Model 1	Model 2	Model 3
Type of jurisdiction	-.217 (1.370)	.227 (3.816)	.477 (4.463)
Type of mechanism	-.132 (1.370)	-.059 (2.013)	-.050 (2.768)
Carbon price		.146 (1.797)	.025 (2.766)
Power distance		-.311 (3.963)	-.541 (6.028)
Individualism		-.517* (3.590)	-.313 (5.276)
Masculinity		-.358* (1.573)	-.477* (2.081)
Uncertainty Avoidance		.225 (2.368)	.506* (3.451)
Long-term orientation		.209 (3.009)	.302 (3.765)
Indulgence		.035 (2.897)	.098 (4.272)
Carbon price x power distance			-.069 (3.380)
Carbon price x individualism			.413 (3.579)
Carbon price x masculinity			.014 (1.999)
Carbon price x uncertainty avoidance			.152 (3.794)
Carbon price x long term orientation			-.335 (2.229)
Carbon price x indulgence			-.244 (3.166)
Adjusted R^2	.055	.245	.292
ΔR^2		.293	.126
F-test for ΔR^2		2.733*	2.317*

N=49. Standardized coefficients are reported. Variance inflation factors are in parentheses. Significance levels are based on two-tailed tests.

*p<0.05

**p<0.01

Moreover, a significant and negative relationship between Individualism and the CO_2 emissions' growth rate was identified (β = -.517, t (39) = -2.177, p=0.04), supporting Hypothesis 4_B, which indicated that highly individualistic jurisdictions have lower CO_2 emissions' growth rates. Additionally, Model 2 shows a significant and negative relationship between Masculinity and CO_2 emissions' growth rate (β = -.358, t (39) = -2.276, p=0.03) in the opposite direction as expected. Hence, Hypothesis 4_C is not supported. Power distance, Long-term Orientation, Uncertainty Avoidance, and Indulgence are not significantly related to the CO_2 emissions' growth rate. The introduction of these variables explains the additional significance variance compared to the base model (ΔR^2=.245) and the significant F-statistic (F (9,39) = 2.733, p<.05).

Model 3 in Table 4 adds the interactions between carbon prices and the six cultural dimensions. Type of mechanism and type of jurisdiction control variables remain insignificant. The negative relationship between Masculinity and the CO_2 emissions' growth rate remains significant (β = -.477, t (33) = -2.724, p=.01), and in the opposite direction as expected. Individualism becomes insignificant but remains in the expected direction. Uncertainty Avoidance becomes significant and in the expected direction (β = .506, t (33) = -2.241, p=.04), supporting Hypothesis 4_D, which indicated that the lower the levels of Uncertainty Avoidance, the lower the levels of CO_2 emissions. Power distance, Long-term orientation, and Indulgence remain insignificant. There are no significant interactions in this model. Nonetheless, the introduction of these interactions explains the increasing significance variance compared to Model 2 (ΔR^2=.126) and the significant F-statistic (F (15,33) = 2.317, p<.05).

5. Discussion

This chapter begins by examining the effects of the carbon prices on the two dependent variables: economic growth and carbon dioxide emissions. Following with an analysis in deeper detail of the impacts of carbon-pricing instruments and cultural dimensions on the real GDP growth rate and the hypotheses associated with this economic growth. Finally, the chapter addresses the findings of the relationships between the independent and the moderating variables with the carbon dioxide emissions' growth rate.

5.1. The influence of carbon prices on real GDP and CO_2 emissions

As described in the literature, one of the major challenges that policymakers face while designing climate change policies is deciding on the correct carbon price to achieve desired outcomes from these policies. Determining carbon prices is a difficult task, especially, considering the profound uncertainties involved in estimating the economic value of negative impacts caused by climate change, the imperfect information about climatological events, and the extent of the impacts (Bowen, 2011). However, carbon pricing is the best tool available for market-based strategies to reduce emissions, and carbon prices constitute the structural underpinnings of climate change policies (Aldy & Pizer, 2016). Carbon prices are intended to efficiently promote a low-carbon economy by reflecting the marginal cost of emitting an extra unit of greenhouse gas emissions and are expected not to produce regressive effects on economic growth and productive activities (Iyer et al., 2018). Bearing in mind the relevance of carbon prices, it's important to recognize that they are not always directly comparable across the carbon-pricing initiatives because of the differences in terms of the sectors covered, the share of emissions covered, greenhouse gases covered, emission allocation methods applied, specific exemptions, and different compensation methods. These differences affect not only the comparability of carbon prices between the initiatives but also the efficiency of the carbon-pricing instruments and their impacts on economic growth and carbon dioxide emissions. For this study, the share of emissions covered and the currency exchange rates at the moment of implementation were considered to estimate the carbon prices' impacts on emissions and real GDP, converting the explicit carbon prices into effective carbon rates. Other characteristics of carbon prices are strongly dependent on the nature of the policy instruments applied, and the particularities of each jurisdiction, which might constitute a limitation in terms of comparability. For example, Sweden has the highest carbon tax rates among the jurisdictions analyzed in this study, which is the main reason why the absolute decrease of CO_2 emissions in Sweden is larger than in other jurisdictions (Lin & Li, 2011). Nevertheless, as the carbon tax rate for manufacturing industries is one half of the general level in Sweden, its impact on mitigation of the industrial sector is limited. Between 1990 and 2008, the total emissions in Sweden decreased by 13%. The CO_2 emissions in the manufacturing and the construction industries went down by 13.3%, while that of the iron and steel industry increased by 27%. Additionally, due to the high carbon tax rate, the CO_2 emissions in the residential sector decreased by 81%, which is the largest decrease in emissions among all sectors in Sweden (Lin & Li, 2011). This example reflects the differences of explicit carbon prices in explaining the impacts of carbon-pricing instruments on GDP and emissions, and the variability of those impacts across jurisdictions. Explicit carbon prices send an important price signal to markets, but also depend on the methods applied and the objectives of the climate policies to reflect accurately the ultimate effects of carbon-pricing instruments. The overall impacts of carbon-pricing instruments are shown in Figure 3, depicting trends of increasing GDPs while CO_2 emissions are decreasing.

Keeping in mind these differences between the explicit carbon prices and the carbon-pricing instruments is important to understand the impacts on the dependent variables employed in the hierarchical regression analyses for this study.

5.2. Impacts of carbon prices and cultural dimensions on GDP

The literature indicates that in the absence of climate policies, when the economic growth rate increases, the environmental performance indicators are negatively affected, which is in accord with the Environmental Kuznets Curve for jurisdictions in early stages of economic development, indicating that jurisdictions in those stages of economic growth display a poor environmental performance, improving in later stages (Stern, 2003). The majority of the jurisdictions analyzed in this study are developed ones and belong to the OECD, within an income segment that is consistent with the EKC (Aldy, 2005). However, it's important to keep in mind that this study employed the growth rate of real GDP as dependent variable and not the size of GDP. Thus, the regression results were expected to suggest that those jurisdictions with the largest economic growth rates have poor environmental performance, which in this case are some of the fastest growing economies, such as the Chinese provinces, Korea, and some countries from Eastern Europe like Latvia, Czech Republic, and Estonia. For example, Chongqing GDP's growth was 11% in 2015 (Global Times, 2016), the year after the ETS initiative implementation. This reflects that the individual results described in the CO_2 and GDP trends section are in line with the EKC, indicating that jurisdictions with faster economic growth present a positive relationship between GDP and the level of emissions.

With respect to the regression results, in the first stage of the hierarchical regression on the real GDP's growth rate dependent variable, none of the control variables shows a significant relationship, indicating that the type of jurisdiction and the type of mechanism are not related to the GDP's growth rate. This result was counterintuitive, at least with respect to the type of jurisdiction, considering that the carbon revenue management strategies were expected to have a stronger impact in the local economies at the subnational level compared to those at the national level.

Hypothesis 1, which proposed a negative relationship between the level of carbon prices and the economic growth rate, wasn't supported. Although, the coefficients are small and close to zero, the direction of the relationship was opposite as expected in the first regression state, and not statistically significant in the two regression stages where the variable carbon price was included. The expected results were based on empirical studies, which indicate that carbon pricing is an effective policy tool because it can reduce carbon emissions with little negative impact on economic growth (Lu et al., 2010). However, it is appropriate to emphasize that the GDP of a jurisdiction depends on many factors and it's difficult to explain its dynamics without considering other macroeconomic aspects that have relevant influence on economic growth. With that being said, an alternative explanation for observed results, may be that policy design features related to carbon revenue management play a key role in minimizing the negative economic impacts of a carbon tax or an ETS. Moreover, the distributional impacts and impacts on competitiveness have important implications not only for fairness or distributive justice but also for political feasibility (Goulder & Parry, 2008), implying that policymakers pay special attention to this potential effects of carbon pricing. Accordingly, several studies agree that welfare and distributional implications of carbon prices significantly depend on how carbon revenue recycling is defined in policies (Arlinghaus, 2015). For example, Chateau and Saint-Martin (2013) found that an adequate redistribution of carbon revenue can impact positively the labor market, especially in the clean energy sector. However, other authors argue that no consensus has been established regarding the progressivity or regressivity of the carbon pricing itself (Caron, Cohen, Brown, & Reilly, 2018), which depends on the different approaches employed in the policy designs. For instance, Goulder and Hafstead (2013) found that a tax equivalent to $10 per ton of CO_2 starting in 2013 and increasing by 5% per year until 2040 reduced GDP by 0.56% when revenues are returned in lump-sum fashion to households, 0.33% when revenues are used to reduce personal tax rates, and 0.24% when revenues are used to reduce corporate tax rates. This suggests that negative impacts on economic growth vary widely depending on the design and the objectives of the carbon-pricing instrument. Furthermore, the regression analysis results suggest that explicit carbon prices may be limited in explaining impacts on real GDP. Although, this study considered some features of the carbon pricing designs, such as the share of emissions covered by carbon prices, the type of emissions covered (CO_2 emissions), and the currency exchange rates of carbon prices in their respective jurisdictions; the study didn't consider other specific elements of the carbon-pricing policies implemented in the jurisdictions.

It can be seen from the above analysis that, despite carbon prices are core elements of carbon-pricing policies, they might not reflect accurately all the effects of carbon taxes or emissions trading schemes on economic growth. For instance, explicit carbon prices are not able to manifest the influence of carbon revenue management measures to reduce the negative impacts on competitiveness, household incomes, and EITE sectors. Therefore, they only show a partial vision of the net cost to society of emissions abatement; consequently, the lack of statistical significance of carbon prices with respect to real GDP impacts is attributed to measures such as exemptions and free-allocation of allowances. On the other hand, Figure 3 shows clearly that carbon-pricing instruments achieved the intended outcome of not affecting negatively the GDP trend in the majority of the jurisdictions, which is consistent with the literature.

Hypothesis 3_D was supported, which indicated that lower levels of Uncertainty Avoidance promote higher economic growth rates, suggesting that those jurisdictions open to innovation and with flexible legal frameworks that promote entrepreneurism, technological innovation, and business development, have economies that grow more than jurisdictions with high uncertainty avoidance levels.

Among the jurisdictions with the lowest levels of Uncertainty avoidance are Denmark, Sweden, the Chinese provinces, UK, and Ireland, followed by the U.S. subnational jurisdictions, which coincide with some of the larger economies observed in the study. These societies have the ability to adapt to changing circumstances, and a tendency to manage adequately ambiguity in unstructured environments. This suggests a certain degree of comfort in dealing with investment risks and relatively new businesses, such as renewable energies (Papamarcos & Watson, 2006). For instance, Ireland’s carbon tax is notable for its ambitious price per ton of CO_2 covering almost all sectors not covered by the EU ETS. Although the Irish carbon tax was mildly regressive based on income and household characteristics for home heating expenditures, it was progressively distributed across the income spectrum for electricity and petrol use (Farrell, 2017). This tax system is also known for its implementation during the global recession and a time of peak austerity in Ireland, which is a remarkable indication of low Uncertainty Avoidance because of the ambiguity involved at that time. Despite the adverse conditions, the carbon tax revenue represented for Ireland's economy about 12.4% of the cumulative tax increases between 2010 and 2012 (Convery, Dunne, & Joyce, 2013) and has generated over €2 billion in revenue so far.

The results suggest that low Uncertainty Avoidance levels are relevant in the context of carbon pricing with respect to economic growth, because it involves the adoption of new and innovative technologies. On the other hand, the potentially regressive effects of carbon pricing on the economic growth can be reverted with an adequate implementation of carbon revenue management strategies, but require a certain degree of tolerance toward uncertain economic conditions.

