International Center for Public Policy
Working Paper 21-05
Month 2021

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Jorge Martinez-Vazquez

Georgia State University | Andrew Young School of Policy Studies

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February
2021

International Center for Public Policy
Andrew Young School of Policy Studies
Georgia State University
Atlanta, Georgia 30303
United States of America

Phone: (404) 413-0235
Fax: (404) 651-4449
Email: paulbenson@gsu.edu
Website: http://icepp.gsu.edu/

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International Center for Public Policy
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Adapting Fiscal Decentralization Design to Combat Climate Change

Jorge Martinez-Vazquez[1]

February 2021

Abstract

There are still many countries around the world that have not effectively engaged their subnational governments in their climate change strategies and policy frameworks. Where subnational levels *are* involved, generally they still play a relatively small role. This paper examines how the principles of fiscal decentralization design (in expenditure and revenue assignments, transfers, and borrowing) can be adapted for successfully engaging subnational governments in fighting climate change. In addition, the paper critically reviews already ongoing promising and unhelpful international practices engaging those subnational governments in climate-change mitigation. Shared responsibility for policy and program design and implementation, fee- or charge-funded adaptation activities, objective-targeted intergovernmental transfers, and the use of green bonds are some of the most promising approaches analyzed. Clearly, there is ample space ahead for the further involvement of subnational governments across the world in combating climate change.

[1] This paper has been prepared under the auspices of the World Bank Mainstreaming Climate Change in Governance Program. I am thankful to Nicholas Menzies and Serdar Yilmaz, for multiple discussions, and to Adrian Fozzard, Stephane Hallegatte, James Newman, and Roland White for additional very useful inputs. I am also indebted to Abdulaziz Almuzaini, Amakoe Alognon, Yasin Civelek, Kshitiz Shrestha, and Chris Thayer for excellent research assistance and inputs.

1. Introduction

There is little doubt that one of the most preeminent policy issues faced by policymakers around the world today is that of taking action to address the causes and consequences of climate change.[1] At the same time, over the past several decades, one of the most salient institutional transformations for how governments make decisions in many countries has been the devolution and decentralization of fiscal, administrative and political powers to subnational governments.

Despite their individual prominence, these two thrusts of policy reforms have, with a few notable exceptions, largely ignored each other. Not so, however, with research: as seen throughout this paper, there have been numerous academic contributions to the design of environmental policy in fiscal decentralization settings, especially from the side of environmental research, and notable though fewer contributions from the fiscal decentralization literature. Despite the important role of subnational governments in public expenditures—in some countries hovering around two-thirds of the total aggregate expenditure—and the importance and urgency of climate changes issues, there has been little discussion of how intergovernmental fiscal design should adapt to this new reality.[2] In addition, there has been little explicit work in the literature on intergovernmental relations to inform the appropriate design and balance between regulations, fiscal transfers and devolved tax powers as incentives for climate action and tools to address moral hazards.

The main goal of this paper is to attempt to integrate the need for climate change policy action into the existing best practice framework of intergovernmental fiscal design. It does so by

[1] The COVID-19 pandemic has reset governments' priorities at least in the shorter run. The hope is that the longer-term issue of climate change will not lose political support and funding, both of which can be better assured when legislation has been passed demanding action on climate change. An extensively widespread shared hope is that stimulus packages in response to the COVID crisis will provide an opportunity for heightening aggressive decarbonization and mitigation policies worldwide.

[2] Some notable exceptions, which will be further discussed below, include UNDP (2013).

bringing closer together climate change policy and intergovernmental design, focusing on how the four pillars of fiscal decentralization—the assignment of functional expenditure responsibilities, the assignments of taxes and other revenue sources, the design of fiscal transfers, and subnational credit and borrowing—could be adapted for fiscal federalism and decentralized fiscal structures to become more effectively supportive of climate change action.[3]

Beyond the conceptual redesign of the intergovernmental fiscal architecture, a second objective of this paper is to review and highlight how different countries, both federations and other fiscally decentralized countries, have been responding to the prospect of implementing effective policies addressing the challenges of climate change. The important question is whether decentralized governance has been a way to leverage the effectiveness of climate change policies of central governments, or instead, if it has been a hindrance (or neutral) to the implementation of such policies. This can only be answered by identifying good and not-so-good international practices in the assignment of functions for fighting climate change, approaches to tax assignments enabling climate change action, the design of intergovernmental transfers with the same purpose, and the redesign and adaptation of borrowing and other fiscal rules to facilitate subnational governments' engagement in climate decarbonization and adaptation.

The third aim of this issues paper is to provide in-depth recommendations and guidance that will inform the World Bank's work, as well as that of other organizations, on the design of intergovernmental fiscal relations, in all their dimensions: functional assignments, devolved tax powers, the design of transfer regimes, and borrowing, so to strengthen subnational governments'

[3] It is well accepted that for decentralization to work, fiscal decentralization needs to be accompanied by administrative and political decentralization. Although it is likely relevant for adapting country policies to combat climate change, the redesign of administrative and political decentralization falls outside the scope of this paper. See Smoke and Cook (2021) for an analysis of adapting administrative decentralization to combat climate change.

capabilities to take climate change action on their own, and to enable them to more effectively collaborate with central authorities on these matters.[4]

The remainder of this paper is organized as follows. In section two, it outlines the stylized facts defining the main issues related to climate change that are salient to the design of intergovernmental fiscal relations. In section three, it explores how the assignments of expenditure responsibilities among different levels of government must be adapted for the most effective multilevel government response to climate challenges. Section four covers the same type of issues in relation to the assignments of taxing powers; for example, if a carbon tax is one of the good responses to climate change, what level of government should implement that tax, or should it be shared? Section five explores the role of the different types of transfers, subventions, and agreements federal and central authorities can take to stimulate action by subnational governments against climate change. Section six analyzes whether the need for climate change action at the subnational level justifies redrafting and relaxing borrowing and other fiscal rules that have been introduced in recent years in many countries with the objective of ensuring overall fiscal sustainability. Section seven summarizes the most important findings and options for reform and concludes.

2. Climate change and the need for government action: the stylized facts relevant to fiscal decentralization design

The consensus in the scientific literature is that the stock of greenhouse gases (GHG) in the earth's atmosphere is rising, trapping heat and causing global warming and other changes in the climate. Climate change, in turn, affects nations and individuals directly through violent storms, floods, droughts, rising sea levels, melting ice caps and other severe changes (Stern

[4] A separate guidance note is being prepared on administrative issues.

2008) and indirectly through a number of consequences from these disruptions.

The economic impact of climate change has been estimated to be quite severe, but there are differences as to how it should be aggregated. The Stern Review (2006) estimates that under 'Business as usual (BAU),' global GDP would fall at least by 5% every year. Similarly, the cost of extreme weather events could reach 0.5 to 1% of world GDP by the mid-century. However, not everyone agrees with the dire predictions of the Stern Review. For example, some researchers have qualms about the low discount rate used in the Stern Review (Weitzman 2007; Nordhaus 2007). Others have emphasized the significant uneven distributional impacts of climate change, with the effects depending on the location of countries, some of which could actually experience increases in income or reduced expenditures, thus offsetting the losses in income and increased related expenditures in other countries (Tol 2002).[5] For example, Leppanen et al. (2017) find that higher temperatures from climate change has led to lower regional government expenditures in Russia, although the positive effects have been smaller in warmer regions.

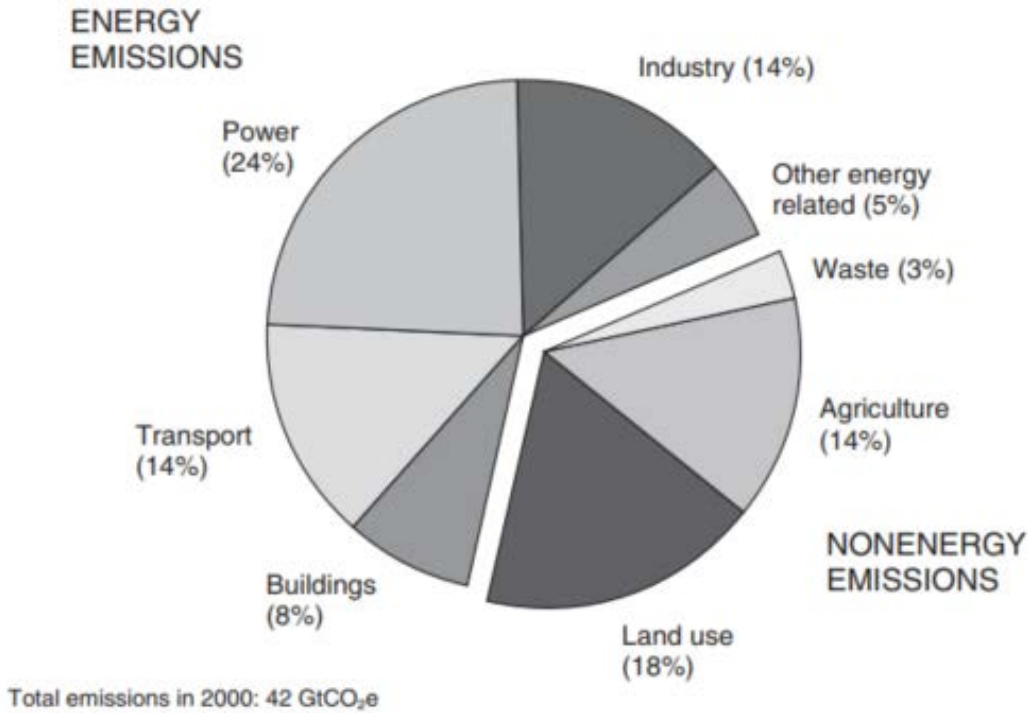
More recently, the World Bank Outlook 2050 (Mukhi et al. 2020) highlights the further critical implications of climate change on poverty and other development challenges, such as health and food security. For example, conditions related to climate change have enabled the recent desert locusts' swarms in the Horn of Africa, the Arabian Peninsula and southwest Asia (UNEP 2020). As shown in Figure 1, reproduced from the Stern (2007) report, emissions of GHG come from a variety of production and consumption activities involving both direct energy

[5] There is also uncertainty regarding the science behind the economic models of climate change. In a recent paper, Dietz et al. (2020) claim that most economic models of climate change assume a far too long delay on the impact of CO2 emissions on global warming and that they also ignore that there are decreasing returns to policy actions the higher the stock of emission and temperature grows.

emissions (e.g., power generation) and non-energy emissions (agricultural activities). The power of Figure 1 is that it can help us relate those sources to the conventional assignment of functional expenditure responsibilities in fiscally decentralized systems of government, especially regarding the decarbonization question. But the role of subnational governments, as seen below, becomes even stronger in terms of adaptation policies, generally because of the smaller role played by externalities and economies of scale issues in this dimension of fighting climate change. In terms of direct energy emissions, transport activities (responsible for 14% of emissions) and buildings (8%) typically tend to be regulated and taxed by regional and local governments, although, of course, there are differences across decentralized systems. Also, in terms of non-energy emissions of GHG activities, land use (18% of emissions) and waste (3%) tend to be activities that to a large extent are regulated or intervened upon in different ways by subnational governments, although, again, there are differences across countries.[6] Other significant sources of GHG, such as power generation, industry or agriculture, tend to be more the purview of central governments authorities, although in some decentralized countries these activities may also be regulated and taxed by subnational governments. Adding things up, over 40% of GHG emissions may come from activities over which subnational governments typically exert regulatory and taxing powers. This means prima facie that subnational governments in decentralized countries have an important role to play in the implementation of policies fighting climate change such as regulation, emission controls and energy-efficiency standards, promotion of alternative ("green") energy, carbon taxation, and so on.[7]

[6] Subnational governments also manage land use zoning, which has consequences on climate change; for example, urban sprawl has contributed to emissions by increasing daily commute distances and reducing green spaces.
[7] Note that there is no complete agreement that these conventional policies to combat climate change will be ultimately effective. An important skeptic, Sinn (2012) suggests that by regulating and reducing the demand for fossil fuels, suppliers of carbon resources will respond by trying to pre-empt the impact of future regulation via the acceleration of the production of fossil energy. This is what Sinn calls the "Green Paradox": pushing for the future

Figure 1. Sources of Emissions



Source: Stern 2007, 196

An alternate way to consider the potential role of subnational governments is offered by the World Bank "Decarbonization Development" report (Fay et al. 2015). This report highlights that achieving zero net emissions by 2050 will require action on four fronts:[8] (i) the decarbonization of electricity generation (i.e., generation using renewable, nuclear, and/or CCS methods); (ii) electrification (to increase reliance on clean electricity), and where that is not possible, a switch to cleaner fuels; (iii) improved efficiency and reduced waste in all sectors, including building, transport, and agriculture); and (iv) the preservation and increase of carbon

reduction in carbon consumption leads to the acceleration of climate change in the present. The alternative policy suggested by Sinn is supply-side policies based on inducing suppliers to leave more of the carbon resources underground by levying source taxes on capital income. There are also disagreements on what conventional policies are most effective in combating climate change. For example, McKibbin and Wilcoxen (2002) are highly critical of the Kyoto Protocol of 1997, as an agreement with no real chance of reducing greenhouse gas emissions because it focuses on rigid targets and timetables for emissions reductions instead of the supposedly more efficient and practical approaches relying on emissions taxes and tradable permits.

[8] These fronts are based on recent reports by the IPCC (Intergovernmental Panel on Climate Change), which analyze thirty plus climate change models based in turn on a variety of assumptions on decarbonization and mitigation activities and technological possibilities simulating a wide range of future scenarios.

sinks such as forests and other vegetation and soils to increase the removal of carbon from the atmosphere. The role that can be played by subnational governments in those four pillars is not as directly obvious. Nevertheless, thinking of ways in which subnational governments can contribute policy measures according to those pillars can be a useful way to operationalize the role of fiscal decentralization in fighting climate change. For example, subnational governments have been playing, as discussed below, increasing roles in improving efficiency and reducing waste in the building and transport sectors, as well as in the preservation of forests and other means of removing carbon from the atmosphere.

The recognized major advantage of the decentralized provision of climate related functions, as well as for other public goods, is the ability to cater to differences in needs and preferences, which may promote much faster action in some places, as well as providing a laboratory for incubating innovations and testing the effectiveness of different approaches, which can be subsequently imitated in others places. The big *dis*advantage of decentralization for the efficient provision of climate related functions –and other public goods—is that it may be much less effective in dealing with externalities or spillover effects across government boundaries and in taking advantage of economies of scales in the production and delivery of services. It is far from clear which of these attributes, on balance, is more dominant, but given the high importance of externalities in climate action (in comparison with many other public goods), there may be an initial presumption that centralized provision would be preferable to decentralized provision when it comes to decarbonization policies, but not necessarily so for adaptation interventions.[9]

Thus, it appears that the most important consideration for the question of what level of

[9] For example, Banzhaf and Chupp (2012) simulate decentralized and centralized models of air pollution control of the US electricity sector and show that centralized policy may outperform decentralized policy because inter-state externalities may be more important that inter-state heterogeneity.

government should assume responsibility for the different sources of climate action is that of how the presence of significant externalities are handled in decentralized environments. As is discussed in more detail in the next section, the theory and principles of fiscal federalism, enshrined in Oates' (1972) "decentralization theorem," point out that those areas where significant externalities exist, subnational decision making may be less optimal than national decisions, unless there is a great deal of coordination and incentives for subnational governments to consider the externality effects.[10] On the other hand, climate change policies in practice take many forms and many of those activities may yet be implemented by subnational governments. This is so because in climate change situation significant externalities are not always present. For example, subnational governments could be better implementers of medium-term sectoral targets regarding building or public transit. In the next sections below, with a more granular approach at the relevant policy questions, it becomes clear that the roles of subnational governments to combat climate change are multiple and important.