Hypothesis 5_D was supported. This hypothesis reflects an interaction term between carbon prices and uncertainty avoidance on economic growth, which indicates that at lower levels of uncertainty avoidance the relationship between carbon prices and economic growth becomes more negative. This result suggests that jurisdictions with low uncertainty avoidance are more receptive to adopt climate policies that impose higher carbon prices and may impact negatively the economic growth in order to reduce emissions. As described before, low uncertainty avoidance societies embrace change and seek new opportunities through innovation. From this perspective, low-uncertainty-avoidance jurisdictions might be open to invest in new technologies such as clean energy and energy efficient technologies, like in the case of the Chinese provinces, which have invested US$ 2.9 trillion since 2004 in green energy sources, leading the way towards solar power (Frangoul, 2018). Moreover, Chinese ETS pilots are notable for their innovative allowance allocation and distribution methodologies that suit the local structural and economic conditions of the respective jurisdictions (Xiong, Shen, Qi, Price, & Ye, 2017), indicating flexibility in the design of those carbon-pricing instruments to meet particular requirements.

At the other end of the spectrum, the jurisdictions with high Uncertainty avoidance values are Greece, Portugal, Ukraine, Belgium, and Poland. These jurisdictions, as opposed to Scandinavian countries, adopted carbon-pricing initiatives relatively late. As expected, Greece, Portugal, and Ukraine present increasing CO_2 growth rates for the periods analyzed.

Poland and Ukraine, two of the jurisdictions transitioning from the coal-era infrastructure, have imposed through carbon taxes the lowest carbon prices observed in this research (US$0.08/ton$CO_2$ eq and US$ 0.02/tonCO_2 eq, respectively). In the case of Ukraine, in 2011, it was reported that Ukrainians have one of the highest carbon intensities (CO_2 emissions per GDP) in the world (IEA, 2017). In this regard, Frey (2017) found that in order for Ukraine to achieve its target emission reductions of 10% with respect to the emissions level of 2010, Ukraine needs to raise its carbon tax from US$0.02/ton$CO_2$ eq to US$3.07/ton$CO_2$ eq. Furthermore, she states that “the feasibility of such a carbon tax strongly depends on the power of the lobbying groups and the overall political will” (Frey, 2017, p. 12), making an allusion of the role that cultural values play in such situations. On the other hand, at the EU level, Poland opposes more ambitious GHG reduction targets and the further development of climate change policies (Zelljadt, Velten, Prahl, Duwe, & Poblocka, 2014). In 2016, Poland’s Energy Minister Krzysztof Tchorzewski claimed that “building more efficient coal power plants will get us better results in cutting CO_2 emissions than building renewable energy sources like wind or solar” (Zulinski, 2018, para. 5), which can be interpreted as a significant characteristic of high uncertainty avoiding cultures.

In terms of findings, the results of this study show that the moderating effect of uncertainty avoidance on the relationship between carbon prices and economic growth is significant. Consequently, high uncertainty avoiding jurisdictions that are new to carbon-pricing instruments may be especially reluctant to adopt such technologies, in light of a potential negative impact on their economic growth. In this regard, the transfer of carbon-pricing technologies to other jurisdictions should consider their levels of uncertainty avoidance to prevent difficulties during the implementation.

5.3. Impacts of carbon prices and cultural dimensions on CO_2 emissions

In the first stage of the regression analysis on the CO_2 emissions growth rate, none of the control variables produced a significant relationship with the dependent variable. Although, these variables have explained about 5.5% of the CO_2 emissions growth rate variable.

The type of mechanism and type of jurisdiction variables remained insignificant in the three regression stages. The type of jurisdiction variable was expected to indicate that carbon pricing has been increasingly adopted at the subnational level, where local authorities are developing and implementing climate policies, and working to address climate change within their own jurisdictions as they have direct control of critical sources of emissions (Burch et al., 2014). Additionally, carbon revenue could be locally managed without the intervention of a federal government. This allows subnational jurisdictions to implement carbon-pricing measures that are suitable and specific to the local conditions, including cultural values, which might change from province to province within the same country. Evidently, the link between subnational jurisdictions and cultural values in carbon-pricing initiatives requires further research, mainly considering the lack of information for cultural values at the subnational level. For example, it's relevant to highlight that the province of Québec in Canada is culturally different from the rest of the provinces (Berry & Kalin, 1995), and having their own ETS gives the local government more flexibility to address their particular environmental issues, which are certainly physically and culturally different from the ones in other provinces.

Hypothesis 2 expected a negative relationship between the level of carbon prices and the CO_2 emissions growth rate, but it wasn't supported. The coefficients are small and close to zero; the direction of the relationship for the two regression stages were the opposite as expected and not statistically significant in the two regression stages where the variable carbon price was included. This result can be explained in a similar fashion that the lack of statistical significance of carbon prices was described for the GDP growth rate, indicating that explicit carbon prices have limitations in reflecting the impacts of non-carbon-pricing policies that reduce CO_2 emissions such as performance standards and renewable portfolio standards (Flues & Lutz, 2015). Moreover, explicit carbon prices may be also limited in manifesting the influence of carbon-pricing strategies such as carbon revenue recycling, which in many cases as shown in Table 1 are used to reduce emissions and enhance policy efficiency. For instance, Quebec deposits its carbon tax revenue into a “green fund” that supports initiatives offering the largest projected reduction in, or avoidance of, GHGs (Sumner et al., 2009), and the RGGI also tends to direct most of its revenue to encourage energy savings (Tietenberg, 2013).

In the second stage of the regression, the hypothesis 4_B was supported, indicating a significant and negative relationship between individualism and CO_2. This relationship became insignificant in the last regression stage and remained in the expected direction. Nevertheless, this result suggests that individualistic societies provide self-empowerment and individual responsibility toward climate change. This has critical implications about the suitability of climate policies in certain societies. For instance, climate policies should address collectivistic societies differently, indicating that a careless attitude toward climate change and its impacts could affect the interests of the in-group of business people and workers in the long run (Husted, 2005). Additionally, social acceptance and tradition are more important than self-respect in collectivistic countries (Hofstede, 1997). As a result, the adoption of renewable energies and energy-efficient technologies, for example, must be presented to business people in collectivistic countries as corporate and socially acceptable.

The jurisdictions with high individualism values are the U.S. subnational jurisdictions, Australia, United Kingdom, Netherlands, and the Canadian provinces. These jurisdictions have implemented innovative carbon-pricing instruments. For instance, the RGGI in the U.S. is notable for its transparency and commitment to periodic program reviews to adjust its ETS market. RGGI is also known for full auctioning of its allowances, significant revenue generation ($2.7 billion so far), and investment of revenue towards other emissions-reducing activities (Tietenberg, 2013). By the same token, Canadian provinces have implemented ambitious carbon-pricing initiatives in British Columbia, Quebec, Alberta, and Ontario (World Bank & Ecofys, 2018). Nevertheless, U.S. and Canada have walked away from the Kyoto Protocol in the past, and the U.S. has also recently abandoned the Paris Accord. Also, in July 2018, the recently elected, Ontario's Premier, Doug Ford, announced the ending of the Ontario's cap-and-trade system (Rieti, 2018). Also, Australia in 2014 voted to cancel its national carbon tax initiative.

As the caveats described in the literature review, these political events appear contradictory to the broad tendencies indicated in the hypotheses, but political leaders may make decisions opposing to society's tendencies, meaning that in the long run it's expected that the society's preferences will prevail.

On the other hand, the least individualistic jurisdictions are the Republic of Korea, the Chinese provinces, Ukraine, Slovenia, and Portugal, which as no surprise are among the jurisdictions that have increasing CO_2 emissions growth rates. For example, the Korean ETS may face difficulties in achieving its NDC commitment of 37% emissions reductions below BAU by 2030, due to several reasons such as emissions leakage from noncompliance in the downstream electricity consumption; a lack of liquidity in the market; and the political nature of allowance allocations has reduced confidence in the system (Narassimhan et al., 2017). These difficulties may indicate that the carbon-pricing initiative faces complications to enter the political agenda, which may be indicative of a highly collectivistic jurisdiction.

Finally, hypothesis 4_C, which proposed that higher levels of Masculinity increase CO_2 emissions growth rate, is significant, but in the opposite direction as expected. Hence, the hypothesis was not supported. This result suggests that masculine jurisdictions have a tendency to present lower growth rates of CO_2 emissions, which is the opposite that theory indicates, considering that societies with high values of masculinity prioritize material success over environmental conservation (Hofstede, 2001). An alternative explanation for this result is that while societies with high scores of masculinity may prioritize economic development over climate protection, masculine societies may be inclined to combat the environmental problems by coercion rather than consent, when CO_2 emissions and climate change impacts reaches alarming levels (Husted, 2005).

The jurisdictions with the highest values of masculinity included in this study are Japan, Austria, Italy, Switzerland, and Mexico, with a significant difference between Japan (score of 95 out of 100) and the rest of the jurisdictions.

According to the explanation provided before, five decades ago Japan had serious air pollution problems. Emissions of nitrogen dioxide and sulfur dioxide tripled during the 1960s. Japan became known for pollution-related diseases named after the cities where they first appeared. As a result, they took drastic measures to reduce pollution, passing 14 laws at once, what became known as the Pollution Diet of 1970 (Harney, 2013). Despite these past experiences, today Japan has a modest carbon tax rate of $3 per ton of CO_2, which doesn’t seem to help the country in achieving its emissions reduction goal of 26% below 2013 levels by 2020 (Narassimhan et al., 2017), and reflects the dominant masculine culture in the country.

In the third stage of the regression, Uncertainty Avoidance became significant and positive, supporting Hypothesis 4_D, which proposes that the lower levels of Uncertainty Avoidance, the lower levels of CO_2 growth rate. This result suggests that Uncertainty Avoidance influences carbon emissions reductions. For instance, Sweden has achieved one the highest emission reductions (Lin & Li, 2011), and is among one of the jurisdictions with lowest Uncertainty Avoidance scores. This is derived from an aggressive policy to reduce emissions in the early 1990s, when the Nordic countries were pioneers in implementing carbon-pricing initiatives and enforced strict environmental laws.

Finally, it’s important to highlight that cultural profiles of countries may be useful in predicting the adoption of carbon-pricing initiatives. For example, individualistic and low-uncertainty-avoiding jurisdictions might be more propense to implement carbon-pricing initiatives than collectivistic-uncertainty-avoiding jurisdictions.

These cultural profiles of jurisdictions are potentially a relevant factor in the trend of linking jurisdictions through carbon-pricing initiatives. For instance, the linkage between Quebec, California, and Ontario with different cultural backgrounds could reflect in the long-run the relevance of cultural values in such joint emission trading systems. Currently, Ontario, led by a new Premier, decided to cancel its cap-and-trade system, suggesting that the voters at that moment agreed on that decision during his campaign, which hasn’t happened in the case of Quebec or California since 2014. Measuring the degree of influence that culture inflicts on such decisions is a major challenge, but evidence shows that there is a link between these factors.

Knowing the cultural profiles of the countries won't necessarily provide policymakers with tools to influence culture and induce behavior, but they would gear policymakers with a better understanding of the particularities and local conditions that enable a successful adoption and implementation of climate policies.

5.4. Summary of hypotheses accepted/rejected

Table 5. Hypotheses accepted/rejected

Hypothesis	**Result**
H1. The higher the carbon price the lower the short-term GDP growth rate.	Not supported
H2. The higher the carbon prices, the lower the short-term growth rate of CO_2 emissions.	Not supported
$H3_A$. The lower the level of power distance in a jurisdiction, the higher the GDP's growth rate.	Not supported
$H4_A$. The higher the level of power distance in a jurisdiction, the higher the CO_2 emissions' growth rate	Not supported
$H3_B$. The more individualistic a jurisdiction, the higher the GDP's growth rate	Not supported
$H4_B$. The more individualistic a jurisdiction, the lower the CO_2 emissions' growth rate.	***Supported***
$H3_C$. The greater the masculinity of a jurisdiction, the higher the GDP's growth rate.	Not supported
$H4_C$. The greater the masculinity of a jurisdiction, the higher the CO_2 emissions' growth rate.	*Not supported but significant*
$H3_D$. The lower the uncertainty avoidance, the higher the GDP's growth rate.	***Supported***
$H4_D$. The lower the uncertainty avoidance, the lower the CO_2 emissions' growth rate.	***Supported***
$H3_E$. A higher level of long-term orientation will produce a higher growth rate of the GDP.	Not supported
$H4_E$. A higher level of long-term orientation will produce a lower growth rate of CO_2 emissions.	Not supported
$H3_F$. A higher level of indulgence will decrease the growth rate of GDP.	Not supported
$H4_F$. A higher level of indulgence will increase the growth rate of CO_2 emissions.	Not supported

H5_A. Lower levels of power distance strengthen the negative relationship between carbon prices and the GDP growth rate.	Not supported
H6_A. The higher the level of power distance, the weaker the negative relationship between carbon prices and the CO_2 emissions growth rate.	Not supported
H5_B. The higher the level of individualism, the stronger the positive relationship between carbon prices and the GDP growth rate.	Not supported
H6_B. The higher the level of individualism, the stronger the inverse relationship between carbon prices and the CO_2 growth rate.	Not supported
H5_C. The higher the level of masculinity, the weaker the negative relationship between carbon prices and the GDP growth rate.	Not supported
H6_C. The lower the level of masculinity, the stronger the inverse relationship between carbon prices and the CO_2 growth rate	Not supported
H5_D. The lower the level of uncertainty avoidance, the stronger the negative relationship between carbon prices and the GDP growth rate.	***Supported***
H6_D. The higher the level of uncertainty avoidance, the weaker the inverse relationship between carbon prices and the CO_2 growth rate.	Not supported
H5_E. The higher the level of long-term orientation, the weaker the relationship between carbon prices and the GDP growth rate.	Not supported
H6_E. Lower levels of long-term orientation weakens the negative relationship between carbon prices and the CO_2 growth rate.	Not supported
H5_F. A high level of indulgence weakens an inverse relationship between carbon prices and the GDP growth rate.	Not supported
H6_F. A low level of indulgence strengthens a negative relationship between carbon prices and the CO_2 growth rate.	Not supported

6. Conclusions

Acknowledging the importance of cultural factors in climate policy is an important first step. Accordingly, the results of this study indicate that culture influences carbon prices, and consequently, economic growth and carbon dioxide emissions. These results are relevant findings for policymakers, who should consider culture as an important factor in developing and implementing climate policies. The relationships between the variables analyzed are complex, but they reveal that culture plays a role in the development of carbon-pricing instruments. Cultural values are hardly manipulated by policymakers as opposed to carbon prices that do change behavior. But considering cultural variability while developing climate policies, might constitute a significant difference between a successfully implemented policies and failed “well-intentioned” instruments.

Including culture as a factor in the construction of carbon-pricing instruments remains a challenge, which should consider the appropriate scale to ensure its effective application. Potentially, smaller scales will require more efforts and resources, but are expected to have the desired outcomes.

Carbon prices and the cultural dimensions were able to explain between 1.5% and 67.3% of the variance in the real gross domestic product growth rate, with uncertainty avoidance and the interaction between carbon prices and uncertainty avoidance as the strongest significant predictors.

Jurisdictions with low Uncertainty Avoidance levels have higher GDP growth rates, indicating that such jurisdictions are open to the adoption of new technologies and innovation, even when it implies small regressive impacts on economic growth in the initial phases, like in the case of the carbon-pricing initiatives. These results suggest that low Uncertainty Avoidance levels are relevant in the context of carbon pricing with respect to economic growth. Additionally, the negative effects of carbon-pricing instruments on the economy can be reverted with the implementation of carbon revenue management strategies, requiring a certain ability to manage adequately ambiguous economic conditions during the initial stages of its implementation, which is also in line with low uncertainty avoiding cultures.

The moderating effect of Uncertainty Avoidance on carbon prices with respect to economic growth shows that high uncertainty avoiding jurisdictions are unwilling to increase carbon prices and adopt stricter climate instruments, considering the negative impacts that those instruments impose on their economies. This cultural distance is a useful indicator of the transferability of carbon-pricing technologies to other jurisdictions that prioritize economic growth over environmental performance.

6.1. Contributions to theory

The climate change debate has been dominated by the physical and economic sciences, but this study provides initial clues that culture plays a role in the development and implementation of carbon-pricing instruments, which have been widely adopted as mitigation tools. Nonetheless, more research is required to establish in detail to what extent the relationships between culture, carbon taxes and emissions trading systems influence climate policies. The contributions described below reflect those initial cues mentioned before.

Carbon prices and the cultural dimensions were able to explain between 5.5% and 29.2% of the variance in the carbon dioxide emissions growth rate, with individualism, masculinity, and uncertainty avoidance as the strongest significant predictors.

Individualistic jurisdictions are more inclined to adopt climate policies to reduce emissions, which has critical implications in terms of the suitability and introduction of carbon-pricing instruments in certain jurisdictions. Nevertheless, several examples of the opposite exist, where highly individualistic jurisdictions abandon climate change agreements. These examples reflect political events where political leaders that at certain point make decisions opposing to society's tendencies. But it is expected that in the long run the society's preferences overcome those decisions. Moreover, it's difficult to explain particular events from a cultural perspective with such a broad approach like in the case of the Hofstede's framework.

With respect to the results of the Masculinity cultural dimension, which are significant in the model but in the opposite direction as expected, reflect those masculine jurisdictions that normally prioritize economic growth over the environment, but they rapidly adapt their approach if the environmental conditions reach alarming levels that may threat productive activities in the long-run and prioritize environmental issues.

The major constraint that this study had was the lack of cultural dimensions at the subnational level, limiting the understanding of the cultural nuances within countries and their different approaches with respect to carbon-pricing instruments and having an accurate perspective of the cultural profiles of jurisdictions at the subnational level.

6.2. Contributions to practice

Jurisdiction’s cultural profiles could be a powerful tool that supports the development of culturally congruent carbon-pricing policies and facilitates the transferability of climate change policies among jurisdictions. This feature is critical in the near future, considering that linkage of jurisdictions is becoming rapidly important to achieve emissions reductions, because it can reduce costs substantially. Lower costs, in turn, may contribute politically to embracing more ambitious objectives (Mehling et al., 2018), and enhance the chances to achieve a global carbon price. Linkage of jurisdictions may be key in creating political momentum to move forward climate policies where they don’t exist, considering also that linkage is an entirely voluntary process. In this regard, cultural profiles are especially useful, considering that the Paris Agreement implies a large number of NDCs aiming to reduce emissions at the lowest cost possible, but also with big disparities in terms of capabilities and practical knowledge of carbon-pricing instruments, requiring transfer of technology. For instance, low uncertainty avoiding-individualistic jurisdictions are more likely to join regional carbon-pricing initiatives than jurisdictions with a different cultural profile.

Accordingly, culture might be a useful “soft” tool in the challenge of decarbonizing the environment. And acknowledging that carbon-pricing instruments that are effective in reducing carbon dioxide emissions in one jurisdiction may not be as effective or easily implemented in another due to cultural differences is a relevant improvement. Furthermore, because cultural values are rooted in societies and change slowly, the transferability and application of climate policies from one society to another may be very limited in the short-run (Disli et al., 2016), requiring locally designed modifications in order to ease implementation.

Policymaking institutions should promote the development of culturally congruent incentives for addressing carbon dioxide emissions in the different jurisdictions, differentiating carbon-pricing instruments for different regions and subnational jurisdictions within countries. Also, future climate policy and global environmental initiatives that encourage sustainable development should incorporate the impacts of culture at the subnational, national, and regional level in the environment-economic growth nexus.

6.3. Future research

Future research could incorporate complementary policies and other carbon-pricing elements along with carbon prices in the analysis of impacts on economic growth and carbon dioxide emissions to provide a comprehensive perspective and an apples-to-apples comparison between jurisdictions of those impacts. In order to achieve an adequate comparison, it is crucial to have information of cultural values at the subnational level.

The role of culture with respect to the willingness-to-pay for carbon emissions reductions is another interesting topic that helps to understand potential difficulties for carbon pricing implementation across jurisdictions. Additionally, the role of culture in linking jurisdictions through carbon-pricing initiatives is also an interesting subject to explore.

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Appendices

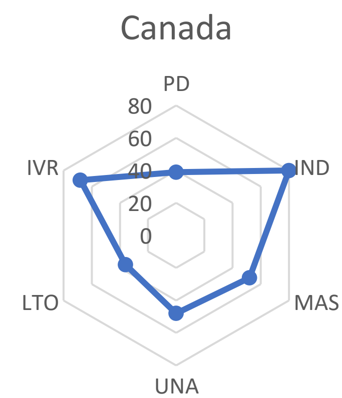
Appendix A.

49 carbon-pricing initiatives – national and subnational jurisdictions

The cultural dimensions are on the right of each table. PD: Power distance; IND: Individualism; MAS: Masculinity; UNA: Uncertainty avoidance; LTO: Long-term orientation; and IVR: Indulgence versus restraint.

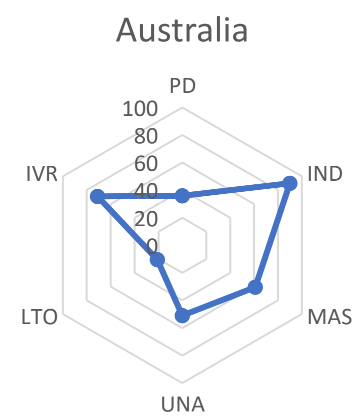
1. Alberta, Canada

Year of implementation	2007
Type of jurisdiction	Subnational
Type of mechanism	ETS
Price at implementation	US$15
Share of emissions covered	45%
Alberta's carbon tax rate, launched in 2017, increased from CAN$20/tCO2e US$16/tCO2e) in 2017 to CAN$30/tCO2e (US$23/tCO2e) in 2018.	



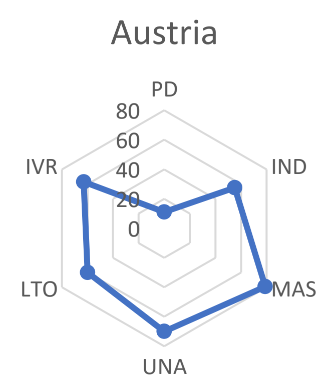
2. Australia

Year of implementation	2007
Type of jurisdiction	National
Type of mechanism	ETS
Price at implementation	US$14
Share of emissions covered	50%
The initiative has contracted 438 projects against a cost of A$2.28 billion (US$1.75 billion) to deliver 191 MtCO2e of emissions abatement over 2015–2029.	



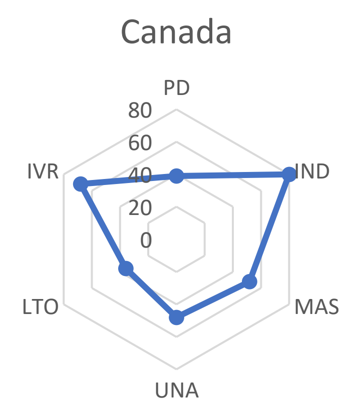
3. Austria

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
Key post-2020 reforms include changing the linear annual cap reduction from 1.74 per cent to 2.2 percent	



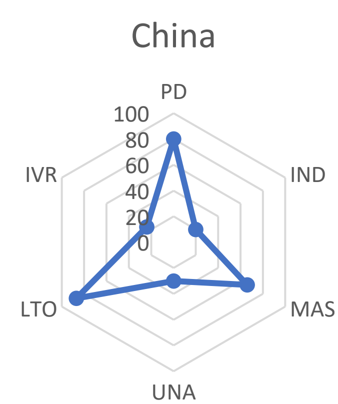
4. British Columbia, Canada

Year of implementation	2008
Type of jurisdiction	Subnational
Type of mechanism	Carbon tax
Price at implementation	US$ 9.55
Share of emissions covered	70%
British Columbia's tax rate increased from CAD$30/tCO2e to CAD$35/tCO2e (US$23/tCO2e to US$27/tCO2e) on April 1, 2018 and will continue to increase annually by CAD$5/tCO2e (US$4/tCO2e) until the rate is C$50/tCO2e (US$39/tCO2e) in 2021	