When significant externalities are present, even with coordination and incentives, the case for decentralized provision gets somewhat further complicated because the nature of the externalities generated from GHG emissions tend to differ from other externalities in several relevant ways (Stern 2008): (i) they tend to be global in their origins and impacts; (ii) some of the effects are very long term and governed by a complex flow-stock process; (iii) there is a great deal of uncertainty in most steps of the scientific chains; and (iv) the effects tend to be quite substantial and may be irreversible. Given the gravity of these special features and the fact that expenditure assignments and taxing powers for some of the key activities are indeed

[10] For example, Hankla et al. (2019) argue for a "strong decentralization theorem": They suggest that decentralized provision will still be efficient in the presence of externalities if fiscal decentralization is supported by political decentralization institutions, such as integrated national parties, where nominated electoral candidates need to internalize externality effects across jurisdictions.

decentralized in many countries, intergovernmental coordination in any country also needs to be extended to intercountry or international coordination. Therefore, the relevant questions are: will decentralized governance institutions in any country be able to coordinate internationally more effectively than centralized ones? Or what may be the most effective division of responsibilities for domestic and international responses to the challenges posed by climate change?

The issue of roles and responsibilities is a matter to be assessed and discussed in the following sections of this paper. However, it is clear and generally accepted that subnational governments need to be involved in the two main categories of issues pertaining to climate change: (i) decarbonization issues: whereby efforts are made to reduce emissions of GHGs through limiting energy consumption such as in burning of fossil fuels, solid waste generation, etc. and (ii) adaptation issues: coping with the consequences of climate change through the management of the localized impact of natural disasters resulting from or heightened by climate change, such as hurricanes, sea-level increases, droughts, flooding, bushfires, disease outbreaks, and the like.[11]

In reality, subnational governments are important for both mitigation and adaptation policy actions; indeed, in some countries (as seen in the following sections) subnational governments have taken the lead in climate action when national governments have lagged in their policies. On the side of decarbonization actions, subnational governments are commonly responsible for land use planning and enforcement, water and power utilities, waste disposal, transport systems and urban management. On the side of adaptation actions, climate change

[11] Even though they are different tools and most of the time are carried out by different agencies, mitigation of climate change and adaptation to climate change are policy substitutes both working to reduce the impacts of climate change. Adaptation and mitigation can therefore be considered simultaneously, allowing for the tradeoffs between them in terms of budget and other dimensions (Tol 2005).

implies that infrastructure investments on energy, transport, and water and sanitation systems will have to be built to be resilient to extreme events (Fay et al. 2017).[12,13] In reality, as seen in other sections of the paper, subnational governments are on the front line of disaster response and charged with investing for climate adaptation.

Before turning to examining what may be the best design of the fiscal decentralization pillars for effective decarbonization and/ adaptation policies, it is useful to review what the evidence is so far on the impact of fiscal decentralization on pollution and global warming and whether fiscal decentralization tends to aggravate or ameliorate the damage impact of natural disasters associated with climate change. Does fiscal decentralization lead to more or to less spending on decarbonization and adaptation? Does fiscal decentralization result in higher standards and lower levels of emissions or in lower standards and higher emissions?

The theoretical models analyzing the effects of decentralized environmental policymaking predict a variety of often-contradictory results, such as both a "race to the top" *and* a "race to the bottom" (Garcia-Valiñas 2004). Several researchers emphasize the virtues of decentralized governance and positive competition among units to conclude that decentralization will yield less pollution, unless local governments solely pursue maximizing their tax base and revenues (Oates and Schwab 1988, 1991, 1996; List and Mason 2001). On the other hand,

[12] The impact of natural disasters can complicate subnational governments' ability to address climate adaptation needs. For example, Jerch et al. (2020) report that since 1980, over 2,000 local governments in US Atlantic and Gulf states have been hit by a hurricane, and that in the case of major hurricanes, local revenue losses of up to 7% persist at least ten years after the hurricane event, leading to cuts in important public goods and services and a significant increase in the risk of default on municipal debt; localities rated as riskier by ratings agencies face higher borrowing costs and therefore lower ability to invest in climate change adaptation.

[13] The needs associated with adaptation policies can interact with other trends, such as urban sprawl and slum creation, leading to significant increases in related costs. For example, Fay et al. (2017) note that urban density has declined in many large cities in Latin America driven by transport, land use, and housing policies. If expansion patterns continue unchanged, built-up urban areas could double in the region by 2035, pushing up infrastructure and climate adaptation costs. Denser urbanization may reduce infrastructure investments and maintenance costs by half, while slum infrastructure upgrading can cost two to eight times more than regular land development.

Markusen et al. (1993, 1995), assuming firms operate under increasing returns to scale, find that competition will generally lead to higher levels of pollution. Fredriksson and Gaston (2000) conclude that both centralized and decentralized governments may have similar effects depending on how firms get to form lobbying groups affecting policy decisions. Empirically, the findings are more hopeful but still mixed and, not surprisingly, country-dependent. Therefore, no clear picture emerges with respect to the impact of decentralization on the level of emissions.

More specifically, a number of empirical studies have examined whether a race to the bottom effect exists in setting environmental standards at the subnational level in the United States. Some studies do not find evidence of a race to the bottom but instead, in some cases, report a race to the top with spatial correlation and mimicking (Dinan et al. 1999; List and Gerking 2000; Fredriksson and Millimet 2002; Millimet and List 2003; Fomby and Lin 2003). For example, Millimet (2003) examined the impact of decentralized environmental policymaking under President Ronald Reagan. In terms of pollution abatement expenditures, he found that Reagan's decentralization had no significant impact prior to the mid-1980s, but afterwards, the results support a “race to the top” process. However, he finds no statistically significant effects on actual gas emissions. However, Woods (2006) finds supportive evidence of a race to the bottom among US states involving surface-mining regulations. In summary, a race to the bottom may not always be expected, but neither can it be excluded from consideration as an outcome of any scenario. In this respect, Kunce and Shogren (2005) explore conditions under which a race to the bottom may or may not happen in the context of inter-jurisdictional competition and environmental federalism.

Several papers have also highlighted some drawbacks of fiscal decentralization when it comes to environmental pollution, namely free riding of states and coordination failures. For

instance, water pollution is greater when the rivers cross subnational borders (Sigman 2004; Lipscomb and Mobarak 2011) and international borders (Sigman 2007). Moreover, subnational governments are inclined to spend less on the preservation of species that are directly in conflict with development (List et al. 2002). When such governments have different level of environmental regulation, bodies with stricter environmental policies tend to strategically locate the polluting firms near the boundaries (Monogan III et al. 2017; Helland and Whitford 2003).[14] De Mello Jr. (2000) highlights the coordination failures in intergovernmental fiscal relations as result of fiscal decentralization. These failures, he describes, might arise from agency problems due to information asymmetry between the central and the local governments regarding the costs and benefits of government spending. While decentralization brings government closer to people and allows local jurisdictions to identify the preferences of local community, it also increases the informational distance between the central and subnational governments. For instance, a central government may be unable to monitor the local government's revenue utilization, spending, and delivery of services. Another cause for coordination failure is the "common pool" problem. It arises when a large share of the subnational government's revenues comes from revenue sharing with the central government. If a large share of the subnational government's revenue comes from revenue-sharing, subnational governments might underutilize their own tax bases. Indeed, using a sample of 30 countries, De Mello Jr. (2000) shows that co-ordination problems arising from decentralization causes fiscal deficits.

Given the severity of air pollution in China, it is not surprising a good number of studies

[14] Internationally, research has been conducted on whether stricter environmental standards in some countries would lead to the creation of pollution havens in others, a proposition that does not appear to have been supported by the empirical evidence (Brunel and Levinson 2021). In a related manner, interestingly, Shapiro and Walker (2021) do not find breaches of locational environmental justice across jurisdictions in US air pollution offset markets; specifically, pollution is not relocated to or from low-income or minority communities.

have examined the relationship between fiscal decentralization and carbon emissions (and other forms of pollution) in China. The findings are mixed, with negative, positive and even neutral effects within the same overall country context. Cheng et al. (2020) find that the impact of fiscal decentralization on CO2 emissions is nonlinear and that higher per capita levels of decentralized expenditure are more effective in reducing carbon emissions, especially when emissions reduction policies are conducted at the intermediate (province and city) levels of government. Ran et al. (2020) find a strong positive spatial correlation in regional carbon emissions in China, and that their measure of environmental decentralization promotes carbon emissions, suggesting that China's environmental decentralization system may be unconducive to carbon emission control. However, they also find that the decentralization of environmental supervision activities dampens emissions. Even though they use similar data and approaches, Zhang et al. (2019) are far less conclusive, finding that there is considerable heterogeneity on the impact of fiscal decentralization across regions. Last, He (2015) finds that fiscal decentralization has no significant effect on environmental pollution (wastewater, gas emissions or solid waste), although fiscal decentralization has a significant, positive effect on pollution abatement spending and pollutant discharge fees charged.

China is far from the only country to be studied in relation to this issue. Additional evidence from the Philippines shows that decentralized subsystems are more likely to solve collective action problems such as free riding, conflict resolution, and rule enforcement in large scale irrigation efforts (Araral 2011). Local governments are more responsive to complaints about water pollution in Indonesia (Bedner 2010). However, the lack of resources to carry out the environmental tasks remains. For cross country findings, Farzanegan and Mennel (2012) analyzed the impact of fiscal decentralization on different indicators of pollution for a large panel

of countries over three decades and found that fiscal decentralization tends to increase pollution, but the effects are mitigated by the quality of institutions and central and local preferences for environmental quality. Their findings would also seem to weakly support the prediction of a "race to the bottom" under decentralization.

A possible avenue for a causal relationship between fiscal decentralization and environmental pollution is through economic growth. Several papers have provided theoretical framework for an inverse U-shaped relationship between environmental pollution and economic growth (Lopez 1994; Stokey 1998; Hartem and Kwon 2005; Taylor 2004). Recent papers have shown an inverted U-shaped relationship between fiscal decentralization and environmental pollution (Liu and Li 2019; Hao et al. 2020; Liu et al. 2019).

Another set of recent papers explore the relationship between fiscal decentralization and (renewable) energy consumption. Elheddad et al. (2020) finds a non-linear relationship between fiscal decentralization and renewable energy consumption in Chinese provinces. Su et al. (2020) also finds evidence of a positive relationship between fiscal decentralization and renewable energy consumption in OECD countries.

There is less empirical evidence so far on whether fiscal decentralization aggravates the damage impact of natural disasters associated with climate change. The few empirical studies that have been conducted on this question seems to point in the direction that fiscal decentralization is not a catalyst for increased damages.[15] Toya and Skidmore (2013), using data

[15] *A different question is whether there are long-term damages associated with natural disasters independent of the level of fiscal decentralization. Here, again, the evidence is not very robust. For example, Koconik-Mina et al. (2020) study the question of permanent damage* in the context of floods, which they find have displaced more than 650 million people worldwide over the last 35 years, and find that *damages are not permanent and that flooded areas tend to recover rather quickly.* In a similar vein, Gignoux and Menéndez (2016) examine the long-term effects of earthquakes in rural Indonesia since 1985 and find the stocks of productive assets, notably in farms, are reconstituted and public infrastructures are actually improved, seemingly partly through external aid.

from a large panel of countries, find that fiscal decentralization leads to a smaller number of disaster related deaths.[16] Similarly, Escaleras and Register (2012) find that relatively more decentralized countries fare better when natural disasters strike in terms of its effects on the population, with the effects being much more robust in developing countries.

Measuring the current involvement of subnational governments in climate action

If there are good reasons for subnational government to be active agents in climate change action, an important question is how involved they actually are. Measuring this involvement poses significant difficulties with the information that is available. This paper approaches this question from two different complementary angles. First, it looks at the quantitative evidence on the relative share of environmental expenditures of subnational governments across developed and developing countries. This clearly provides only a limited view, since subnational governments are likely involved in other related decarbonization activities (transportation, housing, sanitization, etc.) and the category "environmental expenditures" quite likely does not include either expenditures in adaptation projects.[17] But the functional budget classifications currently in use do not separately identify those other types of expenditures.[18] Second, it looks at the evidence on subnational government involvement in the Nationally Determined Contributions (NDCs) under the Paris Agreement.

[16] Note that Toya and Skidmore (2013) consider all types of natural disasters, not just those linked to climate change.
[17] On the other hand, not all environmental expenditures might address climate change.
[18] Admittedly, as just pointed out above, subnational governments undertake substantial expenditures in areas such as urban transit and waste management which may not count as expenditure on a "climate action" but still could have relatively strong climate impacts. If those expenditures were added in, the picture of subnational government involvement in climate change action in many countries would likely change rather significantly, but measuring what subnational governments do in these areas and how they contribute (or not) to mitigation and adaptation in tangible ways poses significant difficulties. How much of the spending, for example, on sanitation or transportation could be linked to climate change adaptation or mitigation? To what extent should the existing deficiencies in the provision of those services otherwise linked to climate change be accounted for as contributing to the aggravation of the problem? Such fundamental complications make nuanced measurement very challenging.

On the first issue, Gilmore and St. Clair (2018) find that that climate decarbonization and adaptation activities represent less than 1% of total public spending in most states in the United States. This is sobering information since state governments in the United States are well placed to identify opportunities for mitigation and needs for adaptation to climate change and further have a very high degree of budgetary autonomy. The evidence reported by the OECD (2018) for a sample of 30 countries over the period 2000-2016 is not much more positive (Plouin and Allain-DuPre 2018). In these countries, the majority of environmental and climate related spending occurs at subnational level (55% for total spending and 64% for capital investments). However, the share of environmental and climate-related spending and investment is very low with respect to GDP. Subnational climate-related spending represented 1.3% of GDP on average and subnational climate-related investment represented around 0.4% of GDP on average, over 2000-2016. Perhaps more of a concern is that both environmental and climate-related spending and investment saw minimal change between 2000 and 2016 on average in the 30-country sample, both in real terms and as a share of GDP. As a third piece of evidence, Table 1 summarizes the most recent information available in the World Observatory of Subnational Government Finance and Investment (SNG-WOFI) on subnational government spending on environmental spending across developing and developed countries in six regions of the world (OECD/UCLG 2019). For the vast majority of countries included in that work, the share of environmental expenditures in total subnational expenditures or GDP are still very small.