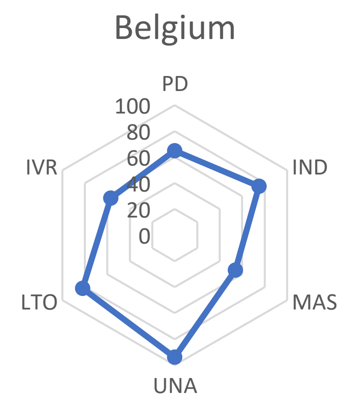
5. Beijing, China

Year of implementation	2013
Type of jurisdiction	Subnational
Type of mechanism	Pilot ETS
Price at implementation	US$ 8.20
Share of emissions covered	45%
A decrease in free allocation in the Beijing pilot ETS of up to ten percentage points for existing facilities in various sectors including cement and petrochemicals	



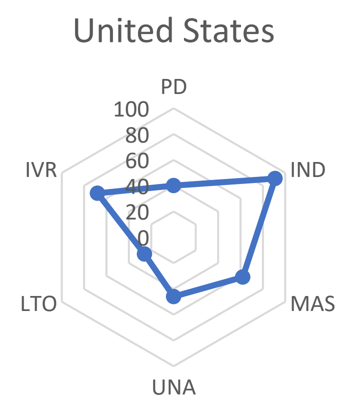
6. Belgium

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
Key post-2020 reforms include changing the linear annual cap reduction from 1.74 per cent to 2.2 percent	



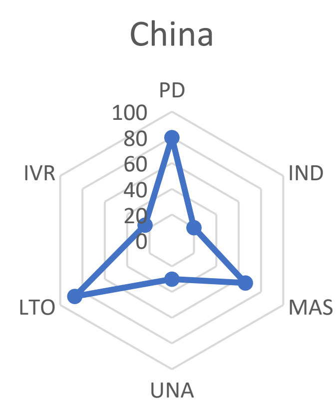
7. California, United States

Year of implementation	2012
Type of jurisdiction	Subnational
Type of mechanism	ETS
Price at implementation	US$ 10.00
Share of emissions covered	85%
Proposed modifications to the ETS include the establishment of a price ceiling, the allowance price containment reserve, free allocation, and the use of offsets	



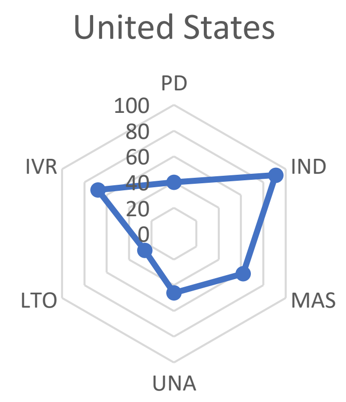
8. Chongqing, China

Year of implementation	2014
Type of jurisdiction	Subnational
Type of mechanism	Pilot ETS
Price at implementation	US$ 4.30
Share of emissions covered	40%
Reduced the cap from 106 MtCO2e in 2015 to 100 MtCO2e in 2016.	



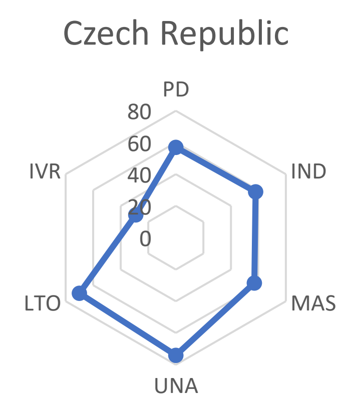
9. Connecticut, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
In 2021, the emissions cap will be 75 million short tons of CO2 per year.	



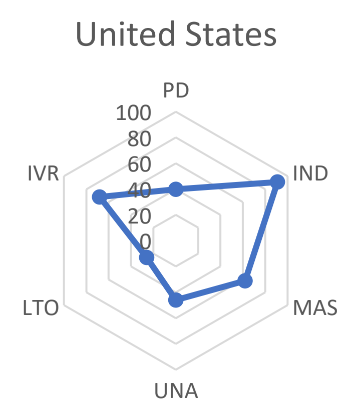
10. Czech Republic

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
Key post-2020 reforms include changing the linear annual cap reduction from 1.74 per cent to 2.2 percent	



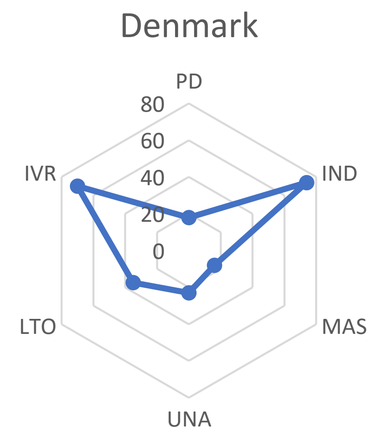
11. Delaware, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
The cap will decrease annually by approximately 3 percent, resulting in a 30 percent reduction in the cap in 2030 compared to 2020 levels.	



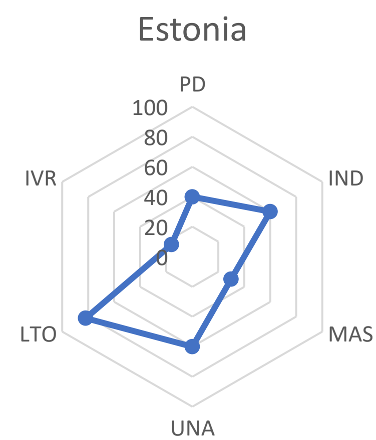
12. Denmark

Year of implementation	1992
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 17.00
Share of emissions covered	40%
Per capita emissions were reduced by 15% from 1990 to 2005. Industrial emissions were reduced by 23% during the 1990s, after adjusting for growth and market-induced industry restructuring	



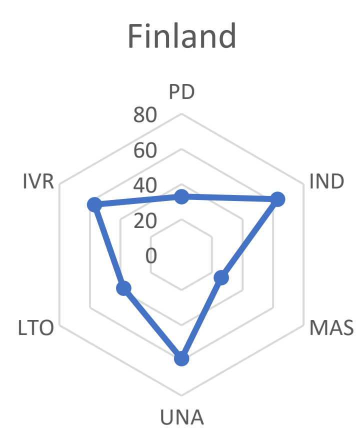
13. Estonia

Year of implementation	2000
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 0.46
Share of emissions covered	3%
The environmental tax revenues of the Republic of Estonia totalled 5.9 billion kroons in 2007.	



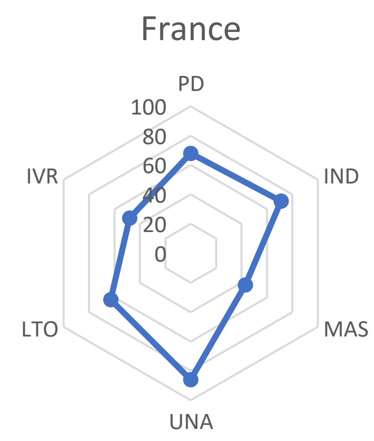
14. Finland

Year of implementation	1990
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 17.50
Share of emissions covered	36%
From January 1, 2018, the carbon tax rate for coal, heavy fuel oil and light fuel oil was increased from €58/tCO2e to €62/tCO2e (US$72/tCO2e to US$77/tCO2e).	



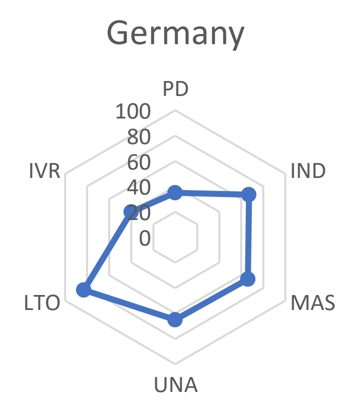
15. France

Year of implementation	2014
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 8.00
Share of emissions covered	35%
The new trajectory for the next four years involves an annual increase of €10.4 (US$13) from €44.6/tCO2e (US$55/tCO2e) in 2018 to €86.2/tCO2e (US$107/tCO2e) in 2022.	



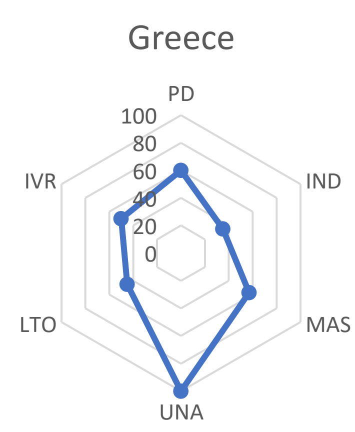
16. Germany

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
The proposed Effort Sharing Regulation, which sets binding emission reduction targets for sectors not covered by the EU ETS post-2020, is also under consideration.	



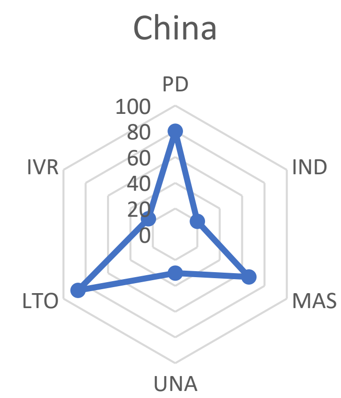
17. Greece

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
Key post-2020 reforms include changing the linear annual cap reduction from 1.74 per cent to 2.2 percent.	



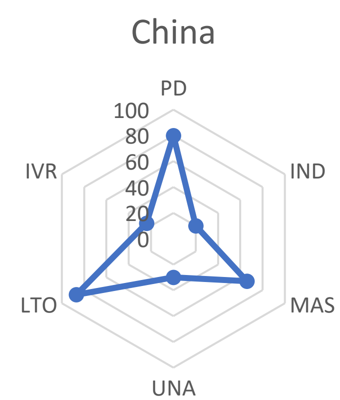
18. Guangdong, China

Year of implementation	2013
Type of jurisdiction	Subnational
Type of mechanism	Pilot ETS
Price at implementation	US$ 10.50
Share of emissions covered	60%
Benchmark values for the power sector in the Guangdong pilot was adjusted in 2017 to levels that are closer to the values published in the allocation plan for the national ETS.	



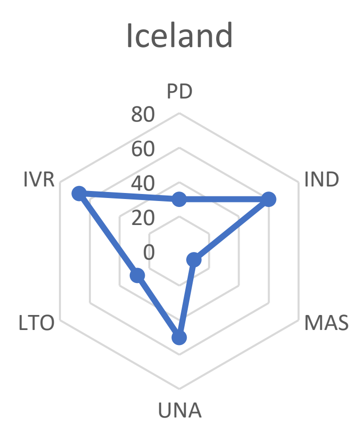
19. Hubei, China

Year of implementation	2014
Type of jurisdiction	Subnational
Type of mechanism	Pilot ETS
Price at implementation	US$ 9.90
Share of emissions covered	35%
The scope of the ETS increased in 2017 to cover all entities in the power and industry sectors with an energy consumption over 10,000 tons of standard coal equivalent in any year from 2014 to 2016.	



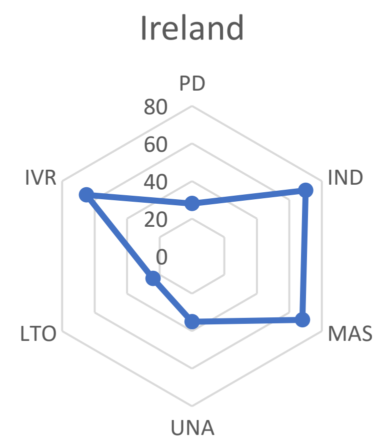
20. Iceland

Year of implementation	2010
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 18.62
Share of emissions covered	55%
The Iceland carbon tax rate increased to approximately ISK3500/tCO2 (US$36/tCO2) on January 1, 2018.	



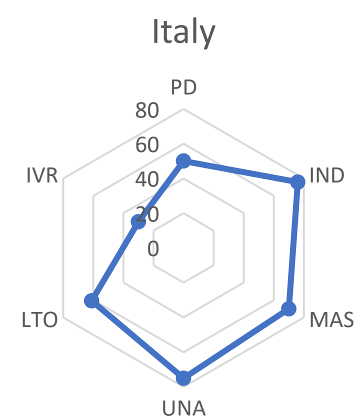
21. Ireland

Year of implementation	2010
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 19.95
Share of emissions covered	49%
Introduced a carbon tax from most sectors not covered under the EU ETS; including transport, heat for residential sectors, commercial buildings, and small industry.	



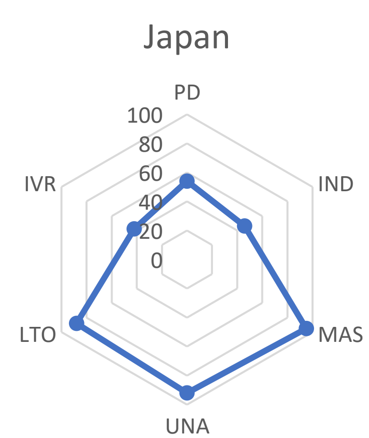
22. Italy

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
Post-2020, the share of allowances to be auctioned is set at 57%, but can be lowered by up to 3% to avoid the triggering of the cross-sectoral correction factor.	



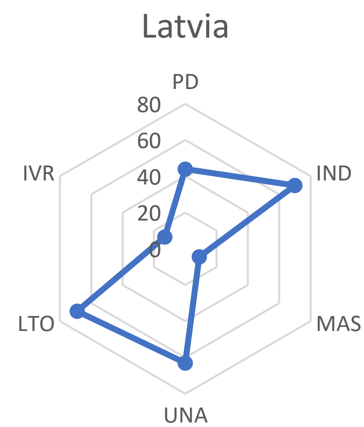
23. Japan

Year of implementation	2012
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 2.00
Share of emissions covered	68%
It's notable for its efficient use of revenue towards low carbon technologies and energy efficiency. In 2016, the special account received JPY 596 billion (US$5.37 billion).	



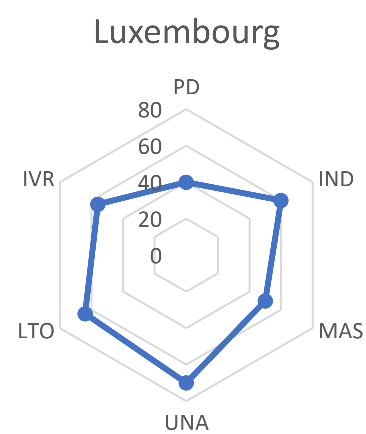
24. Latvia

Year of implementation	2004
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 1.17
Share of emissions covered	15%
The carbon tax increased from €3.5/tCO2 (US$4/tCO2) in 2016 to €4.5/tCO2(US$5/tCO2) in 2017.The carbon revenue is used for environmental protection, including climate change measures.	



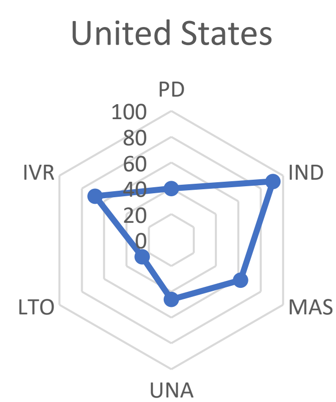
25. Luxembourg

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
Post-2020, the share of allowances to be auctioned is set at 57%, but can be lowered by up to 3% to avoid the triggering of the cross-sectoral correction factor.	



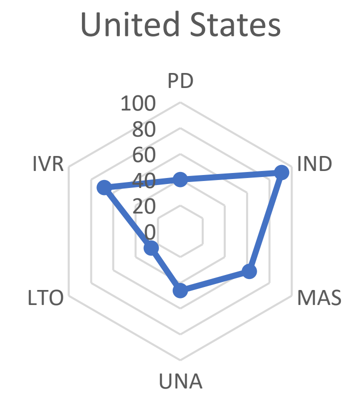
26. Maine, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
The cap will decrease annually by approximately 3 percent, resulting in a 30 percent reduction in the cap in 2030 compared to 2020 levels.	



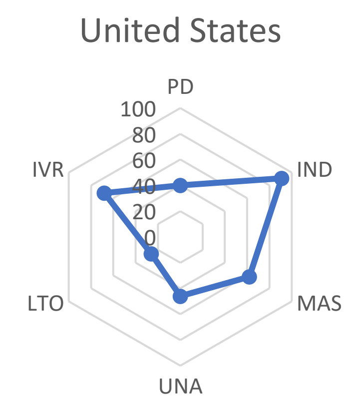
27. Maryland, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
The ECR will curb any oversupply of allowances from 2021 onward. States participating in RGGI will now start their state-specific processes to bring these changes into effect.	



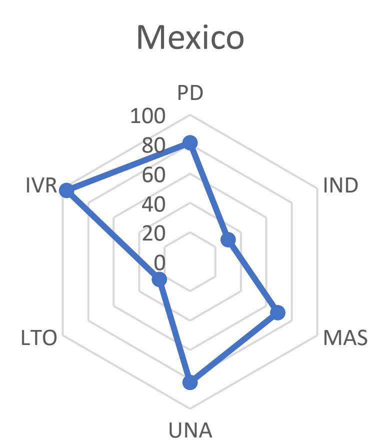
28. Massachusetts, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
On January 1, 2018, Massachusetts launched its ETS, which directly covers power plants. The ETS is a cap-and-trade system, with a cap that will decline annually by 2.5 percent until emissions reach 1.8 MtCO2 in 2050.	



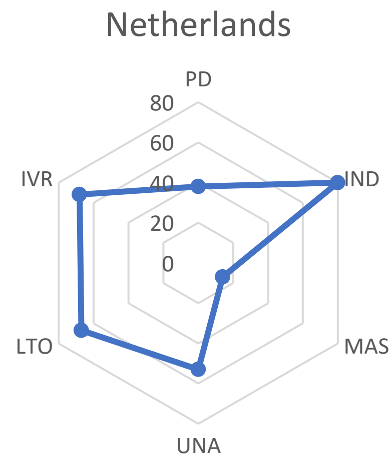
29. Mexico

Year of implementation	2014
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 3.50
Share of emissions covered	46%
On December 12, 2017, the Mexican Lower Chamber of Congress approved amendments to the General Law on Climate Change, establishing the mandate to design and launch an ETS in Mexico.	



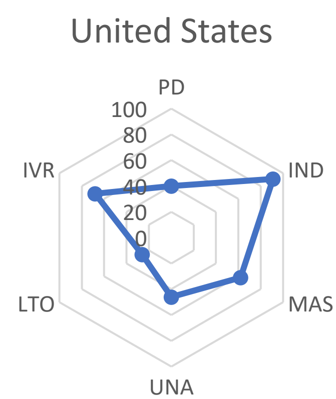
30. Netherlands

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
On October 10, 2017, the government announced the introduction of a carbon floor price for electricity generators covered under the EU ETS, including facilities in the power sector and other autogeneration facilities.	



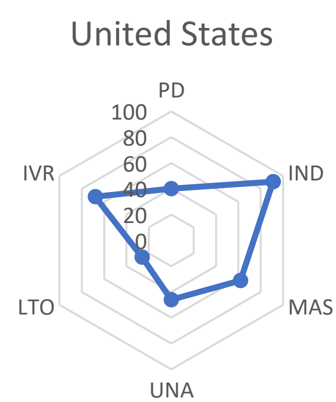
31. New Hampshire, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
The number of states participating in the RGGI allowance market may be increased to eleven by 2020.	



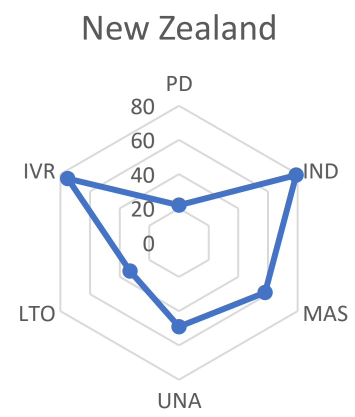
32. New York, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
On August 23, 2017, the US states participating in RGGI reached an agreement on the draft design elements of RGGI for the period after 2020.	



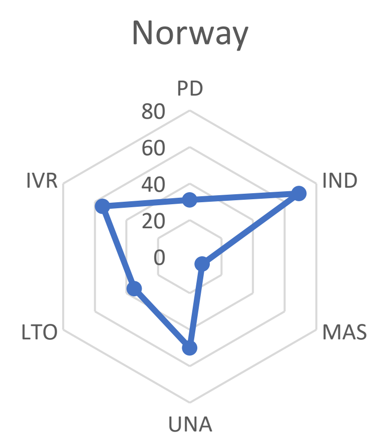
33. New Zealand

Year of implementation	2008
Type of jurisdiction	National
Type of mechanism	ETS
Price at implementation	US$ 9.63
Share of emissions covered	51%
In May 2016 initiated a phase out of the one-for-two measure, which allowed non-forestry ETS facilities to surrender 1 emission allowance for every 2 tons of CO2e.	



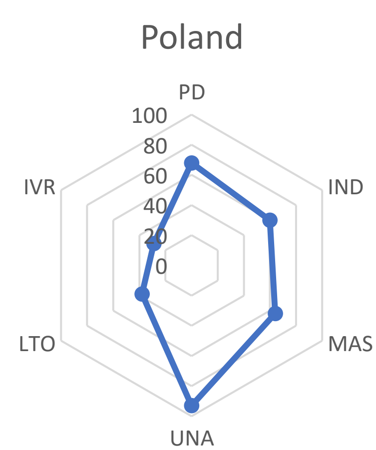
34. Norway

Year of implementation	1991
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 18.00
Share of emissions covered	60%
On January 1, 2018, the full carbon tax rate in Norway increased to NOK500/tCO2e (US$64/tCO2e), and most exemptions and reduced carbon tax rates were abolished.	



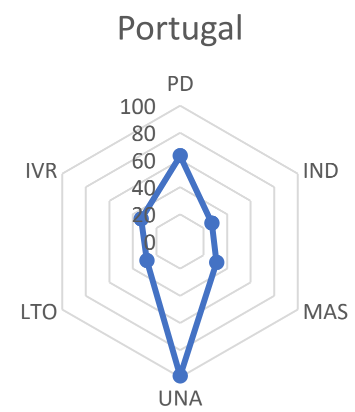
35. Poland

Year of implementation	1990
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 0.08
Share of emissions covered	4%
In 2012, Poland priced 75% of carbon emissions from energy use, and 16% were priced above EUR 30 per tonne of CO2; a large share of these emissions was from road transport.	



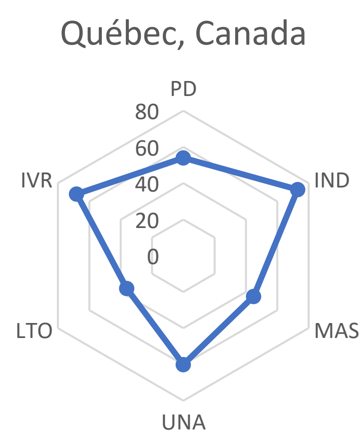
36. Portugal

Year of implementation	2015
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 5.00
Share of emissions covered	29%
To decarbonize the Portuguese economy, energy tax exemptions for coal-fired electricity generation and co-generation facilities are gradually being abolished.	



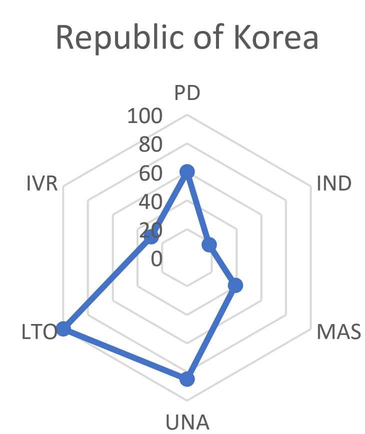
37. Québec, Canada

Year of implementation	2013
Type of jurisdiction	Subnational
Type of mechanism	ETS
Price at implementation	US$ 11.46
Share of emissions covered	85%
In November 2017, the government adopted legislation to prepare its ETS for the post-2020 period, including rules for free allocation of emission allowance from 2021-2023140 and the cap for 2021-2030.	



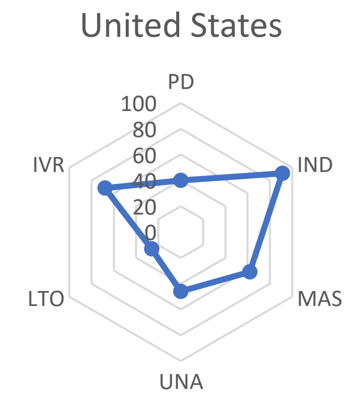
38. Republic of Korea

Year of implementation	2015
Type of jurisdiction	National
Type of mechanism	ETS
Price at implementation	US$ 10.00
Share of emissions covered	68%
In January 1, 2018, the ETS entered its second phase until 2020. An emissions cap of 538.5 MtCO2e will apply in 2018, which is 0.4 MtCO2e less than the previous year.	