Table 1. SNG Spending on Environmental Protection: Breakdown by Region/Country

Region	Country	SNG Spending on Environmental Protection
Africa	Mauritius	Environmental protection was ranked third and made up 17% of total SNG expenditure.
	Rwanda	Environmental protection is the least funded category (0.2%).
	Uganda	Noteworthy is the low expenditure in economic affairs/transport, housing/community affairs, and environmental protection due to the lack of capital finance for local governments.
	Zimbabwe	Environmental protection makes up less than 1% of subnational government spending.
Eurasia	Azerbaijan	Environmental protection makes up 0.8% of total SNG expenditure.
	Belarus	0.1% is allocated to environmental spending.
	Georgia	Environmental spending makes up 4.2% of SNG expenditure.
	Kazakhstan	Environmental protection makes up 0.3% of total SNG expenditure.
	Kyrgyzstan	Expenditure items, such as environmental protection, have a negligible impact on subnational budgets.
	Moldova	Environmental protection makes up 0.3% of total SNG expenditure.
	Russia	Environmental protection is not among the primary areas of SNG and 98.7% of environmental protection expenditures are undertaken by the state governments.
	Tajikstan	Environmental protection makes up 0.1% of total SNG expenditure.
	Ukraine	Environmental protection makes up 0.4% of total SNG expenditure.
	Uzbekistan	Environmental protection less than 1% of total SNG expenditure.
Latin America	Brazil	Environmental protection makes up 0.7% of total SNG spending.
	Colombia	Environmental protection makes up 1.9% of total SNG spending.
	Dominican Republic	Local expenditure is primarily devoted to general public services (42.5%), followed by environmental protection (24.7%) and housing and community amenities.
	El Salvador	There is very little intervention by municipalities in environment (3.1%).
	Guatemala	Local government expenditure is concentrated in four sectors: public administration (civil registration), economic affairs (roads), environmental protection (7.4%) (waste management and sewerage) and cultural and recreation activities and infrastructures.
	Nicaragua	Environmental protection makes up 2.6% of total SNG spending.
	Peru	Other significant items, after “general services expenditure”, are health (regional responsibility) and environmental protection (10.9%).
	Uruguay	Environmental protection makes up 11.4% of total SNG expenditure.
Asia-Pacific	Australia	Environmental protection makes up 3% of total SNG expenditure. Local government areas are responsible for the majority of public spending (52%). They also play a key role in environmental protection and management of green areas, being responsible for 61% of SNG spending in this sector, amounting to 42% of total public spending.
	China	Environmental protection makes up 3.7% of total SNG expenditure.
	India	Environmental protection makes up 0% of total SNG expenditure in India.
	Indonesia	Environmental protection makes up only 2% of total SNG expenditure. However, regencies and cities are also heavily involved

		in housing and community amenities and environmental protection (respectively 65.5% and 55.2% of public expenditure).
	Japan	Environmental protection makes up 6.8% of total SNG expenditure.
	Korea	Environmental protection makes up 4.4% of total SNG expenditure.
	New Zealand	Major categories of SNG spending include general public services, environmental protection (16.9%) (including waste and waster), housing and community amenities (including water distribution) and recreation and culture.
	Philippines	Environmental spending makes up less than 2% of total SNG expenditure.
Middle East and West Asia	Israel	Environmental protection makes up 9% of total SNG expenditure. Israeli local governments are responsible for the vast majority of overall public spending in the areas of environmental protection (87% of public spending) and housing and community amenities.
	Turkey	The two most important SNG expenditure items (excluding general public services) are community amenities (mainly drinking water, housing and community development) and economic affairs and transport. They are followed by environmental protection (9.5%), recreation and culture.
Europe	Albania	Environmental protection makes up less than 0.1% of total SNG expenditure.
	Austria	Environmental protection makes up 1.2% of total SNG expenditure.
	Belgium	Environmental protection makes up 3% of total SNG spending.
	Bulgaria	Environmental protection makes up 8% of total SNG expenditure.
	Croatia	Environmental protection makes up less than 0.2% of total SNG expenditure
	Cyprus	The second most important item is housing and community amenities (mainly urban lighting, water supply), recreation and culture, and environmental protection (14.2%).
	Czech Republic	Environmental protection makes up 6.3% of SNG expenditure. SNGs are responsible for 82% of total public expenditure in environmental protection policies, as well as for 68% in the sector of housing and community amenities.
	Denmark	Environmental protection makes up 0.6% of total SNG expenditure.
	Estonia	Environmental protection makes up 2.9% of total SNG expenditure.
	Finland	Environmental protection makes up 0.4% of total SNG expenditure.
	France	Environmental protection accounts for 7.4% of total SNG spending.
	Germany	Environmental protection makes up 2.1% of total SNG expenditure.
	Greece	The main categories of SNG spending include general public services, economic affairs and transport, environmental protection (14.9%) and social protection.
	Hungary	The shares of SNG spending in education, health, housing and community amenities, recreation and culture and environmental protection have sharply decreased since 2011. Environmental protection only makes up 2.1% of total SNG spending.
	Iceland	Environmental protection only makes up 1.7% of total SNG spending.
	Ireland	Environmental protection makes up 10.2% of total SNG spending.
	Italy	Environmental protection makes up 5.7% of total SNG expenditure. SNGs are also responsible for the large majority of overall public

		spending in the areas of environmental protection, and housing and community amenities.
	Latvia	Environmental protection only makes up 1.3% of total SNG spending.
	Lithuania	Environmental protection makes up 3% of total SNG spending.
	Luxembourg	Economic affairs/transports, recreation and culture and environmental protection accounted for around 15% each while education and social protection accounted around 10-12%.
	Malta	Administrative tasks represented almost 37% of their expenditure to be compared to 16.5% in the EU28 in 2016. It is followed by environmental protection (33.7%) (primarily: waste management, landscaping and maintenance of parks and gardens) and economic affairs and transport.
	Netherlands	SNGs are responsible for the vast majority of total public spending in the areas of environmental protection (9.4%), housing and community amenities (water distribution, street lighting, etc.) and recreation and culture, especially since they include infrastructure projects.
	Norway	Environmental protection makes up 4.2% of total SNG spending.
	Poland	Environmental protection makes up 2.3% of total SNG expenditure.
	Portugal	Environmental protection makes up 8.1% of total SNG expenditure.
	Romania	Environmental protection makes up 4.9% of total SNG expenditure.
	Serbia	Environmental protection makes up 3.4% of total SNG expenditure.
	Slovak Republic	Environmental protection makes up 5.5% of total SNG spending. SNGs are responsible for more than half of public expenditure in the area of environmental protection and housing, community and amenities, especially since their tasks include infrastructure related to water supply, sewage, heating, parks and open spaces and public lightning.
	Slovenia	Environmental protection makes up 3.5% of total SNG expenditure.
	Spain	In health, education, environmental protection and housing and community amenities, Spanish SNGs are responsible for almost all public spending at the national level. Whereas for environmental protection and housing and community amenities, funding responsibilities are shared between regional and local governments, with the latter being responsible for the larger share, respectively 70.3% and 66.5% of SNG total spending in each category.
	Sweden	Environmental protection makes up 0.6% of total SNG expenditure.
	Switzerland	Environmental protection makes up 2.5% of total SNG expenditure. Municipalities are responsible for a large share of total public spending on housing and community amenities (they are responsible for 83% of total public spending in this sector), environmental protection (62% of total public spending) and recreation and culture (58% of total public spending).
	United Kingdom	Environmental protection makes up 4% of total SNG expenditure.

Source: Adapted from OECD/UCLG 2019

The second measure of subnational government involvement to consider is the Nationally

Determined Contributions (NDCs) submitted by countries participating in the United Nations Framework Convention for Climate Change (UNFCCC) adoption of the Paris Agreement. These NDCs are not implementation plans nor blueprints for implementation, but they offer the general frameworks for action against climate change by member countries. Sarmiento et al. (2018) report that, in 2015, the NDCs submitted 60 "REDD+ countries" only 14 explicitly mentioned a role for SNGs in mitigation, and only 4 of these latter gave SNGs a decision-making role.[19] Overall, the NDC Partnership, up to 2020, has received 802 requests for support from a wide range of countries, of which 105 (from just 20 countries) have specifically requested support for subnational action (NDC Partnership 2020). The most common requests include institutional capacity building to integrate climate change policies and planning at both the national and subnational levels.[20]

In summary, up to now and despite its potential, subnational governments' involvement in climate related actions is generally modest in most countries. This finding provides further justification for this report, seeking to lay out the general venues through which subnational governments could become leading agents in the planning and implementation of decarbonization and adaptation policies.

[19] Each REDD+ Country Participant is a developing country located in a subtropical or tropical area that has signed a Participation Agreement to participate in the Readiness Fund of the United Nations Framework Convention on Climate Change (UNFCCC).

[20] By region, the countries requesting subnational action support are: (i) East Asia and Pacific (9 requests: 1 from Mongolia, 4 the Philippines, 1 Marshall Islands, and 3 Vietnam); (ii) Europe and Central Asia (3 requests: 2 from Albania, 1 Georgia); (iii) Latin America and the Caribbean (8 requests: 5 from Colombia, 1 Mexico, and 2 Peru); (iv) Middle East and North Africa (21 requests: all from Jordan); (v) South Asia (2 requests: both from Nepal); and (vi) Sub-Saharan Africa (62 requests: 2 from Burkina Faso, 15 Ethiopia, 5 Kenya, 15 Mozambique, 3 Namibia, 6 Nigeria, 1 Rwanda, 3 Uganda, and 12 Zimbabwe).

3. Reassessing the assignment of functional expenditure responsibilities for more effective action on climate change

One fundamental reason for assigning some climate change actions in general, and in particular environmental responsibilities, to subnational governments is the fact that, as for any other types of public services, they are expected to be more responsive and accountable to residents.[21] However, as in the case of other services, given the scope of associated externalities or the economies of scale in the production and delivery of services, analysts should expect there are environmental activities that are logically better assigned to central governments. Thus, the basic question is: what level of government is best equipped to address the different policy challenges in decarbonization and adaptation posed by climate change? How should expenditure responsibilities be assigned between central, regional, and local-level governments to maximize the effectiveness of decarbonization and adaptation activities?

Regardless of the specific assignment of expenditure responsibilities arrived at, vertical and horizontal coordination between government units can lead to improved outcomes.[22] However, even if free rider concerns are set aside, effective coordination still demands an assignment of functional responsibilities that is as clear as possible bringing balance between central, top-down control and subnational, bottom-up discretion in climate change action.

[21] For example, Bedner (2009) finds that local governments are more responsive to complaints about water pollution in Indonesia. For empirical evidence on the responsiveness of subnational government in other general area of public services, see Martinez-Vazquez et al. (2017).

[22] There has been a lack of consensus among theorists on the need for coordinated action among governments in the presence of significant externalities such as those associated with climate change. Some claim that the presence of pollution spillovers in decentralized settings does not always have to result in inefficient allocation of public resources to combat pollution. For example, in a well-known paper, Ogawa and Wildasin (2009) analyze a situation in which jurisdictions compete with each other in taxing mobile capital and find that uncoordinated policymaking leads to an efficient allocation of resources, even without any central government intervention or subnational coordination. However, others have shown that under alternative assumptions those results do not hold. For example, Yamagishi (2019) shows that if the level of environmental regulation is endogenized, a likely outcome is a race to the bottom and thus environmental policy coordination across jurisdictions is needed.

To proceed, next is a review of the general theoretical principles for expenditure assignments as well as the most common errors and problems with assignments in actual practice. The goal of such review is finding how best to use those principles and lessons to inform decisions and assess actual practices in the assignment of functional responsibilities in the area of climate change.

Basic principles and most common problems with expenditure assignments

Expenditure assignments tor subnational governments are usually guided by several specific principles, as follow:

First, the "*correspondence*" principle simply states that the geographical dimension of the benefits received from a service should match the geographical dimension of the level of government responsible for its provision. Thus, services spreading throughout the national territory (for example, air traffic control) should be assigned at the central level, services with benefits with regional dimensions (for example, tertiary specialized hospitals) at the regional government level, and those with a local dimension (for example, street cleaning) at the local government level. The correspondence principle implies that given the nationwide externalities associated with income distribution and macro stabilization policies, these activities should be mostly reserved for the central government. Local and regional governments may have difficulties sustaining independent (self-financed) redistribution programs because they risk attracting the needy from other areas while more heavily taxing their (potentially mobile) residents. For stabilization policies, such as massive investment or unemployment compensation, subnational governments may be relatively too small to be effective and their efforts may be quickly diluted within the open borders with the rest of the national economy

Second, the "*subsidiarity*" principle states that the responsibility for services that can be

provided at different levels should be assigned at the lowest possible level of government compatible with the size of the "benefit area" associated with those services.[23] This also works as a default clause for the assignment of residual (not explicitly assigned) and any new functions.

Third, efficient service provision is generally enhanced by making use of the "*benefit*" principle of service finance: wherever possible, utilizing fee structures and issuing service charges to service users. This general "pricing" mechanism not only contributes to recovering the costs of provision, but it also helps reveal users' demands and preferences for services and reduce congestion by rationing demand.[24]

Fourth, the principle of "*affordability*" considers whether subnational authorities have enough resources to adequately deliver the service and expenditure responsibilities assigned to them. Although a basic question, it is difficult to answer well; it is a complex issue that depends on how needs and standards are defined and the design of the entire subnational government financing system (own revenues, transfers, and so on).

Fifth, the principle of "*capacity*" puts the focus on whether subnational governments are administratively and technically capable of delivering the service function assigned. Wider behavioral notions of "capacity" are sometimes used to include subnational political responsibility for duly prioritizing functions perceived to be of national priority. This latter tends to be a thorny issue, especially in newly decentralized systems where there is central mistrust

[23] The *European Charter of Subnational Governments* uses the "subsidiarity" principle as the most prominent guide for expenditure assignments. In academia, a prominent defender of the application of the principle of subsidiarity to the assignment of responsibilities in environmental issues is Wallace Oates and his coauthors (Oates 1998, 2002; Oates and Schwab 1996; Oates and Portney 2001). Assigning responsibility to the lowest level of government that spatially encompasses most of the benefits and costs associated with the service allows tailoring the service to the preferences and needs of residents and to the costs of production and other local conditions, and therefore yields higher social welfare (Dalmazzone 2006).

[24] In practice, however, fees and charges are not as frequently used because of fairness considerations regarding lower income users, especially when there are no offsetting alternative income compensation and redistribution mechanisms.

about the capacity and intentions of newly appointed subnational authorities. Some countries address these issues by differentiating between obligatory versus discretionary or voluntary responsibilities or by imposing compulsory minimum standards and other forms of expenditure rules or mandates (for example, some minimum percentage of budget resources should be spent on education or no more than certain percentage may be spent on public employee salaries).