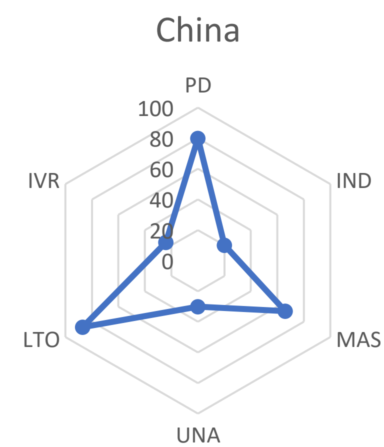
39. Rhode Island, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
On August 23, 2017, the US states participating in RGGI reached an agreement on the draft design elements of RGGI for the period after 2020.	



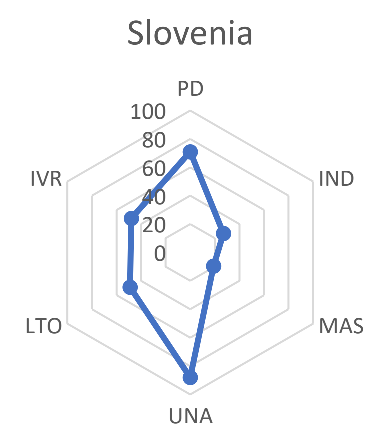
40. Shanghai, China

Year of implementation	2013
Type of jurisdiction	Subnational
Type of mechanism	Pilot ETS
Price at implementation	US$ 4.43
Share of emissions covered	57%
Benchmark values for the power sector were adjusted in 2017 to levels closer to the draft allocation plan for the national ETS. Lowered the limit for CCER usage for compliance in 2017 from 5% of annual emissions to 1%.	



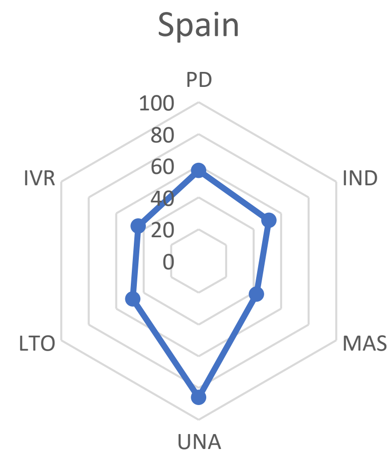
41. Slovenia

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
Post-2020, the share of allowances to be auctioned is set at 57%, but can be lowered by up to 3% to avoid the triggering of the cross-sectoral correction factor.	



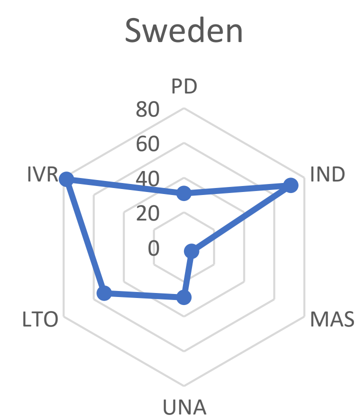
42. Spain

Year of implementation	2005
Type of jurisdiction	Regional
Type of mechanism	EU ETS
Price at implementation	US$ 31.33
Share of emissions covered	40%
In August 2017 the Catalonian Law on Climate Change was adopted, aiming to implement a carbon tax in 2019, which will apply to GHG emissions from large installations in the power industry, agriculture, and waste sectors, including EU ETS installations.	



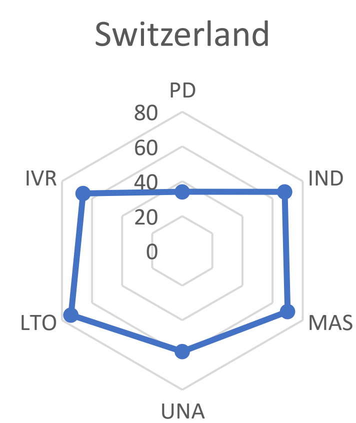
43. Sweden

Year of implementation	1991
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 45.00
Share of emissions covered	40%
Starting from July 1, 2018, Sweden introduced an emission reduction obligation scheme for petrol and diesel to promote low blending of biofuels, and previously exempted combined heat and power plants covered by the EU ETS are being taxed 11% of the full tax rate.	



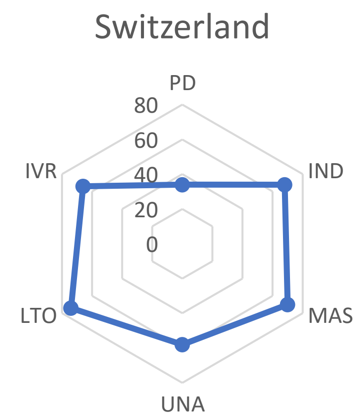
44. Switzerland

Year of implementation	2008
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 39.00
Share of emissions covered	33%
In January 1, 2018 the tax went from US$88/tCO2e to US$101/tCO2e, after the government found that its GHG emissions were higher than the target for 2016.	



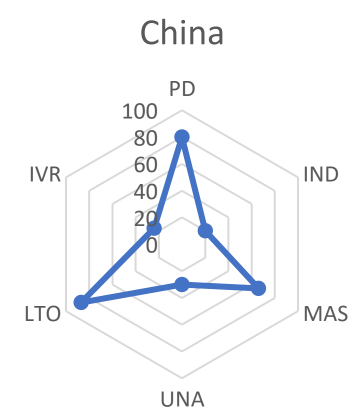
45. Switzerland

Year of implementation	2008
Type of jurisdiction	National
Type of mechanism	ETS
Price at implementation	US$ 42.00
Share of emissions covered	11%
The first phase, from 2008–2012, was voluntary for firms wanting to be exempt from the CO2 levy. In the latest phase, 2013–2020, it imposes an economy-wide emissions cap, mandatory enrollment for large entities, a combination of free and auctioned allowances with auctioning set to increase to 70% by 2020.	



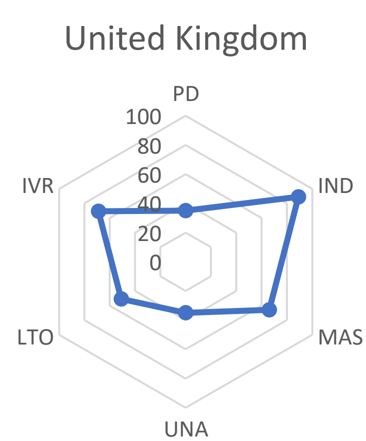
46. Tianjin, China

Year of implementation	2013
Type of jurisdiction	Subnational
Type of mechanism	Pilot ETS
Price at implementation	US$ 4.45
Share of emissions covered	55%
Extended the legal provisions to govern its pilot ETS to June 30, 2018.	



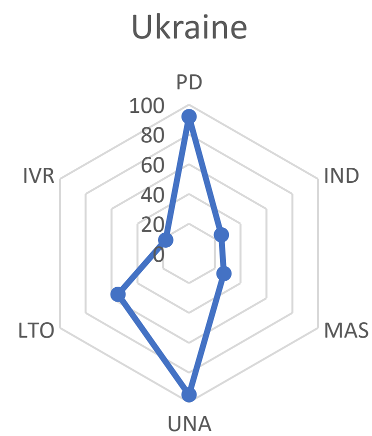
47. United Kingdom

Year of implementation	2013
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 15.75
Share of emissions covered	23%
From 2021, the government will target a "total carbon price rate" that will apply to businesses; the format of this rate is yet to be defined. Further details on carbon pricing in the UK post-Brexit are expected.	



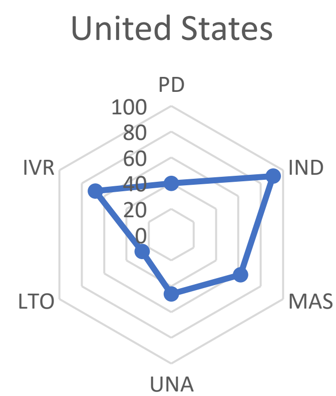
48. Ukraine

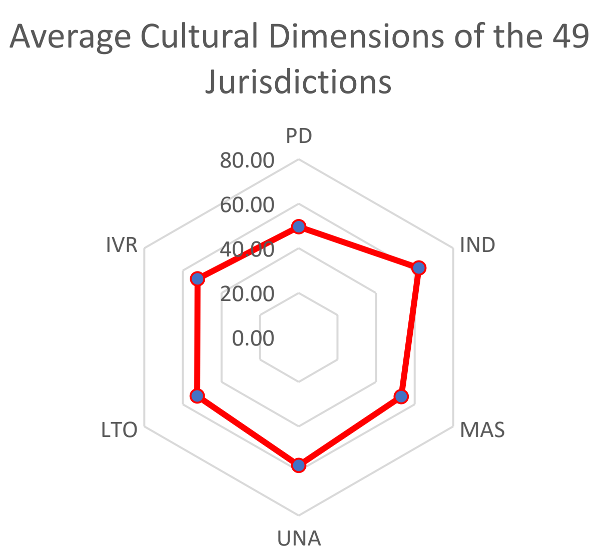
Year of implementation	2011
Type of jurisdiction	National
Type of mechanism	Carbon tax
Price at implementation	US$ 0.02
Share of emissions covered	71%
Ukraine plans to establish a national ETS in line with its obligations under the Ukraine-EU Association Agreement, which entered into force on September 1, 2017	



49. Vermont, United States

Year of implementation	2009
Type of jurisdiction	Subnational
Type of mechanism	RGGI ETS
Price at implementation	US$ 3.07
Share of emissions covered	21%
On August 23, 2017, the US states participating in RGGI reached an agreement on the draft design elements of RGGI for the period after 2020.	





Appendix B.

Paired difference T- test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	CO2_post	177.096218408	49	222.9919684784	31.5358266122
	CO2_pre	183.878793807	49	226.2570903259	31.9975845722
Pair 2	GDP_post	713732.616249164	49	1029516.0858484470	145595.5611288137
	GDP_pre	660011.379606714	49	979994.3415262392	138592.1288835298

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	CO2_post & CO2_pre	49	.997	.000
Pair 2	GDP_post & GDP_pre	49	.998	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	CO2_post - CO2_pre	-6.782575	18.3766421496	2.5988496559	-12.005159	-1.5599914856	-2.610	48	.012
Pair 2	GDP_post - GDP_pre	53721.23664245	81221.3336729070	11486.431163425	30638.389	76804.0842714	4.677	48	.000

Appendix C

Test for outliers, normality, multicollinearity, and homoskedasticity.

Outliers tests

Cut- off points for values:

Mahalanobis distance

(Chi square) X^2 degrees of freedom => $p<.001$

Cook's distance

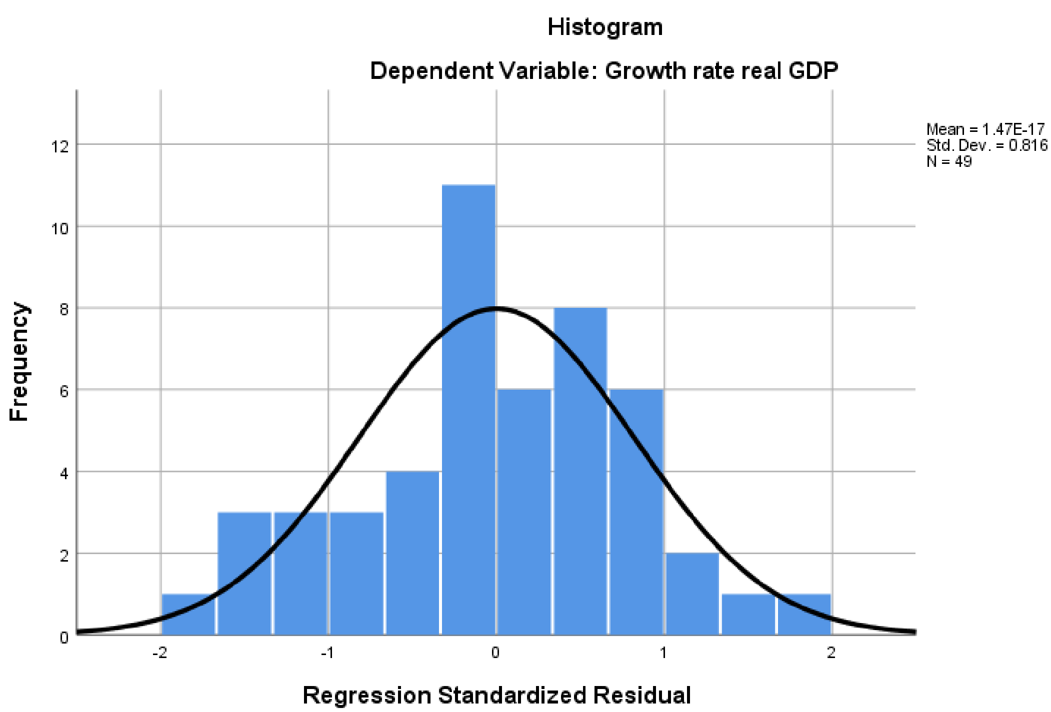
(4)/N-k-1

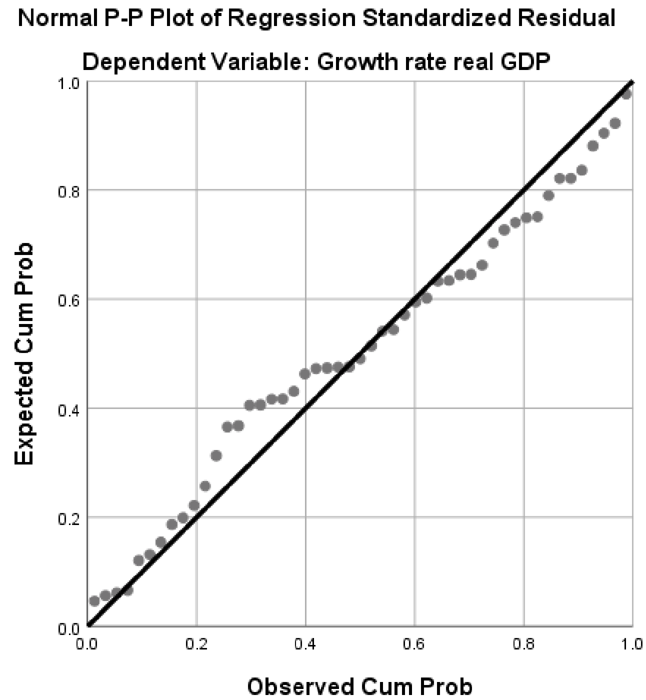
Leverage's point

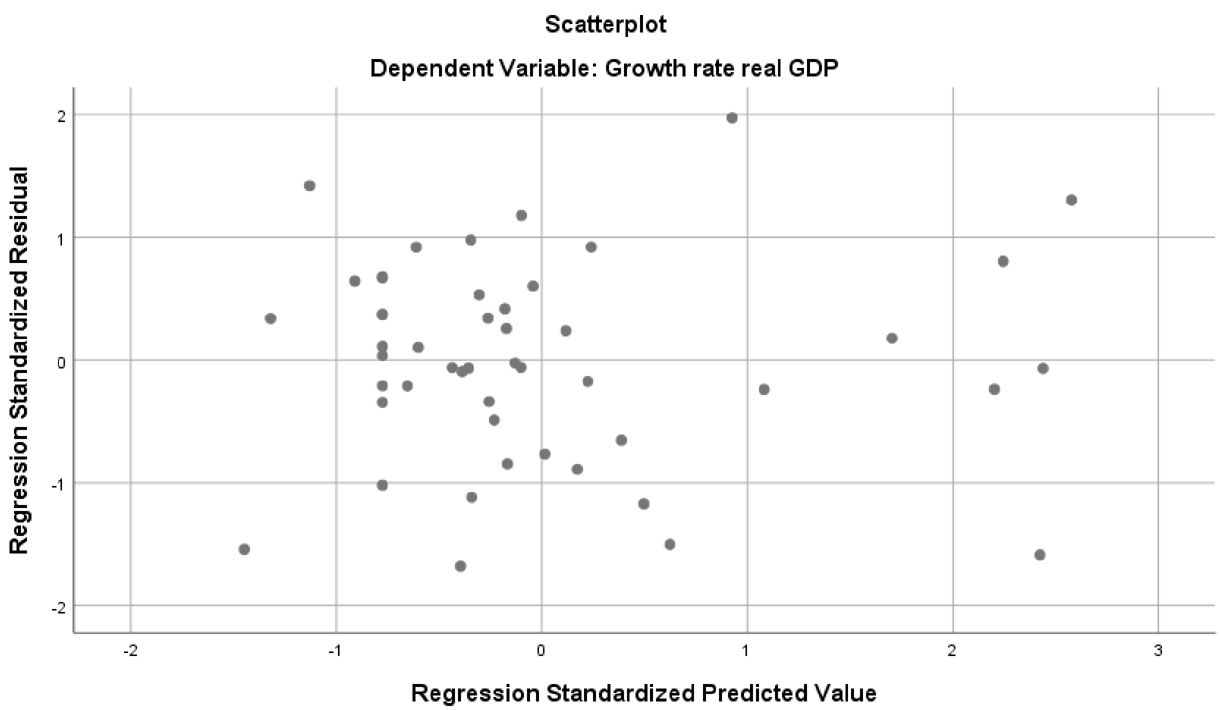
(2k+2)/N

Normality

Dependent variable: Real GDP growth rate




Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Growth rate real GDP
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0


Scatterplot
Dependent Variable: Growth rate real GDP
Regression Standardized Residual
Regression Standardized Predicted Value
-2
-1
0
1
2
3

Homoskedasticity

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Unstandardized Residual	49	-.043	.337	-.263	.662
Valid N (listwise)	49				

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34.738	16	2.171	1.508	.156[b]
	Residual	47.514	32	1.440		
	Total	82.251	48			

a. Dependent Variable: gdp

b. Predictors: (Constant), CP*IDLG centered, Power distance, Uncertainty avoidance, Carbon price at implementation, CP*MAS centered, CP*UNA centered, Masculinity, CP*PD centered, CP*LTO centered, Long term orientation, Type of mechanism (Tax=0; ETS=1), CP*IND centered, Indulgence, Type of jurisdiction (National=0; subnational=1), Individualism

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.8352	2.9643	1.0000	.84198	49
Residual	-2.75850	2.58514	.00000	.98472	49
Std. Predicted Value	-2.180	2.333	.000	1.000	49
Std. Residual	-2.299	2.154	.000	.821	49

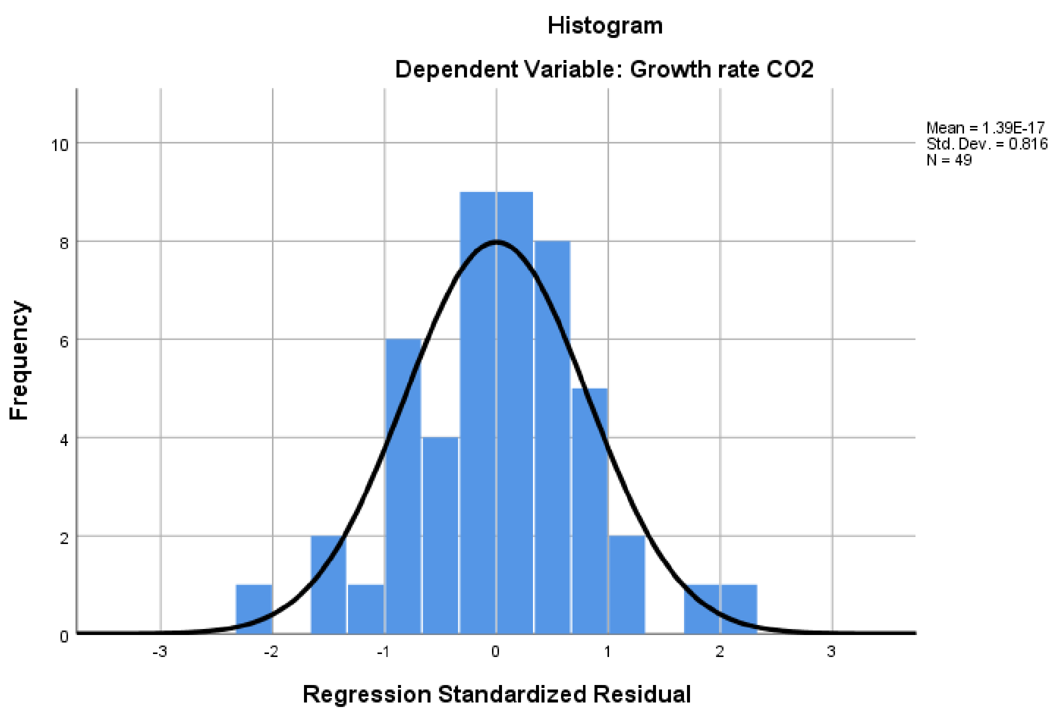
a. Dependent Variable: gdp

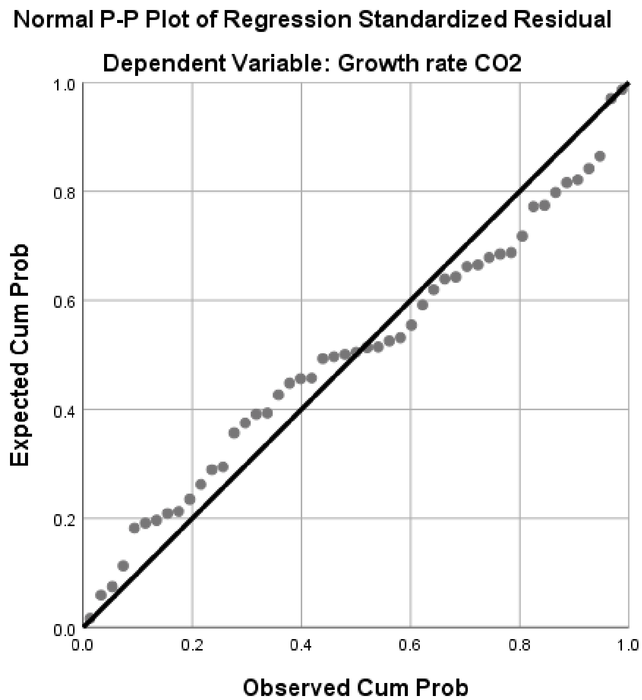
```
Run MATRIX procedure:

 BP&K TESTS

 ==========

Regression SS
  34.7377

Residual SS
  47.5137

Total SS
```

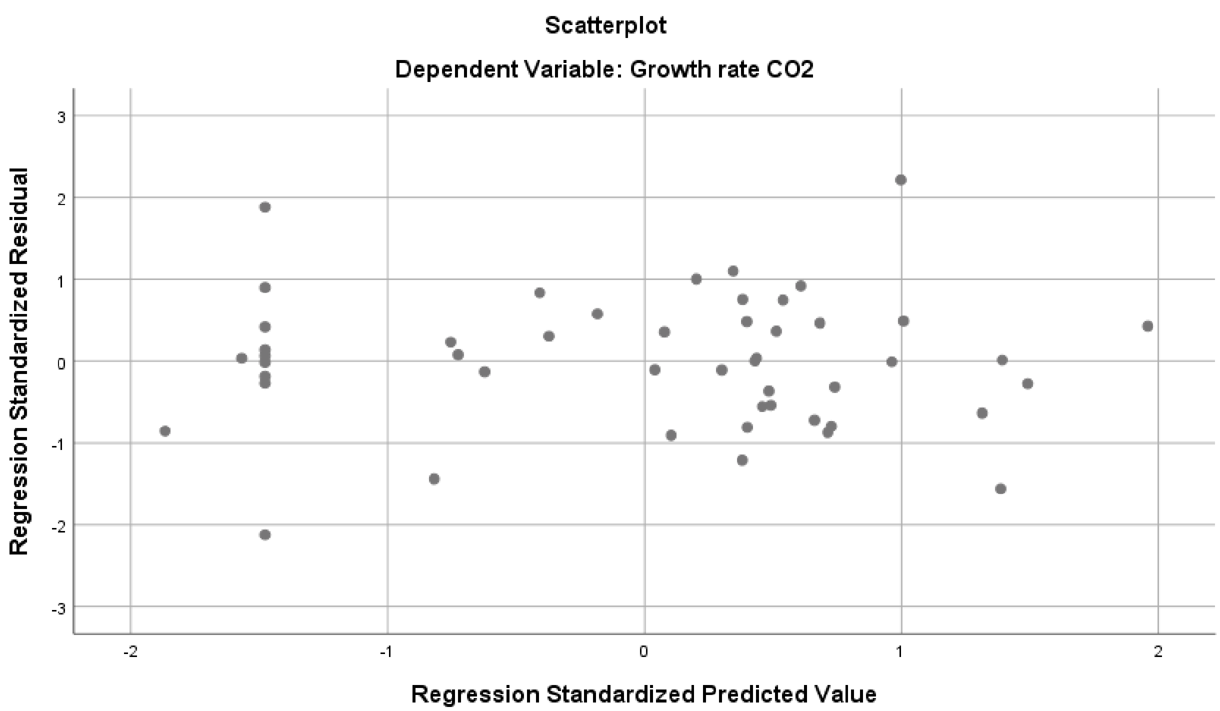
```
  82.2514

R-squared
     .4223

Sample size (N)
   49

Number of predictors (P)
   16

Breusch-Pagan test for Heteroscedasticity (CHI-SQUARE df=P)
   17.369

Significance level of Chi-square df=P (H0: homoscedasticity)
     .3621

Koenker test for Heteroscedasticity (CHI-SQUARE df=P)
   21.117

Significance level of Chi-square df=P (H0: homoscedasticity)
     .1741

Fail to reject null hypothesis.

------ END MATRIX -----
```