Last, and as already pointed out above, for any system of expenditure assignments to work smoothly there is always a need for the principle of "*coordination"* among the different levels of government. No expenditure assignment can ever be detailed enough to preempt the need for coordination and dialog among the different levels of government, especially in areas of concurrent responsibilities. Ultimately, disagreements must be left for interpretation and rulings by the courts of law.

The application of the above principles facilitates the assignment of expenditure responsibilities. For certain functions, it is possible to arrive at "exclusive" assignments. All attributes of that function, including regulation, financing, and implementation, are to be carried out by one single level of government. Exclusive assignments are desirable because they more easily lead to transparency and accountability. For other functions, some of the attributes, such as regulation, may be assigned to one level while other attributes, like financing or implementation, are assigned to other levels of government. In some cases, some attributes may be the responsibility of several levels of government. All these are concurrent or shared responsibilities. But even in these cases clarity and accountability may (to some extent) be preserved if the main attributes imbedded in any service responsibility (regulation or norming, financing, and implementation) are explicitly assigned.

One of the most useful lessons from the theory and practice of expenditure assignments is

that it is not meaningful to talk about “the single best” assignment. Other relevant factors, such as the nature of the state (federal versus unitary), available technologies, citizens’ preferences, and traditions and history may affect the final shape of assignments. What may be considered a good assignment is likely to change over time with changes in the costs of provision as well as technological innovations. More important than the “best” assignment is to achieve an explicit, clear, and stable assignment of expenditure responsibilities.

The assignment of responsibilities may also need to take into account the presence of corruption and other political economy constraints. For example, it is not uncommon for zoning and city planning to be exposed to corruption pressures; this may require the reassignment of responsibilities or monitoring and third-party oversight by central government officials.

The international experience provides some other valuable lessons on what to avoid as poor practice in expenditure assignments. First, a commonly-found problem is the lack of a formal or explicit assignment of responsibilities in the laws. In some cases, that may not be a problem if there is a long tradition and stability of *de facto* assignments; however, these arrangements can take a long time to get established and are exposed to more institutional friction and inefficiencies (including duplications or preemption). Second, the risk of the presence of inefficient or wrong assignments, which openly break with the correspondence principle. Third, it is important not to establish unstable and constantly shifting assignments, such as those that change according to annual budgets. The final pitfall to avoid is the extensive use of concurrent responsibilities, lacking clarity on what level of government is responsible for the different “attributes” of the service.

Applying basic principles and best practices to the assignment of responsibilities for climate change policy action

How can those principles and lessons on general functional assignments be applied to the area of climate change? What level of government is better equipped to address each of the potential challenges from climate change and maximize the effectiveness of decarbonization and adaptation activities? From the discussion above, the strong argument for the decentralization of services weakens as the costs of decentralized provision get higher (because of economies of scale or scope in the delivery of services) or because of the presence of substantial spillovers or externalities. Thus, an important component of determining suitable responsibility assignments is how economies of scale and externalities manifest themselves in different activities and policies related to climate change. For example, when one asks the question of which level of government should be assigned the responsibility for "emissions or pollution control," the answer is that it depends on to which sub-function or aspects of pollution control or climate change policies the term refers. Generally, three different dimensions of polluting activities have been discussed in the economics literature (Oates, 2002; Alm and Banzhaf 2012):[25]

First, a national or global type, where environmental quality in any location depends on the sum or aggregate level of emissions from all local areas, even though conditions may change locally with weather patterns etc. This type of externality is at the core of climate change caused by GHG as well as pollutants that deplete the earth's ozone layer, etc. Second, a local type where pollution in each locality depends exclusively on the level of emissions in that locality, with no

[25] The same applies to other services. For example, conservation activities such as sustainable water management or biodiversity are associated with regional, national, or even global public goods. And again, when large spatial externalities are present and no mechanisms are in place to sufficiently compensated for them, the likely result is an under provision of the services. Typically, central governments utilize conditional grants to make subnational governments internalize some of the externalities otherwise ignore in their decisions. That use of transfers is discussed in another section of the paper below.

externalities or spillovers beyond the boundaries of the local government itself; for example, the solid waste generated in the locality. Third, one that lies between the two previous polar cases, a local type with regional externalities to other neighboring jurisdictions, but without adding up to an "aggregate" national or global externality; examples include shared water basins, acid rain, etc.

So, the question of which level should be in charge can be answered by applying the correspondence principle to the geographical scope of the externality (Alm and Banzhaf 2012). In the case of a national or global type of externality, the central government should be in charge since subnational levels of government likely will not consider the full geographical effects of the emissions. Of course, what being in charge means depend on the policy choices actually made, for example, setting the overall regulatory context and emissions targets, determining the role of local governments or leaving it to the market with an ETS and carbon tax, etc. For the second type of externality, the local type, it is local governments that should be responsible, according to the correspondence and subsidiarity principles. For the third type with the presence of regional externalities, regional or intermediate level governments would be the most indicated by again applying the correspondence and subsidiarity principles.

Indeed, the "correspondence" principle is at the heart of getting the expenditure assignments right for environmental and climate issues in a variety of other ways. For example, it is of standard use with the establishment of water resource management districts because water basins are often different from the geographical boundaries of administrative units.[26] This is also why, for example, the Netherlands created separated administrative units to manage floods, different from other administrative units. Getting the right correspondence of the service

[26] See, for example, Van den Brandeler et al. (2019).

provision with the right geographical area for things such as flood zoning regulations is the high level of fragmentation and competition among small municipalities in large metropolis or lose urban areas.[27] However, the useful application of the correspondence principle is contingent on the fulfillment of the other principles of expenditure assignments, such as capacity and affordability. So, will local governments have the capacity to monitor and sanction polluters of the local type or perform other needed activities? Capacity has become an everyday problem for many climate issues. As mitigation increasingly relies on new fast-evolving technologies, capacity constraints become a bigger issue.[28] In addition, many subnational government cannot afford to hire experts on disaster management and only when the funds are available can they rely on private contractors that are more or less reliable. In this sense, capacity can be a main binding constraint for allocating responsibilities for climate change activities.

Even if the answer is that both capacity and affordability are present, things can go wrong if subnational governments adopt harmful strategic behavior by competing among themselves, selecting low levels of service (with correspondingly lower charges and taxes) in order to attract more economic activity. Thus, whether subnational governments will make efficient decisions on the level of the service (for example, control of the local level pollution) – that is, whether the functional assignment is right – will also depend on the absence of strategic behavior. Exposure to corrupt practices is another consideration to keep in mind in the final assignment of

[27] For example, Przyluski,and Hallegatte (2012) describe how many of the mayors of municipalities affected by the storm Cynthia on the coast of France mentioned the intense competition to attract population and tax resources and the risk to lose them at the expense of neighboring municipalities if they were to take flood zoning too seriously. Similar difficulties are common in large metropolitan areas with many fragmented jurisdictions.

[28] The problem seems to be widespread. For Japan, Takao (2012) finds that only prefectures and the largest municipalities in the country have technical capacities to develop comprehensive plans for climate adaptation. In a similar vein, Næss et al. (2005) find deficient capacity for flood adaptation and prevention policies at the local level in Norway. USAID (2017) reports on similar local capacity constraints at the local level for climate change adaptation in Mali.

responsibilities.

More generally, the assignment of responsibilities among different levels of governments is likely to differ for the broad categories of decarbonization and adaptation activities. For *decarbonization* activities, in the presence of extensive negative externalities from consumption and production activities that lead to the emission of GHG with extensive externalities, the assignment of responsibility should first consider how necessary the role of higher levels of government is. The assignment at higher levels of government would increase the chances that to some extent those extensive externalities would be sufficiently taken into account in policy decisions. But even that may not be the case – when the negative externalities' effects go beyond national boundaries, there might be justification for international action, thus the reason for the existence of Paris Climate Agreement and other international fora.

However, not all decarbonization activities need to be centrally assigned. There are a good number of activities that have a local dimension, such as urban transport, housing construction codes, and land use regulations, which also have a related impact on GHG emissions.[29] In most of these cases, given the local dimension of the activity, it would not make a lot of sense to transfer the responsibility to upper-level government. Nevertheless, even for these decidedly subnational activities, there may be a role to be played by the central authorities regarding development of regulations, establishment of minimum standards, help with financing, or implementation of information dissemination, monitoring and oversight.

[29] A more complete list of how subnational governments engage in mitigation activities includes: maintaining building codes and infrastructure standards to increase energy efficiency, establishing land-use and urban planning standards to promote and preserve green areas and forests, reducing water and energy use in the provision of public services, promoting green activities such as soil and water conservation, rain water harvesting, or crop diversification and agricultural practices, and improving public transport, vehicle emissions standards, and vehicle energy mix (Danida 2009).

In some cases, subnational authorities may be able to deal efficiently with activities representing large externalities if strong institutions for policy coordination are present. The intergovernmental fiscal system should incentivize local officials to consider all types of externalities in making their decisions. Fiscal incentives could be in the form of conditional transfers or subsidies to particular actions and programs.[30] Political decentralizations institutions, such as centralized political party arrangements, can also better ensure that externalities and the national good will be internalized by subnational officials.[31]

All in all, the considerations above indicate that a good number of responsibilities involving decarbonization policies will call for concurrent assignments involving two or more levels of government. In this case, as described in the discussion of principles of expenditure assignment, what becomes important is how to design these concurrent responsibilities to ensure maximum clarity and coordination.[32] The key for this is clearly identifying what level of government is responsible for the different attributes of the function (regulation, financing, and actual implementation).[33]

The two most common non-tax economic instruments used to correct externalities such

[30] See further below in the intergovernmental transfers section the discussion of actual country practices.
[31] See, for example, Hankla et al. (2019). In this regard, Estache et al. (2016) find that the hierarchy within a political party allowed the governor of São Paulo, Brazil to provide aligned mayors with tailored incentives to significantly improve local sanitation infrastructure.
[32] When there is shared responsibility for the production of some services, the lack of clarity in regulation and responsibility powers at the different level of government can lead to inefficiencies and the under provision of services. For example, Kresch (2020) documents how regulatory uncertainty between state and local governments in Brazil's water and sanitation sector led to the undersupply of services and how a legal reform that clarified responsibilities led to the almost doubling of total system investment by municipal companies, leading to significant increases in system access and decreases in child mortality.
[33] The assignment to subnational governments may involve the attribute of financing. One argument often raised against giving more responsibility to subnational governments on environmental and climate change issues is their lack of resources to finance these tasks. This issue of financing climate action is addressed separately in the next section.

as those associated with GHG emissions are a "cap and trade" framework—whereby trades or offsets are allowed among polluters and the total level of pollution does not exceed the cap—and a "command and control" system—used when pollution is not easily measurable (Cointrau and Hornig 2003; Alm and Banzhaf 2012).[34] Because "cap and trade" applications require a relatively broad geographical market, it is most likely that this type of instrument will be applied by either central governments or very large regional or state governments. In the case of "command and control," this is an instrument that all levels of government may apply as long as they have monitoring capacity; and in some cases, subnational governments may have better information, which is also a traditional justification for decentralization.

In the case of *adaptation* activities, unlike decarbonization policies, the risks and consequences of climate change-related disasters tend to be more localized, covering the extent of some localities or even regions or states, but with few cases in which significant externalities are present affecting other jurisdictions. However, slow-onset adaptation needs (e.g. changes in agricultural zones) may require more of a national perspective. From this perspective, using the correspondence and subsidiarity principles, the assignments of responsibilities for adaptation policies would appear generally to fall more logically with the potentially-affected subnational jurisdictions. Typical subnational government adaptation activities will include regulations on land-use planning and zoning that avoids construction or use of areas at high risk of flooding, developing and preparing contingent response plans for climate disaster emergencies, and improving infrastructure to better handle flooding or other climate change-related risks.

However, the incidence and costs of extreme climate events also imply the need for

[34] It must be also recalled that there are certain potential equivalences between tax and non-tax economic instruments, such as quotas. See, for example, Li 2020.

redistributive or compensatory actions from upper level governments.[35] In this regard, most decentralized systems contain an important element of national insurance covering individual jurisdictions for the effects of extreme climate events. Thus, it will be also the case that many adaptation activities will call for the assignment of concurrent responsibilities. While subnational governments have responsibility for prevention measures, such as building the necessary infrastructure, and remedial actions, such as cleaning and rebuilding in the aftermath of those climate events, higher levels of government including central or federal authorities have responsibility for contributing financing to the recovery efforts as well for regulating general prevention measures.[36] But this typical division of responsibilities between central and subnational government creates a thorny *moral hazard* issue. While subnational governments typically rely on federal/central support funds when natural disasters occur, these are the jurisdictions that are responsible for the capital infrastructure necessary to reduce the impact of those events.[37] Private insurance markets can play a positive role in reducing adaptation costs for subnational governments.[38]

[35] Another form of risk for subnational governments is that of "stranded assets," that is, current infrastructure that is not appropriate for the new natural disaster environment. There are other variations on the stranded assets' implications. See, for example, Morris et al. (2020) who study the significant tax revenue implications of future carbon constraining policies for counties in the United States that are heavily reliant on coal-based revenues.
[36] Nevertheless, central disaster relief is not always assured to work properly. Sobel and Leeson (2006) examine the failure of the Federal Emergency Management Agency (FEMA) and other government agencies in the United States to provide effective relief support in the wake of Hurricane Katrina.
[37] For example, Goodspeed and Haughwout (2012) show that when central authorities commit to full insurance against natural disasters, subnational governments have an incentive to under-spend on costly adaptation measures. Lower levels of insurance transfers may result in larger preventive investment spending, but a good balance is probably hard to achieve. Mcleman and Smith (2006) review possible examples from Canada, New Zealand, and the United States where central government actions have encouraged forms of development putting more people and property at risk. Similarly, Bagstad et al. (2007) highlight for the United States how fragmented federal programs for coastal disaster protection have promoted growth in areas of increased risk.
[38] In general, there may be little awareness of the risks associated with natural disasters (Edwards et al. 2019 and the Resilient Cities 2018 - the 9th Global Forum on Urban Resilience and Adaptation Report). When private insurance companies withdraw from certain markets, that may signal less development and smaller damages form natural disaster. Insurers may also incentivize local governments to undertake appropriate preventive measures (ICLEI 2017a). Linnerooth-Bayer and Mechler (2006) discuss possible strategies for supporting developing country adaptation to the risks of climate change via insurance, building on the intent of Article 4.8 of the United Nations Framework Convention on Climate Change (UNFCCC). Linnerooth-Bayer and Mechler (2006) discuss two

It is also questionable whether many subnational governments would have the capability to conduct their own disaster and climate risk assessments. This is especially true in the case of subnational governments in developing countries, which may lack awareness as well as personnel and other resources to conduct those risk assessments for land-use planning, and so on. This is clearly another area in adaptation activities where central governments may need to support the subnational governments.[39]

Other potential obstacles to the devolution of climate change responsibilities to subnational governments: political economy considerations, free riding, and common pool problems

Central government authorities might not want to devolve decision making to subnational governments, even when it's more efficient to do so. For example, there are central government incentives to be politically perceived as the primary responder to emergencies as well as to ensure that disaster assistance is seen to be attributed to the central government (Friis-Hansen et al. 2013). In addition, some arguments frequently made against decentralizing responsibility for environmental and climate change issues involve the presence of free riding, common pool problems, coordination failures, and strategic behavior among subnational governments (de Mello Jr. 2000). Coordination failures in intergovernmental fiscal relations could arise from agency problems due to information asymmetry between the central and the local governments regarding the costs and benefits of government spending. Coordination failure may also follow from "common pool" problems, often present when a large share of subnational governments'

potential international examples. First, the Turkish Catastrophe Insurance Pool (TCIP) launched in 2000 with support from the World Bank to cover earthquake risks –but which could be expanded to other natural disasters. Second, Mexico's taxpayer-supported national catastrophe fund (FONDEN) in combination with a mixed catastrophe bond issued as part of an insurance risk-transfer strategy to protect FONDEN (investors receives an above-market return when a specific catastrophe does not occur in a specified time but sacrifice interest or part of the principal following the event).

[39] Colombia and the Philippines are country examples in building subnational government indices for disaster risk. See, respectively, Mejía 2018 and World Bank 2017.

revenues come from revenue sharing with the central government, leading subnational governments to underutilize their own tax sources and inflate their spending needs.

The empirical evidence on the presence of strategic behavior and competition among subnational units regarding pollution standards and other environmental related issues is somewhat mixed. For example, List and Gerking (2000) found that the devolution of authority from the federal to the state governments on environmental quality standards during President Reagan's new federalism in the 1980s did not lead to a reduction of those standards. Similarly, Konisky and Woods (2012) do not find any supporting evidence of environmental free-riding behaviors across U.S. states regarding enforcement of the federal Clean Water Act. Under most federal environmental laws in the United Sates, states may apply for "primacy," that is, authority to implement and enforce federal law, through a process known as "authorization." There have been fears that states may use that process to put into place laxer regulations. But, in fact, Chang, Sigman, and Traub (2007) find that states applying for "authorization" tend to adopt stricter environmental norms compared to the federal standards. Relatedly, Araral (2011) found that in the Philippines, decentralized subsystems were more likely to solve collective action problems such as free riding, conflict resolution, and rule enforcement on large scale irrigation programs.

On the other hand, Sigman (2002) finds that pollution on international rivers is worse than on domestic rivers, except for EU countries where cooperation is greater. Also, in a well-known paper, List et al. (2002) found that during 1993 to 1998, the devolution by the Environmental Protection Agency to the states in the US (where delegation increased by 75%) led to widespread free riding by the states; more specifically, states were less inclined to spend money on the preservation of species that would require a large habitat area or which were directly in conflict with development goals.

What are current promising (and unhelpful) practices in expenditure assignments in different countries?

The international practice with expenditure assignments for climate relates policies is varied and rich, and therefore difficult to categorize.[40] Expenditure assignments are multidimensional, involving the attributes of norming or regulation, financing, and implementation. A complete taxonomy of expenditure assignments for combating climate change, therefore, would require a complete listing of all policies involved and the identification of which level of government is responsible for regulation, financing, and implementation of each such policy. That task is beyond the scope of this paper; however, it is useful to look at what general approaches countries have followed to the division of responsibilities for climate change policies. The most distinctive attribute to differentiate among country approaches to expenditure assignments for climate change is the level of government that is responsible for norming or regulating climate related standards and economy-wide targets. In the experience of most countries, both financing and implementation are generally concurrent attributes implemented by all levels of government. From that perspective, the international practice shows three clearly distinctive options: a first group of countries where climate related standards and economy-wide targets are exclusively centrally mandated/determined; a second group of countries, with a mixed approach, where both central and subnational governments contribute to the determination of targets, with national ones working as floor targets and with subnational governments being allowed to innovate and improve of those targets minimum targets; and a third group of countries, where standards setting is totally decentralized, with no central mandates or targets. What follows in terms of financing and implementation, then, is that under the first approach the

[40] There is also little precedent in the literature. See, for example, Breton et al. (2007) for a collection of country essays on multilevel coordination of environmental policies.

implementation may be only national or also delegated to subnational governments; with the second and third approaches, subnational government are always also involved with financing and/or implementation.

The section that follows below identifies and describes in some detail a few countries operating in each of those three categories. Later, there will be a more exhaustive look at how many other countries may possibly fit into each of those categories, but for now, some general reflections on the classification process and the advantages and disadvantages of each are possible. First, each country case is complex and distinct, and so, some countries may not neatly fall into any of the three categories. Second, of the three approaches, the first (the centralized approach) sets minimum standards but only utilizes subnational governments as implementers, while in the third (the decentralized approach), subnational government are free to innovate and compete—but with no minimum national standards, there is also a risk of competition turning into a race to the bottom. The advantage of the second approach is that besides offering minimum national standards, it also allows for the innovation and initiatives of subnational governments in what possibly may become a race to the top.

Three main approaches to expenditure assignments

(i) First, in some countries, national target setting by the central government is followed by further allocation of targets to sub-national governments for implementation. Two examples of these practices are provided by Belgium and China.

In the case of *Belgium*, this process is more of a conceptual than practical. Belgium's Kyoto-agreed targets with the EU were re-allocated to the regional level through a process of negotiation and regional climate plans were prepared to implement those regional targets

(Happaerts et al. 2011).[41] Most of the climate change policies in Belgium (including GHG reductions and carbon emission trades) have been redesigned and implemented at the subnational level (of Flanders, Wallonia, and Brussels). So, in effect, in the case of Belgium, there is no national *policy* per se but rather a national *framework*, and in practice the regional governments design and implement their own policies within that framework. For this framework, there is an Inter-Ministerial Conference on the Environment (IMCE), composed of the federal and subnational Environment ministers, which is in charge of coordinating intergovernmental cooperation on climate change policies.

In the case of *China*, the tradition of strong, hierarchical, vertical organization of government facilitates the approach of a vertical division of climate change responsibilities and targets. First, the national action plan and targets are set and monitored by the central government, frequently in consultation with the provincial governments. Then, the implementation of environmental, energy, and climate change policies and programs is delegated to the provinces, which in turn organize and supervise the further delegation of policies and targets to the other three levels of subnational governments, from large cities and prefectures to townships.[42] The existing institutional arrangements for the promotion and supervision of subnational officials potentially facilitate the effectiveness of national target settings for GHG reduction. At the national level, the powerful National Development and Reform Commission (NDRC) and the State Environment Protection Agency (SEPA) are the central agencies responsible for environmental planning and energy policies.[43] In contrast, it is the inter-ministerial National Climate Change Policy Coordinating Committee established in 1990 that makes climate policies; unlike the case

[41] The process of agreements is to a large extent anchored in the particular institutions of Belgium federalism, where the principle of non-hierarchy means that the federal government cannot impose on the subnational governments.
[42] See Held et al. (2011) and Kostka and Hobbs (2012).
[43] The 11th five-year plan (2006-2010) included a 20% reduction in energy intensity and a 10% reduction in major pollutants, and these two targets were translated into differentiated targets at the provincial level. Before 2007, no subnational government (from the provincial to the township level) had expressed serious interest in working on climate change issues (Qi et al. 2008). Different capacity to finance environmental policies has also affected the performance of different provinces. Teng and Gu (2007) note the lack of an intergovernmental transfer mechanism to improve energy efficiency and environmental standards in the poorer western China provinces.

of energy and environment policies, for climate policies there is no clear division of responsibilities with lower level governments nor apparent incentives or penalties. Some provinces have adopted a climate change policy, and some others have not; between 2007 and 2008, eight provinces, province-level municipalities, and autonomous regions (of 34 such bodies) established Leading Groups on Climate Change based on the central government's model (Teng and Gu 2007; Held et al. 2011). In addition, the NDRC approved seven provincial pilot cap and trade schemes for carbon emissions in 2011. The participating provinces were intentionally selected at varying stages of development; and although the schemes have some common features (all six greenhouse gases covered under the Kyoto Protocol are subject to the system and output levels require third-party verification), the provinces were given considerable discretion to design their own schemes (Zhang, Z. 2020).

(ii) There are other countries that more explicitly share and coordinate responsibilities for the design and implementation of climate change polices among different levels of government. Countries like India, France, Germany, and Colombia are thus somewhere between the model of central control of design and models of much more decentralized assignment of responsibilities.

In the case of *India*, policy targets are set in a mix of national and subnational regulations. Functional responsibilities are shared between the central government and the state governments on the bases of the "National Action Plan on Climate Change (NAPCC)," at the Union level and the states' "State Action Plan on Climate Change (SAPCCs)," which are developed and implemented separately by each state governments (Dubash et al. 2013). In 2018, the central government asked the states to revise the SAPCCs and most states appear to have done so. While predominantly focusing on the implementation of national level targets, the assignment arrangements allow for sufficient flexibility to pursue state-level goals such as in the cases of the Climate Change department in the state of Gujarat or the Green Fund in the state of

Kerala (Atteridge et al. 2012).[44] However, there have questions about how effective the executive branches have been in implementing policies fighting climate change. For example, Mandal and Rao (2007) highlight how the failure of the executive to regulate and monitor pollution and forest cover has led to the Supreme Court intervention, with the Court issuing several rulings on the implementation of environmental regulation, taking over the role of the executive branch.

Another good example of the mixed approach is France. Even though France is a rather fiscally centralized country, its approach to the assignment of responsibilities for the environment and climate change is a mix of national standards and subnational governments' own initiatives. France's national legislature, Assemble Nationale, adopted the EU objectives as its national goals in 2010; that same law required all urban agglomerations of over 50,000 people prepare 'Climate and Energy Territorial Plans' to meet these goals and to address adaptation needs. This mainstreaming of climate change objectives into ongoing local public planning had the advantage of making sure that all other local planning related to policies for transport, building, urban planning, and energy had to conform and support the national objectives for climate change (Vidalenc 2017). Later, the Modernization of Territorial Public Action and Assertion of Metropolitan Areas (MAPTAM) law of 2014 assigned expenditure responsibilities to the different levels of subnational governments (region, county, and municipalities), with most of the responsibilities for climate change (biodiversity protection, climate, energy, and air quality) assigned at the regional level. In addition, the New Organization of the Republic (NOTRe) Law, passed in 2015, clarifies the responsibilities of the Metropolitan Area of Paris

[44] Reportedly, prior to the NAPCC and the Prime Minister's urging in August 2009 that all states develop a state action plan consistent with the strategies of the NAPCC, there was little initiative at the state level. There is still significant variation across states in recognizing climate change as a priority (Atteridge et al. 2012).

(Grand Paris) and strengthens the role of regional governments on energy transition issues. The summary with highlights of the Territorial Climate-Energy Plan for the City of Paris is shown in Table 2.

Table 2. Example Territorial Climate-Energy Plans (TCEP)

The City of Paris and its TCEP

First adopted in 2007 and then updated in 2012, the Paris climate-energy plan calls for a 75 % reduction in emissions by 2050:

Areas of action	Examples
Land Use Planning	Renewal of 10 % of the city's area (10 km²) to attain high energy efficiency and low carbon standards
Housing/public buildings	15% reduction in emissions (900,000 t CO_2 eq) obtained by building 25,000 public housing units to high energy efficiency standards, and by renovation of 25,000 units
Mobility	• Opening of new tramway lines, large-scale implantation of the Vélib bike-share scheme and the Autolib shared electric vehicle rental service. • Certain metro lines extended, longer service hours on weekends, 15 BRT lines created, 700 km of bike lanes.
Adaptation	• First full audit conducted to assess the robustness and vulnerabilities of Paris in the face of climate change • New green areas planted on over 100 hectares in 10 years • Stronger preventive measures under the national scheme to care for persons at risk in the event of a heat wave
Consumption	• Action to prevent and abate energy and fuel poverty : « 100,000 Low-Energy Light Bulbs » campaign for low-income residents in Paris, 15,000 water-saver kits installed in public housing by the water utility Eau de Paris • Sustainable food resources : 30 % organic foods in city food services (schools, employee canteens), representing 30 million meals/year, and 25,000 t of avoided CO_2 emissions/year
Outreach in the territory	The Parisian Climate Agency was created to proactively support the Climate Plan. A « serious game », Clim'Way Paris, has been launched to give all Paris residents the opportunity to complete their own climate plan by 2050.

Source: ADEME 2015.

In the case of *Germany*, the federal government, which has also adopted the EU objectives as its national goals, has primary responsibility for determining climate change objectives and it initiates most climate actions (Weidner and Mez 2008). Even though the federal states (the *Länder*) have few implementation responsibilities, they can take additional climate-

change actions such as to establish their own additional measures affecting GHG emissions or set other energy efficiency and renewable energy targets; in addition, each state has a comprehensive climate protection plan.

The states also have something of a veto power on central initiatives through their representation in the upper house of parliament, the Bundesrat. However, despite this multilevel governance, conflict is rare in the practice of Germany's cooperative federalism regarding this and other expenditure assignment matters. As an example, the federal and state governments jointly drew up the Dusseldorf Declaration, which proclaims the EU targets as the national climate targets and the federal and state governments hold a biannual Conference of Environmental Ministers. Recently, the "Climate Action Plan 2050" outlining the principles and processes for national policy was developed in consultation with the *Länder* (federal states), local governments, associations, and citizens. The main message in the plan is that success in climate action will require for it to be considered and implemented at all levels of government and by all stakeholders (GIZ et al. 2017). Finally, municipalities in Germany are active in climate-change activities, but with significant variations; some of those activities include retrofitting public buildings and schools, street lighting, public transport and promoting green public procurement and "zero-energy consumption" (Weidner and Mez 2008).

Although *Colombia* contributes little to worldwide GHG emissions, it has the associated pressing problem of the deforestation of its tropical forests. Colombia adopted a vertically integrated climate policy framework in the Intended Nationally Determined Contribution (INDC) and the National System of Climate Change (SISCLIMA) in 2016 (GIZ et al. 2017). This latter organization is charged with the coordination of central, regional, and local climate change efforts, and it is organized into nine regional climate change hubs. The National Climate Change

Policy (PNCC) of 2017 defines territorial and sectoral guidelines for the strategy of low carbon development, the national adaptation plan, the national strategy for the reduction of emissions due to deforestation, forest degradation, and other causes. All 32 departments—regional level governments—have included climate change management in their development plans and a good number of territorial plans have also been formulated. The Financial Management Committee of the SISCLIMA is the interinstitutional coordination mechanism for climate financing; its National Climate Financing Strategy estimates that approximately 0.87% of the annual national GDP would have to be spent to accomplish Colombia´s emission reduction targets up to 2030, and that 62% of the resources would have to come from private sector polluting activities (according to their actual GHG emissions) and 38% from public investment. The financing framework proposes the creation of a tariff for air emissions (equivalent to a carbon tax), the issuance of green bonds, and the provision of subnational governments with soft loans for decarbonization and adaptation projects.

(iii) In other countries, like the Netherlands, Brazil, United States, and Canada, regional and local governments play a leading role in the design and implementation of climate change polices. The lack of an enforced national policy risks not meeting some minimum standards, but it also allows for subnational innovation and initiative. In particular, the United States and Canada provide good examples for how subnational government carbon emission policies can lead and improve on federal/central government actions.