Normality

Dependent variable: CO_2 emissions growth rate




Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Growth rate CO2
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0


Scatterplot
Dependent Variable: Growth rate CO2
Regression Standardized Residual
Regression Standardized Predicted Value
3
2
1
0
-1
-2
-3

Homoskedasticity

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Unstandardized Residual	49	.028	.340	.871	.668
Valid N (listwise)	49				

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.412[a]	.170	-.245	1.83999

a. Predictors: (Constant), CP*IVR centered, Carbon price at implementation times coverage, Uncertainty avoidance, Long term orientation, CP*MAS centered, CP*PD centered, Masculinity, CP*LTO centered, Type of mechanism (Tax=0; ETS=1), CP*IND centered, CP*UNA centered, Type of jurisdiction (National=0; subnational=1), Indulgence, Individualism, Power distance

b. Dependent Variable: CO2

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.213	16	1.388	.410	.969[b]
	Residual	108.338	32	3.386		
	Total	130.551	48			

a. Dependent Variable: CO2

b. Predictors: (Constant), CP*IVR centered, Carbon price at implementation times coverage, Uncertainty avoidance, Long term orientation, CP*MAS centered, CP*PD centered, Masculinity, CP*LTO centered, Type of mechanism (Tax=0; ETS=1), CP*IND centered, CP*UNA centered, Type of jurisdiction (National=0; subnational=1), Indulgence, Individualism, Power distance

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.3704	2.6696	1.0000	.68028	49
Residual	-2.15609	5.60178	.00000	1.50234	49

Std. Predicted Value	-2.014	2.454	.000	1.000	49
Std. Residual	-1.172	3.044	.000	.816	49

a. Dependent Variable: CO2

```
Run MATRIX procedure:

 BP&K TESTS

 ==========

Regression SS
  22.2133

Residual SS
 108.3376

Total SS
 130.5509

R-squared
    .1702

Sample size (N)
   49

Number of predictors (P)
   16

Breusch-Pagan test for Heteroscedasticity (CHI-SQUARE df=P)
   11.107

Significance level of Chi-square df=P (H0: homoscedasticity)
    .8029

Koenker test for Heteroscedasticity (CHI-SQUARE df=P)
    8.337

Significance level of Chi-square df=P (H0: homoscedasticity)
    .9382

Fail to reject null hypothesis

------ END MATRIX -----
```

Appendix D

Linear regression analyses

Hierarchical Regression for Real GDP growth rate

Model Summary[d]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.237[a]	.056	.015	.113008	.056	1.364	2	46	.266
2	.815[b]	.663	.586	.073277	.607	10.058	7	39	.000
3	.880[c]	.775	.673	.065108	.112	2.734	6	33	.029

a. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1)

b. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1), Indulgence, Masculinity, Carbon price at implementation times coverage, Uncertainty avoidance, Individualism, Long term orientation, Power distance

c. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1), Indulgence, Masculinity, Carbon price at implementation times coverage, Uncertainty avoidance, Individualism, Long term orientation, Power distance, CP*MAS centered, CP*LTO centered, CP*PD centered, CP*IVR centered, CP*IND centered, CP*UNA centered

d. Dependent Variable: Growth rate real GDP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.035	2	.017	1.364	.266[b]
	Residual	.587	46	.013		
	Total	.622	48			
2	Regression	.413	9	.046	8.544	.000[c]
	Residual	.209	39	.005		
	Total	.622	48			
3	Regression	.482	15	.032	7.587	.000[d]
	Residual	.140	33	.004		
	Total	.622	48			

a. Dependent Variable: Growth rate real GDP

b. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1)

c. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1), Indulgence, Masculinity, Carbon price at implementation times coverage, Uncertainty avoidance, Individualism, Long term orientation, Power distance

d. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1), Indulgence, Masculinity, Carbon price at implementation times coverage, Uncertainty avoidance, Individualism, Long term orientation, Power distance, CP*MAS centered, CP*LTO centered, CP*PD centered, CP*IVR centered, CP*IND centered, CP*UNA centered

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.051	.027		1.906	.063					
	Type of jurisdiction	.033	.039	.142	.845	.403	.209	.124	.121	.730	1.370
	Type of mechanism	.030	.039	.130	.774	.443	.203	.113	.111	.730	1.370
2	(Constant)	.246	.119		2.071	.045					
	Type of jurisdiction	-.003	.042	-.013	-.073	.942	.209	-.012	-.007	.262	3.816
	Type of mechanism	.033	.031	.139	1.057	.297	.203	.167	.098	.497	2.013
	Carbon price	.001	.003	.065	.522	.605	-.051	.083	.048	.557	1.797
	Individualism	-.001	.001	-.265	-1.508	.140	-.588	-.235	-.140	.279	3.590
	Masculinity	.000	.001	-.035	-.304	.763	.073	-.049	-.028	.636	1.573
	Uncertainty avoidance	-.002	.001	-.415	-2.906	.006	-.266	-.422	-.270	.422	2.368
	Long term orientation	.001	.001	.189	1.174	.247	.618	.185	.109	.332	3.009
	Indulgence	-.002	.001	-.277	-1.753	.087	-.599	-.270	-.163	.345	2.897
	Power distance	.001	.001	.186	1.004	.322	.507	.159	.093	.252	3.963
3	(Constant)	.150	.130		1.152	.258					
	Type of jurisdiction	.006	.040	.025	.144	.886	.209	.025	.012	.224	4.463

Type of mechanism	.003	.032	.012	.089	.929	.203	.016	.007	.361	2.768
Carbon price	-.001	.003	-.032	-.233	.817	-.051	-.041	-.019	.362	2.766
Individualism	-.001	.001	-.134	-.705	.486	-.588	-.122	-.058	.190	5.276
Masculinity	-.001	.001	-.136	-1.143	.261	.073	-.195	-.094	.480	2.081
Uncertainty avoidance	-.002	.001	-.388	-2.534	.016	-.266	-.404	-.209	.290	3.451
Long term orientation	.001	.001	.248	1.551	.130	.618	.261	.128	.266	3.765
Indulgence	.000	.001	-.034	-.200	.842	-.599	-.035	-.017	.234	4.272
Power distance	.002	.001	.257	1.266	.214	.507	.215	.105	.166	6.028
CP*PD centered	-.008	.021	-.054	-.357	.723	-.146	-.062	-.029	.296	3.380
CP*IND centered	.018	.021	.135	.866	.393	.386	.149	.071	.279	3.579
CP*MAS centered	.021	.012	.197	1.685	.102	.202	.281	.139	.500	1.999
CP*UNA centered	.040	.018	.367	2.284	.029	.308	.369	.188	.264	3.794
CP*LTO centered	-.021	.017	-.154	-1.251	.220	-.453	-.213	-.103	.449	2.229
CP*IVR centered	.003	.017	.026	.177	.861	.264	.031	.015	.316	3.166

a. Dependent Variable: Growth rate real GDP

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.06779	.34784	.08284	.100251	49
Residual	-.111054	.139313	.000000	.053984	49
Std. Predicted Value	-1.503	2.643	.000	1.000	49
Std. Residual	-1.706	2.140	.000	.829	49

a. Dependent Variable: Growth rate real GDP

Hierarchical Regression for CO_2 emissions growth rate

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.307[a]	.094	.055	.077535	.094	2.393	2	46	.103
2	.622[b]	.387	.245	.069286	.293	2.658	7	39	.024
3	.716[c]	.513	.292	.067125	.126	1.425	6	33	.235

a. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1)

b. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1), Indulgence, Masculinity, Carbon price at implementation times coverage, Uncertainty avoidance, Individualism, Long term orientation, Power distance

c. Predictors: (Constant), Type of mechanism (Tax=0; ETS=1), Type of jurisdiction (National=0; subnational=1), Indulgence, Masculinity, Carbon price at implementation times coverage, Uncertainty avoidance, Individualism, Long term orientation, Power distance, CP*MAS centered, CP*LTO centered, CP*PD centered, CP*IVR centered, CP*IND centered, CP*UNA centered

d. Dependent Variable: Growth rate CO2

Coefficients[a]

Model		Unstandardized Coefficients: B	Std. Error	Standardized Coefficients: Beta	t	Sig.	Correlations: Zero-order	Partial	Part	Collinearity Statistics: Tolerance	VIF
1	(Constant)	-.003	.018		-.175	.862					
	Type of jurisdiction	-.035	.027	-.217	-1.321	.193	-.286	-.191	-.185	.730	1.370
	Type of mechanism	-.022	.027	-.132	-.804	.426	-.245	-.118	-.113	.730	1.370
2	(Constant)	.093	.112		.831	.411					
	Type of jurisdiction	.037	.040	.227	.926	.360	-.286	.147	.116	.262	3.816
	Type of mechanism	-.010	.029	-.059	-.330	.743	-.245	-.053	-.041	.497	2.013
	Carbon price	.002	.002	.146	.871	.389	.235	.138	.109	.557	1.797
	Individualism	-.002	.001	-.517	-2.177	.036	-.419	-.329	-.273	.279	3.590
	Masculinity	-.001	.001	-.358	-2.276	.028	-.368	-.342	-.285	.636	1.573

	Uncertainty avoidance	.001	.001	.225	1.166	.251	.192	.184	.146	.422	2.368
	Long term orientation	.001	.001	.209	.960	.343	.322	.152	.120	.332	3.009
	Indulgence	.000	.001	.035	.165	.870	-.284	.026	.021	.345	2.897
	Power distance	-.001	.001	-.311	-1.247	.220	.148	-.196	-.156	.252	3.963
3	(Constant)	.033	.134		.248	.805					
	Type of jurisdiction	.077	.042	.477	1.858	.072	-.286	.308	.226	.224	4.463
	Type of mechanism	-.008	.033	-.050	-.246	.807	-.245	-.043	-.030	.361	2.768
	Carbon price	.000	.003	.025	.121	.904	.235	.021	.015	.362	2.766
	Individualism	-.001	.001	-.313	-1.122	.270	-.419	-.192	-.136	.190	5.276
	Masculinity	-.002	.001	-.477	-2.724	.010	-.368	-.429	-.331	.480	2.081
	Uncertainty avoidance	.002	.001	.506	2.241	.032	.192	.363	.272	.290	3.451
	Long term orientation	.001	.001	.302	1.280	.209	.322	.217	.155	.266	3.765
	Indulgence	.000	.001	.098	.391	.698	-.284	.068	.048	.234	4.272
	Power distance	-.002	.001	-.541	-1.815	.079	.148	-.301	-.220	.166	6.028
	CP*PD centered	-.007	.022	-.069	-.310	.759	-.275	-.054	-.038	.296	3.380
	CP*IND centered	.039	.022	.413	1.798	.081	.431	.299	.218	.279	3.579
	CP*MAS centered	.001	.013	.014	.084	.934	.055	.015	.010	.500	1.999
	CP*UNA centered	.012	.018	.152	.641	.526	-.078	.111	.078	.264	3.794
	CP*LTO centered	-.032	.017	-.335	-1.846	.074	-.374	-.306	-.224	.449	2.229
	CP*IVR centered	-.020	.018	-.244	-1.128	.267	.302	-.193	-.137	.316	3.166

a. Dependent Variable: Growth rate CO2

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.13277	.07651	-.03051	.057122	49
Residual	-.142873	.151768	.000000	.055657	49
Std. Predicted Value	-1.790	1.874	.000	1.000	49
Std. Residual	-2.128	2.261	.000	.829	49

a. Dependent Variable: Growth rate CO2