In the case of the *Netherlands*, the central government has a long-established subsidy program to municipalities to combat climate change. As reported by Gupta et al. (2007), a national policy agreement on climate change, Bestuursaccord Nieuwe Stijl (BANS), was negotiated in 1999 with about half of the 487 municipalities of the Netherlands and all 12 Provinces. The central government provided an initial

subsidy of €37 million for this scheme in 2002 and an additional €6 million annually since 2007. BANS covers 50% of the costs incurred by local government while the other 50% should come from other sources, such as provincial- municipal funds, EU funds, or even private sources.

Financed by these subsidies, the Netherlands' local governments get involved in a wide range of climate-change activities. The BANS program has seven themes—municipal buildings and installations; housing; business and business parks; the agricultural sector; traffic and transport; sustainable energy; and international cooperation. Subnational governments can select from three groups of policy options: active, front runner, and innovative, and with almost one-third falling into the last category. An indication of the breadth of involvement is that about two-thirds of the municipalities have a permanent budget for local climate policy, and about one-fourth calculate local GHG emissions. Most of the cities in the Netherlands have developed energy efficiency plans for the housing and transport sector and quantitative targets for GHG emissions; those with adaptation measures are fewer but, importantly, participation in the BANS program cannot be enforced, and therefore mechanisms for monitoring are limited (Gupta et al. 2007).

In the case of *Brazil*, several important cities have taken specific actions for climate-change control going beyond Brazil's national policy targets. For instance, in 2009, São Paulo committed to undertake a significant GHG emission reduction target of 20% by 2020 as compared to its 2005 levels (Lucon and Goldemberg 2010).[45] The first Brazilian city to pass legislation related to climate change was Palmas, in the state of Tocantins, in 2003. Three other cities that issued municipal climate policy legislation in 2011 were Belo Horizonte (in the state of Minas Gerais), Feira de Santana (Bahia), and Rio de Janeiro (Rio de Janeiro) (Barbi and

[45] Law No. 13.798 of November 2009 was enacted prior to the 15th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen (COP15) following an elaborate public consultation process. The establishment of mandatory GHG reduction targets in a region of a non–Annex I country (within the UNFCCC framework) was a matter of political controversy involving the repercussion for economic development and was quite innovative among developing countries, brining comparisons of the role of São Paulo in Brazil with that of California in the United States (Lucon and Goldemberg 2010). Note that in the case of São Paulo, climate-change actions were initiated by the state government and not just the city; in all other cases in Brazil, the policies were city government initiatives.

Ferreria 2013). As in the case of São Paulo, the cities of Belo Horizonte and Rio de Janeiro have set specific deadlines and targets for reducing GHG emissions, plus Rio de Janeiro and São Paulo also include adaptation plans for the impact of climate change.

In the case of the *United States*, federal government policy to reduce carbon emissions has varied markedly, both in intensity and direction, over the different recent presidential mandates. For example, most recently the Trump administration has returned to the polices of President George Bush Jr. of opposing controls (Kolstad 2020). The vacuum created by federal inaction to control carbon emissions has been filled (to some extent) by some states and also local governments, as allowed in the Constitution.[46] As part of the Conference of Mayors' Climate Protection Agreement (2007), more than 1,000 US cities and municipalities signed an agreement to commit reaching the targets signed on by the United States under the Kyoto Agreement. And even with the backtracking by the Trump administration, more than 700 cities continue to be committed to their climate change policies (Mehling and Frenkil 2013). Individual cities have adopted a variety of policies (McGarvery and Morsch 2016). For example, the City of Chicago enacted the Building Energy Use and Benchmarking Ordinance in 2013 to improve the energy performance of the city's building stock; all commercial, institutional, and multifamily properties 50,000 square feet or greater are covered by the ordinance. The City of Seattle enacted legislation in 2016 for reducing emissions from the building sector's largest and least efficient commercial and multi-family buildings, requiring periodic retro-commissioning (a comprehensive audit of equipment for improved performance followed by low- to zero- cost operational and maintenance improvements). New York City is implementing a large mandatory

[46] As Kolstad (2020) also indicates, there is a tradition for this regarding other environmental issues in the United States. For example, the 1963 Clean Air Act sets federal standards but delegates the regulation of pollution sources to the states.

building retrofitting for energy efficiency program, which is part of its target to achieve an 80% reduction in emissions below 2005 levels by 2050. Other cities like Detroit, Los Angeles, and Salt Lake City have similar programs involving transportation, renewable energy, and building energy consumption efficiency. However, as Victor and Muro (2020) report, as of 2017, only 45 of the 100 largest cities had any serious climate pledge at all, and about two-thirds of those are lagging in their targeted emissions cuts, while 13 others don't appear to have emissions tracking in place.

Many states in the United States have been also pursuing aggressive policies to fight climate change. The lead was taken by California in 2006 with the Global Warming Solutions Act followed by nine northeast states, which associated into the Regional Greenhouse Gas Initiative (RGGI) to introduce a region wide cap and trade system for emissions from electricity generation. As reported by the Center for Climate and Energy Solutions (C2ES 2020), twenty-three states plus the District of Columbia have adopted specific targets for GHG reduction involving carbon pricing, emission limits, energy efficiency mandates and incentives, and the promotion of cleaner transportation.

In *Canada,* there are broad-based emissions pricing policies across the entire country, but following the same trend as is other aspects of Canadian federalism, those policies show a high degree of diversity from both policy design and policy implementation perspectives (Winter 2020).[47] In terms of design, besides the differing exemptions, there is one province using a broad-based carbon tax, two with cap and trade systems, and most have both a carbon tax plus an

[47] Expenditure assignments in Canada between the federal and provincial governments are stated in the Constitution, with exclusive and shared assignments, while residual (not assigned) responsibilities rest with the federal government. This latter is important because the Constitution is silent on environment responsibilities. However, following several Supreme Court decisions, de facto, environmental responsibilities are concurrent or shared.

output-based subsidy system (Canada has 13 province-level governments in total). Six provinces and one territory arrived at their own system in a voluntary manner, while two territories adopted the federal scheme, also voluntarily. One province experienced partially voluntary adoption and partially federally-imposed policy, while the federal policy was fully imposed on three other provinces. Earlier policy action by several provinces (Alberta, British Columbia, and Quebec first and Ontario later) led to federal action. Although the federal government had signed the Kyoto Protocol in 1997—committing to a 6% reduction in emissions by 2012, relative to the 1990 baseline—in reality, it moved slowly by focusing on sector-by sector regulations (Hoberg 2016). The already-existing provincial policies on GHG emissions became the foundation and inspiration of the later federal policy that was later imposed on some provinces.

A more exhaustive review of expenditure assignments in other countries

The practice with expenditure assignments in other countries is not easily summarized. The following paragraphs highlight how a long list of other countries may fit into the three different models of expenditure assignment modalities just reviewed above.

First, a good number of other countries fit in the centralized mode, with leadership at the central level delegating implementing responsibility to the subnational level:

In *Bolivia*, the Constitution sanctions the *Law of Mother Earth*, which defines Mother Earth as "a collective subject of public interest," and grants inherent rights to Mother Earth and its constituents (for example, right to clean air and water). The implementation of some functions is delegated to subnational governments. Besides the usual delegation of water and sanitation, etc. services, municipal governments are active in the forest sector, responsible for enforcing the national forestry laws and assisting local forest users in their compliance.

In *Chad*, the Ministry of Environment oversees the design of policies related to energy,

environment, mitigation, and adaptation, while regional governments are charged with the execution and management of national the programs.

In *Colombia*, the national government through the Ministry of Environment and Sustainable Development is mainly in charge of implementing and enforcing environmental laws. At the subnational level, the Regional Autonomous Corporations (CARs) and Corporations for Sustainable Development (CDS) are public environmental authorities responsible for the surveillance of all the environmental matters and natural resources within their jurisdiction and promoting sustainable development at the regional level. The CARs/CDS also have the power to issue environmental licenses for small and medium projects. The Departments, as the political-administrative entity of the regional level, have residual competencies over the administration of the environment. The Urban Environmental Authorities (UEAs) have the same powers as the CARs, with the difference that they discharge them within urban municipalities, districts, or metropolitan areas with a population of at least 1,000,000 inhabitants. The Municipalities, as the political-administrative entity of the local level, also have residual competencies over the administration of the environment.

Ethiopia faces highly erratic hydration patterns of intense rainfall and prolonged drought. The National Adaptation Strategy of Ethiopia (NAP-ETH) approved in 2019, identifies the roles and responsibilities of regional and woreda (district) committees. The Inter-Ministerial Steering Committee is the responsible for formulating and monitoring NAP-ETH at the highest level. The regional bureaus are responsible for the implementation of the strategic adaptation options, monitoring and evaluating regional, zonal, and woreda level performance. The woreda offices are responsible for implementing, monitoring, and evaluating the woreda level strategic options.

In *Pakistan*, the federal government's Environmental Protection Agency (EPA) is the

main government body in charge of implementing and enforcing environmental laws. The provincial governments have their own EPAs which help enforce environmental laws in their jurisdictions.

In *Peru*, the national government through the Ministry of Environment is the main government body in charge of implementing and enforcing environmental policies. The Environmental Assessment and Control Agency (OEFA), part of the Ministry of Environment, is in charge of overseeing the fulfilment of environmental commitments under Environmental Impact Assessments (EIAs) and regulations. However, regional, and municipal governments enforce these laws and regulations in their respective jurisdictions.

Other countries which may also be considered to mainly follow a centralized approach include Algeria, Chile, Czech Republic, Estonia, Democratic Republic of the Congo, Egypt, Hungary, Ireland, Israel, Italy, Japan, Latvia, Lithuania, New Zealand, Nicaragua,[48] Namibia, Niger, Norway, Paraguay, Poland, Portugal, Russia, Slovakia, Slovenia, South Korea, Sweden, Tanzania, Thailand, Turkey, and Ukraine.

Second, a smaller number of countries better fit the model of mixed central and subnational leadership:

In *Argentina*, many of the environment-related responsibilities are distributed among several central ministries but coordinated through the Argentinean National Climate Change Cabinet (GNCC, for its Spanish acronym), which coordinates the responsibilities among several ministries and all interjurisdictional matters regarding different levels of governments. In addition, several provinces have established laws for environmental protection in a variety of

[48] In the case of Nicaragua, citizens between 6 and 65 years of age will have the duty to plant 10 trees a year in areas defined and prepared for that purpose by the municipalities

areas such as soil conservation, water, and forestry. More generally, since there is no national minimum standards regulating waste management, each province has its own law establishing minimum conditions and requirements for the storage of hazardous waste.

In *Austria*, the federal government and the Lander (states) have some excusive responsibilities regarding the environment and climate change policy and share others. Following the national strategy, the states have introduced regional adaptation policies to fight the effect of climate change, including guidelines and responsibilities assignment for the municipalities.

In *Bulgaria*, subnational governments have substantial responsibilities regarding climate change action, including land development, waste management, and programs for the improvement of energy efficiency and the reduction of greenhouse gas emissions. They also share responsibility with the central government for afforestation policies.

In *Finland*, local governments implement nationally agreed emission reduction targets but also municipalities network and work together (the Carbon Neutral Municipalities (Hinku) network) to reduce greenhouse gas emissions more rapidly than the EU targets adopted at the national level.

In *Honduras*, the Natural Resources and Environmental Secretariat (SERNA) at the central level leads climate change related policymaking in the country and since 2012 Regional Development Councils (CDR) have been charged with developing climate change programs, but it is uncertain how effective they have been.

In *Kenya*, the National Climate Change Council (NCCC), chaired by the President, has oversight on the mainstreaming of climate change related functions at national and county levels. At the national level, several ministries and departments have established climate change units

and climate change-related plans and policies. All County Governments are required by the Climate Change Act, 2016, to develop climate change policies in their County Integrated Development Plans (CIDPs). County governments are also expected to establish Climate Change Units that will oversee the implementation of climate change actions. Counties are responsible for: disaster risk management (response measures to address drought, floods, and other climate-driven disasters); food and nutrition security; water and the "blue economy" (water management and implementation of national government policies on water conservation); forestry, wildlife, and tourism; health, sanitation and human settlements; manufacturing; and energy and transport. Counties have formed six Economic Blocs. The counties in each of the Economic Blocs were consulted while preparing the National Climate Change Action Plan (NCCAP 2018-2022). The Climate Change Directorate (CCD) in the Ministry of Environment and Forestry is responsible for coordination of the implementation of National climate change action plan. The County governments work closely with the CCD. County governments designate a County Executive Committee member to coordinate climate change affairs and report to the County Assembly.

In *Mali*, the Ministry of Environment, Sanitation, and Sustainable Development at the central government is mainly in charge of implementing and enforcing environmental laws. However, each local government is also responsible for the management, planning, conservation, and safeguarding of the ecological balance of their area.

In *Nigeria*, the federal government is the main governmental organization in charge of establishing environmental policies and enforcing them. However, each state and local government in the country may set up its own environmental protection unit, and the states are also empowered to make their own environmental laws.

In *South Africa*, the central government's Department of Environmental Affairs has

exclusive competence over natural resources but shares responsibility with the provincial governments over most environmental matters involving legislation, implementation, and enforcement.

Other countries that would seem to fit into the intermediate mixed governance model include Iceland, Romania, Spain, Switzerland, and United Kingdom.

Finally, no other countries, other than those already discussed above, would seem to fit into the decentralized model with bottom up leadership in climate change policies

The importance of intergovernmental coordination and cooperation: Country and international examples

The discussion of the assignment of functional responsibilities for climate change policies in the previous section heightens the importance of intergovernmental coordination and cooperation for effective policymaking, as it has also been highlighted in the literature (see, for example, Nelson et al. 2014).[49] This section highlights the utilization of different fora for intergovernmental coordination on climate work intra-nationally and internationally. In some cases, the mechanisms integrate vertical coordination with horizontal subnational coordination (i.e. among subnational governments), and in some others, the emphasis is exclusively on horizontal coordination.

A good example of single-country horizontal cooperation is Finland. One form of this cooperation is the Association of Finnish Local and Regional Authorities (AFLRA), which coordinates the Cities for Climate Protection (CCP) campaign (Niinistö et al. 2017). The purpose

[49] These authors also argue that cooperative policies (like central transfers to sub-national governments) and coordination policies (like enabling and funding mechanisms) facilitate effectiveness and promote vertical interdependence increasing effectiveness, in contrast to the so-called competitive policies (like federal performance standards and price mechanisms) which are prone to increasing political conflict and decreasing effectiveness.

of this campaign is to encourage cities and municipalities to plan and initiate their own actions for reducing local greenhouse gas emissions. Another instance is the Carbon Neutral Municipalities (Hinku) network, which brings together municipalities, and also businesses and citizens, with the goal of achieving reductions to greenhouse gas emissions more rapidly than EU targets require (by 80%, by 2030) (Hinku 2020). In addition, and as an example of both vertical and horizontal coordination, Finland is one of the few European countries where voluntary means, such as the voluntary Energy Efficiency Agreement scheme, have proven to work effectively and yield results. The Energy Efficiency Agreement for the Municipal Sector is an agreement between the Ministry of Economic Affairs and Employment, the Energy Authority, and the Association of Finnish Local and Regional Authorities on increasing the efficient use of energy in the municipal sector. Municipalities, cities, and joint municipal authorities sign their own Energy Efficiency Agreement, in which they commit themselves to the actions and targets specified in the Energy Efficiency Agreement for the Municipal Sector.

Another example of vertical and horizontal cooperation is the United States' Clean Energy States Alliance (CESA), which created the "100% Clean Energy Collaborative" in 2002. CESA is a national, nonprofit coalition of public agencies and organizations working together to advance clean energy. CESA works with state leaders, federal agencies, industry representatives, and other stakeholders to develop clean energy programs and inclusive renewable energy (Leon 2020). The Collaborative provides and shares information and technical assistance to states, and so far fourteen states plus the District of Columbia have so far set 100% clean energy goals for electricity, either through legislation or Governors' actions. Another example of horizontal cooperation in the United States is the U.S. Conference of Mayors and the Center for Climate and Energy Solutions (C2ES), which have built an Alliance for a Sustainable Low-Carbon

Future, with membership of all US cities with over 30,000 inhabitants (UCM and C2ES 2020).

In addition, subnational governments are increasingly engaging with each other across national boundaries on the international stage, which is likely to have positive demonstration effects on domestic action against climate change. One such example is URBACT, a European exchange and learning program promoting sustainable urban development. It helps share develop sustainable solutions for social and environmental issues. It is financed by EU funds and national and local contributions (URBACT 2020).

Another example is the EBRD Green Cities program. Funded with €1.5 billion in 2016, the Green Cities program has grown to cover 41 cities (EBRD 2020). The program helps cities customize solutions to decarbonization and its environmental needs; on joining the program, each city adopts its own Green City Action Plan, including institutional capacity for implementation, monitoring, sustainable transport, 'blue-green' infrastructure, and sustainable and efficient energy and waste management.[50] Recently, the World Bank (2020) has published its Outlook 2050 providing strategies for supporting client countries in meeting their long-term goals of decarbonization, involving technical assistance, lending, country programs and technical assistance in order to make climate action and country development policies compatible. The EU also encourages municipalities to become greener through initiatives such as the Green Capital Award, the Green Leaf Award, and the Green City Tool (ECGA 2020).

Several other international associations have been recently active. The C40 Clean Air

[50] In addition, the EBRD recently announced that is scaling up its climate and environmental programs devoting over 50 per cent of its annual investments to the green economy by 2025, as well as targeting specific emission reductions over the next five years and setting a date for a decision on when all the EBRD's projects are aligned to the Paris Climate Agreement (Bennett 2020).

Cities Declaration, launched in October 2019, with membership of cities over the world which have agreed to set pollution standards that meet or exceed national targets by 2025, and publicly report on their progress through engagement with nation-states and businesses.[51] The Under2 Coalition is an association of subnational governments around the world aiming to achieve greenhouse gases emissions mitigation.[52] As of 2018, the list of signatories has grown to over 220 jurisdictions which combined encompasses over 1.3 billion people and 43% of the world economy. Another example of international association is the Compact of States and Regions.

4. Improving the assignment of revenue and tax authority for enhancing action on climate change

In theory, subnational governments can use their own source revenue authority—where it exists—in order to penalize or reward, as the case may be, actions by businesses and households related to climate change.[53] As shown later in this section, there are many examples among OECD countries of such policies. From the conventional theory of revenue assignments, one of the most important objectives is to be able to raise revenues with the smallest possible inefficiency costs, or in other words, with the lowest levels of "excess burden" losses." That goal is met when the behavioral response—or the elasticities—of taxpayers is relatively small. That is, the one constraint subnational governments have to raising revenues efficiently has to do with the mobility of businesses or even households. Economic agents will consider relocation to

[51] The cities so far that have signed up to the C40 Clean Air Cities Declaration are: Amman, Austin, Bengaluru, Barcelona, Berlin, Bogotá, Buenos Aires, Copenhagen, Delhi, Dubai, Durban (eThekwini), Guadalajara, Heidelberg, Houston, Jakarta, Los Angeles, Lima, Lisbon, London, Madrid, Medellin, Mexico City, Milan, Oslo, Paris, Portland, Quezon City, Quito, Rio de Janeiro, Rotterdam, Seoul, Stockholm, Sydney, Tel Aviv-Yafo, Tokyo, Warsaw and Washington D.C.

[52] Originally, it was created as a partnership between the governments of California and Baden-Wurttemberg, with The Climate Group acting as secretariat.

[53] The basic question asked in this section is how revenue assignments in fiscal decentralized systems can be best adapted to combat climate change. However, it is also very likely the case there is some sort of reverse causation. That is, climate change events are likely to affect the revenue structure of subnational governments by changing economic activity patterns, development and tax bases. For example, Sanoh (2015) studies the impact of rainfall shocks on local government financing in Mali.

another jurisdiction if, all other things being equal, they can manage to reduce their tax burdens.

All those considerations play quite differently in the case of using taxes to combat climate change. As discussed further below, to correct for the externalities associated with climate change, the main type of economic instrument (EIs) utilized is to tax polluting activities with "Pigouvian taxes." Although these taxes typically yield a "double dividend," in that they discourage the polluting activity *and* raise revenues, the main purpose of these taxes is to affect behaviors and not to raise revenues. Therefore, a good revenue-raising tax and a good Pigouvian tax have different properties. In particular, a general good (subnational) tax falls on goods and activities with limited elasticity, thus being less distortive and raising more revenues. In a Pigouvian setting, however, the goal is to maximize the elasticity of response, so that with small tax levels, for example in the case of carbon, emissions can be reduced as much as possible.[54]

Note that with both "good" subnational revenue raising taxes and also with Pigouvian taxes, economic agents (especially in the case of households) are likely to weigh the benefits of additional general public services and also environmental services (such as a cleaner and safer environment) against the burdens of any additional taxes. However, when the benefits are not localized, the quid pro quo of involving local taxes is more likely to dissipate. In those cases, the potential mobility of economic agents—and therefore of potential tax bases—is likely to impose significant constraints on well-intentioned subnational tax measures for climate change. Raising taxes in one location may just move the polluting activities to another location. These situations call for using taxes at higher level of government, such as regionally or nationally, or indeed, if possible, via internationally coordinated taxation across national boundaries.

[54] In this case, the reduce economic activity is not an "excess burden" but rather a desired benefit. See, for example, Avner et al. (2014) for a discussion of these points.

A second constraint for using taxation at the subnational level to combat climate change and one of a more practical nature is that subnational governments in many countries, and especially so in the case of developing countries, often have very low levels of general taxation authority. This is a more general problem that leads to substantial vertical fiscal imbalances, with subnational governments having much larger expenditure obligations than authority to raise their own revenues, and thus having to rely on central government transfers to finance those expenditure needs. This low revenue or tax authority is likely to be more limiting for subnational governments' decarbonization actions, which generally speaking require some type of Pigouvian taxes, and less so for adaptation policies, which can be also supported with intergovernmental transfers. An additional obstacle for subnational government action is the perception (or reality) that charges for desirable household actions (e.g., improved housing and energy consumption standards) will tend to have a regressive incidence, penalizing lower income groups, while subnational governments have less ability to offset any regressive effects via other tax or expenditure policies.

In order to better assess the potential role that the tax and revenue assignments at different levels of government may play in devising more effective policies for climate change, it is helpful to briefly review the general theoretical principles for revenue assignments as well as the most common hurdles observed in actual practice and how those may be adapted to combat climate change.

Basic principles of revenue assignments

Subnational revenue autonomy is sometimes dismissed as a non-important peripheral issue, but it is at the core of effective fiscal decentralization. The fundamental premise of fiscal decentralization is that it has the potential to increase the overall efficiency of the public sector

and lead to improved social and economic welfare. One critical assumption behind those expected outcomes is that decentralized governments will generally be more knowledgeable, responsive, and accountable to citizens' needs and preferences. At the same time, there is a large consensus among experts in decentralization that the increased accountability associated with decentralization can only be assured when subnational governments have an adequate level of autonomy and discretion in raising their own revenues. This responds to a simple yet powerful logic: subnational authorities will spend resources differently (more responsibly and efficiently) when they need to incur the political costs of taxing their constituents, in comparison to what they would do if the money comes to them, practically cost-free, from the central government in various forms of transfers. As part of a "common pool problem," when subnational expenditures are being financed by other taxpayers outside the jurisdiction, there will be perverse incentives to overspend and/or to spend less efficiently because of the lower scrutiny and accountability for spending funds that come from outside than for funds that have to be raised in the jurisdiction with higher political costs for decisionmakers.

There are multiple trade-offs in designing the tax structure at the subnational level. Given the different criteria that subnational taxes should meet, the choice of particular taxes comes down to a comparison of the advantages and disadvantages that each of those taxes offer. Among the desirable properties are: good revenue potential, with high elasticity or buoyancy (meaning that revenues will grow proportionally with the economy), high adaptability to the benefit principle (so that those paying the tax are those using the public services), an even geographical distribution of tax bases (so that there is less disparity in per capita revenues across jurisdictions), fairness and equity in the distribution of tax burdens (those with higher incomes pay proportionally more), lower costs of administration and compliance by taxpayers, higher

acceptance and better perception about the tax among officials and the public, and high visibility of the taxes to facilitate greater accountability by public officials.

Among those properties that are negative, the most significant to be avoided is the inter-jurisdictional mobility of the tax bases; highly mobile bases make it much harder for subnational governments to imprint their own policies and may be conducive to inter-jurisdictional tax competition, potentially creating scenarios with competing jurisdictions engaging in rounds of lowering tax rates in order to attract large tax bases. Other negative properties to be avoided include the inducement of large inefficiencies in the allocation of economic resources, high sensitivity of revenue collections to the fluctuations of economic business cycles (since subnational governments have less ability to finance deficits), the risk of incentivizing or facilitating corrupt practices among tax administrators and taxpayers, and the risk that tax burdens may be exported to other taxpayers in other jurisdictions (causing less accountability and fiscal responsibility).

In addition, there are some practical considerations to consider in designing revenue assignments:

1. prior establishment of expenditure needs is required since "finance should follow function" in an adequate manner, and because different services may call for different forms of financing (fees or charges versus taxes);[55]
2. providing subnational governments with a closed list of subnational taxes is preferable because it avoids the introduction of nuisance or even highly distortionary taxes;
3. although central governments may prefer the assignment of exclusive tax bases at different levels, the co-habitation of tax bases is generally preferable. This allows meaningful subnational revenue autonomy by providing access to some sizable and buoyant tax bases; if negative vertical externalities (tax decisions at one level affect the tax bases and revenues of other levels of government), these can be addressed by

[55] Fees and charges are a straightforward way to raise revenue in accordance with the benefit principle covering the cost of providing specific local government services. Reliance on user fees tends be low in practice as they are often perceived as potentially regressive.

intergovernmental transfers;

4. revenue autonomy for subnational governments is best provided by allowing them to set tax rates (between minimum and maximum rates) and not by allowing them to determine tax bases; harmonized tax bases across jurisdictions reduce otherwise potentially large compliance and enforcement costs; and
5. the decision of which level should oversee administering each tax should be based on pragmatic considerations regarding information and scale; in particular, some subnational taxes can be best administered by the central tax administration and still remain a subnational-determined tax.

Despite the benefits of subnational tax autonomy, the observed international practices, with some exceptions, have low levels of tax autonomy. This would appear to respond to powerful political economy incentives resulting in a perverse equilibrium between the two main players involved. Central governments are reluctant to devolve taxing powers for fear of having to compete with subnational governments for the same tax bases and fear of losing control over fiscal policy. At the same time, subnational governments are reluctant to take on the responsibility of making politically unpopular decisions to raise their own taxes, preferring central governments transfers as the mode of financing their expenditure needs. A situation of transfer dependence by subnational governments with large vertical fiscal imbalances is a common outcome in many decentralized countries.

Applying basic principles and best practices of revenue assignments for climate change policy action

What do the theory of revenue assignments and the best practices just reviewed tell us about the level of government that is better equipped to impose taxes, fees, and charges for climate action? How should the different “green” taxes be assigned between central, regional, and local-level governments to maximize decarbonization and adaptation activities? An important factor to keep in mind, as already discussed above, is that a good general revenue-raising subnational tax and a good Pigouvian tax have different properties. In order to correct for the externalities associated with GHG, the main policy is to discourage the polluting activity via

Pigouvian tax, and to the extent that pollution is measurable, the goal is to set said tax equal to the marginal damage of the external cost caused, thus setting the proper incentives to the polluters (Cointrau and Hornig 2003; Alm and Banzhaf 2012).[56] Again, the main objective is not to raise revenues but to reduce the polluting activity. Of course, using green taxes begs the question of what level of governments should be responsible for these taxes within the general legislation on revenue assignments.[57] If the externality is confined to a local area, the responsibility for the proper tax should be local. As the area of the externality increases to the regional or national level, then the proper assignment of tax powers should be regional or national.

As already discussed in the introduction, potentially the biggest constraint on subnational taxation is the mobility of tax bases: firms and households may move out of jurisdictions with taxes above the average. Thus, subnational governments need to consider the strategic responses and interactions with neighboring jurisdictions in competing for mobile tax bases.[58] Again, this is not a certain outcome, especially if there is balance in the fiscal exchange and the benefits are perceived to offset the higher taxation costs. As green taxes yield a double dividend (a cleaner environment and increased budget revenues), these additional revenues can be used to produce more and higher quality public services or to invest in adaptation investment measures which

[56] The alternative is a subsidy on pollution abatement that acts as a "carrot" (as opposed to the "stick" represented by the tax). Even though is politically more attractive, it has the significant negative side of incentivizing more pollution. There is also the issue of where the funds for the subsidy will come from. Thus, clean-up subsidies are not an attractive policy strategy. Note that there are other (non-tax) government revenue-generating instruments, such as charges, auctioned permits, or even reductions in subsidies.

[57] However, within the traditionally locally assigned taxes, there may be room for some "green surcharges"; for example, under the property tax, buildings that do not meet certain environmental conditions could be taxed at higher rates, or alternatively, those that do meet the restricts may be taxed at lower rate or be granted credits; the same applies for local motor vehicle taxes.

[58] There is some empirical evidence on the mobility of factors of production and households in response to taxes but how much of a constraint for subnational governments in using taxation to control pollution, GHG emissions and so on is more of an open question. The evidence of subnational tax competition and "races-to-the-bottom" is reviewed in Wilson (1999).

may reduce the incentive to out-migrate.

There are some other additional factors conditioning green revenue assignments. Following the principles of taxation discussed above, many countries will provide subnational governments with closed list of taxes. This means that there must be a willingness of subnational governments to use the "green" taxes but also a willingness by the national authorities to grant those powers in the closed list of taxes for subnational governments. Both, willingness by subnational governments to use the taxes and willingness by central governments to devolve that authority are generally scarce in the actual international practice.[59]

Some technical issues may also act as binding constraints. Even though emission taxes may be more administratively efficient to collect and harder to avoid than, say, income taxes, some forms of environmental taxation are quite complex to administer, and these difficulties can be compounded when taxpayers are sophisticated global multi-unit businesses which practice in different venues for tax avoidance, such as through transfer pricing and profit shifting. It is likely that many subnational governments may not have the required high levels of sophistication in tax administration to overcome such behaviors by the tax base.

Another important technical constraint is related to the ability to measure and monitor pollution emissions levels. Again, it is likely that many subnational governments may lack those abilities even in developed countries. However, in a number of countries, large, sophisticated subnational agencies do, in fact, undertake emission monitoring (for example, South Korea). In addition, the capacity constraint is most relevant to emissions taxes, not to carbon taxes on goods and services which are GHG intensive (such as gas taxes). In the latter case, there would seems

[59] Typically, however, in the case of non-tax policies, such as licenses and fees and charges for forestry, small mining activities, etc., subnational governments are granted much more freedom

to be more significant scope, globally, for the further assignment of such taxes to subnational governments, including developing countries. The next paragraphs more closely cover the specific forms of taxation that can be used for decarbonization activities and also potentially help with the financing of adaptation activities.

Decarbonization activities. Carbon taxes are among the most popular decarbonization tax measures, but would they work as decentralized government instruments?[60] There are some considerations in favor of their decentralization. Carbon taxes not only offer incentives to keep the cost of decarbonization down, but a certain level of flexibility may be desirable for subnational governments to design suitable policy frameworks specific to their local circumstances, which may be harder for national authorities to design because they lack that information about the different types of polluting activities and so on. It is in this context that Metcalf and Weisback (2009) argue carbon taxes can be fully or partially delegated to subnational governments so that tax rates can be set to fit the differing costs of carbon emissions and abatement.

On the other hand, there are several considerations that work against the decentralization of carbon taxes, or of other similar instruments, such as cap-and-trade. As already discussed above and emphasized early on by Hahn and Noll (1981), subnational authorities would need to understand the pre-regulation pattern of emissions, the abatement opportunities available, and have the ability to monitor emissions and pollution levels—again, requirements that are unlikely to be met, especially in developing countries which lack that type of administrative capacity.

[60] More specifically, for example, Ahmad and Stern (2009) discuss the possibilities for implementing a carbon tax, assigning it to the federal/central level, and levying it as an excise tax at the production or import stage (as a specific, as opposed to ad valorem, excise tax) based on quantities imported and produced domestically as opposed to a state/regional tax at the final point of sale, in the contexts of India and Pakistan.

There is also the threat of subnational tax competition yielding a suboptimal equilibrium with low "green taxes." and the resulting outcome may be a suboptimal perverse equilibrium where a large numbers of subnational governments introduce lower than optimal tax rates.

Beyond the reasons just listed, and the generally large level of externalities involved with emissions, there may be other important reasons why the federal or central governments should be the level administering carbon taxes in a federal or decentralized system of finance. From a tax administration perspective, a central government tax would be much easier to administer and enforce for tax officials and easier to comply with for taxpayers than a multitude of potentially different subnational taxes (Ahmad and Stern 2009). Also, carbon taxation is likely to generate an uneven distribution of costs among subnational governments, firms, and households.[61] If distributional considerations matter, and they always do, federal/central collections of revenues would make it simpler to introduce compensatory measures for subnational governments that would be relative losers, for low income groups, or for selected businesses. The introduction of carbon taxes may have to be accompanied by other changes in redistribution policies including direct transfer programs or through changes in direct taxes (Poterba 1991; Callan et al. 2008; Ahmad and Stern 2009; Gago et al 2020). The potentially uneven distribution of the costs of carbon taxes among subnational governments can be an obstacle to their introduction which could be addressed by changes in current system of intergovernmental transfers (Tang 2011).[62] There may also be market considerations requiring government intervention, because carbon taxes and tradable emission permits could have a different effect on firms, for example benefitting larger firms with monopsony powers (Noll 1982).

[61] See, for example, Bureau (2011) for an estimation of the distributional effects of a carbon tax in France.
[62] Tang (2011) argues that uneven distribution of carbon taxes across provinces in Canada has stalled progress on this reform.

But even if carbon taxes may not be the optimal instrument for subnational revenues, there are many other non-tax revenue sources that can be used to encourage climate-friendly actions by citizens and businesses. These involve fees and charges for the preservation of the environment, involving construction, transportation, forestry and so on.[63]

A particularly relevant issue in subnational "green" taxation is whether the revenue proceeds from green taxes and fees should be earmarked to action and programs related to the decarbonization of climate change. For example, the State of Georgia in the US has debated in recent years whether to introduce a (state) constitutional amendment to force the state to spend "green" fees (for tire disposal and landfills) on environmental cleanup programs. Earmarking, in general, is not considered to be a good budgetary practice, because all spending programs should be considered simultaneously at budget time and compete for the scarce resources available in the budget. However, there are exceptions to this general principle, such as gasoline taxes used for highway maintenance, which work as a user fee substitute that is easier to collect. The purpose of taxation would also seem to be a valid argument for keeping the uses of revenues from green taxes and fees for environmental and climate change purposes. However, the main effectiveness of carbon taxes, like other green taxes and fees, in discouraging activities that produce GHG is realized independently of how those revenues are later utilized.

Adaptation activities. These activities may include the building of certain types of infrastructure which can limit economic damages down the road due to climate change. These

[63] However, subnational governments might and do levy related fees and charges more with revenue collection and financial benefit in mind rather than focusing on the reduction of emissions or the preservation of ecosystems. See, for example, Nurfatriani et al. (2015) for a critic of Indonesia's local government forestry fees. In this regard, more generally, the IMF recently has recommended policymakers to use "feebates," which are defined as sliding scales of fees on activities or outputs (such as such as transportation, power generation, agriculture, or forestry) with above-average emission rates, and subsidies or rebates for those with below average emissions (Zhang 2020).

actions can be financed via transfers, especially when geographical externalities are present, or through own revenues. In addition, taxes and other charges can be used by subnational governments to deter certain decisions and behaviors that will tend to increase the costs of adaptation. For example, higher taxes and fees can be imposed on home builders in flood plains if outright forbidding them via zoning does not work. In general, with adaptation activities, the question is not so much of deterrence or creating disincentives to particular activities but instead how to generally help finance adaptation work in response to natural disasters and so on. To the extent that the consequences of climate-change related disasters tend to be more localized, there is more room for using the benefit principle for subnational financing. That would call for the use of fees and charges as well as traditional subnational instruments such as real estate property taxes, betterment levies and other land value capture measures, and property transfer taxes. One issue to take into account is the incidence and distributional impact of these measures. For example, it tends to be the case that the areas most prone to natural disasters in metropolitan areas are more likely to be slums inhabited by low-income households with little access to more desirably-placed housing. Applying the benefit principles under those conditions certainly would be questionable and likely hardly effective, since the ability to pay of those residents would be low.

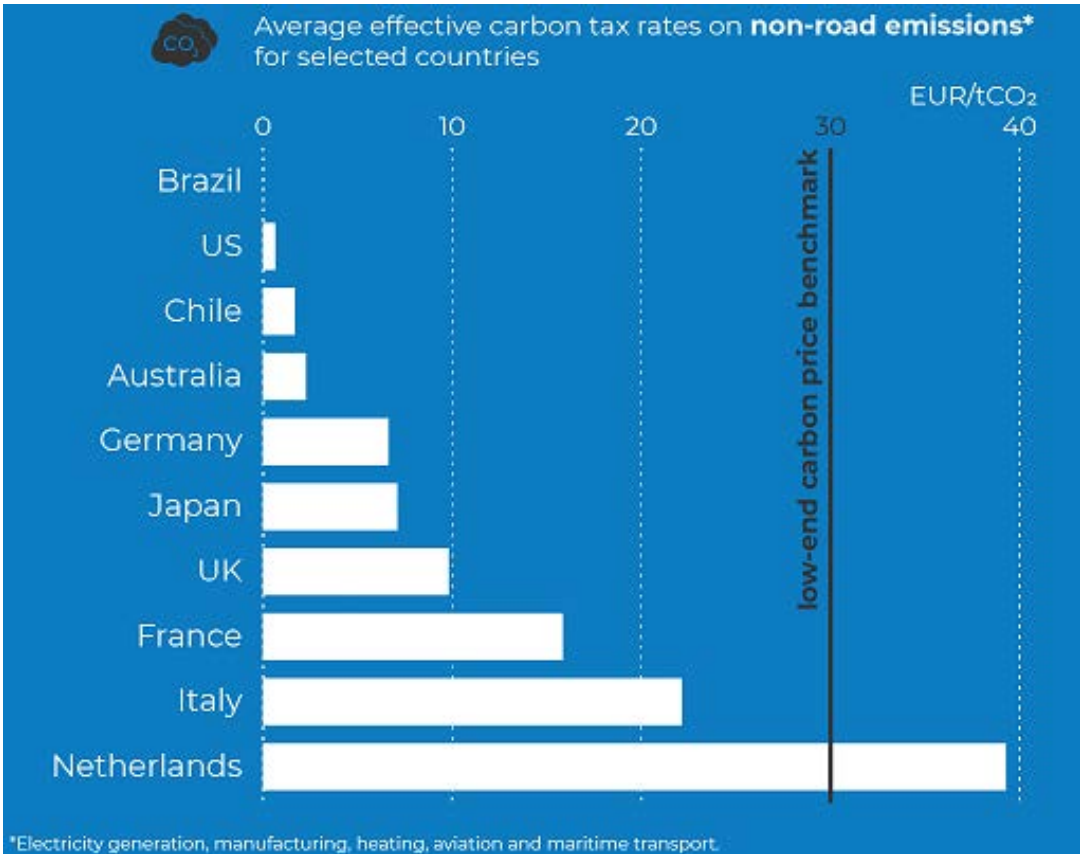
A more recent innovation in the financing of adaptation policies merits special mention. Subnational governments can use taxes and fees that capture the value created by installing green infrastructure, such as storm water management, by using tax increment financing and other land value capture measures. Indeed, land value capture taxes and fees are increasingly being used as revenue raising instruments to implement many types of adaptation infrastructure developments (see, for example, Ingram and Hong 2012; Smolka 2013; Grafakos et al. 2018; Kozak et al.

2020; Welch et al. 2020). This is one of the promising trends the next sub-section will touch upon.

What are current promising (and unhelpful) practices in revenue assignments in different countries?

One of the most conspicuous features of the current state of taxation policy for climate change is its significant underutilization. Revenues from environmental taxes, including carbon taxes and all other levies on products and activities harming the environment, are generally low even in OECD countries. As of 2016, on average OECD countries were raising 1.63% of GDP from environmental taxes, representing only 5.3 % of total revenues and $621 per capita (OECD 2019). Further, currently taxes on polluting fuels appear to be nowhere close to the levels needed to encourage a significant shift towards clean energy. As reported by the OECD (2019) in Figure 2, seventy% of energy-related CO2 emissions from advanced and emerging economies are entirely untaxed and some of the most polluting fuels remain among the least taxed. Thus before describing some current practices in the assignment of tax authority to fight climate change, it is important to notice that, generally speaking, regardless what the actual assignment is, there is ample room for both central and subnational governments to make much more extensive use of green taxation. These overall low levels of green taxation nationally, in combination with the generally large vertical imbalances most decentralized countries experience—that is, the asymmetry between the much larger expenditure decentralization versus the much smaller revenue decentralization or tax autonomy of subnational governments—leads us to anticipate generally low levels of green taxation by subnational decentralized units.

Figure 2. Current Polluting-Fuels Taxes versus Ideal Level



Source: Saint-Amans 2020.

In a relatively large number of countries, just about all green tax decisions and sources are centralized and the overall level of green taxation varies quite considerably across these countries.[64] In another group of countries, subnational governments have been assigned traditional levies that have a potential bearing on green taxation, such as taxes on motor vehicles, road taxes, and water supply, sewage, and waste charges, but which generally are not linked to emissions or environmental performance and where subnational governments have not been

[64] These includes Argentina, Estonia, Chile Czech Republic, Finland, Greece, Hungary, Iceland, Ireland, Japan, Mali, Mexico, the Netherlands, New Zealand, Portugal, Serbia, and the United Kingdom.

granted any authority over revenue yielding non-traditional green levies.[65] In addition, many of these countries have some form of revenue sharing of green national taxes with subnational governments and here again in this group the overall level of green taxation varies considerably.

The text that follows identifies green revenue assignment practices in different countries, which perhaps could be imitated in other countries so to strengthen the role of subnational governments in fighting climate change from the revenue side of the budget. As mentioned before, these and all green taxes provide the double dividend of local budget financing and the decarbonization of local economic activity.

In *Belgium*, the Flemish regionally established climate fund draws its revenues from the auction of emission allowances (under the EU's Emission Trading System [ETS]).

In *Brazil*, most states and large municipalities operate environmental funds partly fed by revenue from environmental fines and oil and gas revenues.

In *Canada*, the Pan-Canadian Framework Implementation is supported by investments from the federal government to meet the 2030 emissions reductions target and consists of several pillars, the main one being the Pricing Carbon Pollution arrangement: The government of Canada introduced a carbon-pricing benchmark in October 2016. The benchmark allows provinces and territories to implement the pricing system of their choice (a carbon tax, a carbon levy and performance-based emission system, or a cap-and-trade system). The revenues from these pricing systems are to remain in the jurisdiction of origin. Still in Canada, the province of British Columbia's "Sustainable Environment Fund" gets financed by a batteries tax and a tires tax

[65] Among these countries are Bolivia, Bulgaria, Colombia, India, Honduras, Kenya, Romania, Russia, and Switzerland.

In *China*, provincial governments have the authority to set the tax rate for coal production activities, within the range of 2 to 10 percent, which is legislated by the central government.

In *France*, both municipalities and departments can charge a tax on electricity consumption. €0.250 per megawatt-hour, multiplied by a factor between 0 and 8 for the municipal part of the tax and by a factor between 2 and 4 for the departmental part of the tax.

In *Indonesia*, provinces and local governments have been assigned a list of environment-related taxes.

In *Italy*, municipalities and provinces can levy an additional tax on electrical energy.

In *Latvia*, local governments can levy an air pollution tax (and get to keep 60% of the revenues), and a tax on the imports of radioactive substances (in this case keeping 30% of the revenues).

In *Lithuania*, local government receive 70% of the air emission non-compliance fees charged on emission amounts exceeding standard limits.

In *Norway*, the local government of Svalbard charges an environmental fee to all tourists visiting the jurisdiction.

In *Poland*, there is a local charge for bush and tree removals and the revenues from the tax on air pollution are shared by all level of government.

In *Slovakia*, there is a local air pollution tax.

In *South Korea*, local governments can levy an ecosystem conservation charge (with half of the revenues shared with the central government) on development projects which have a

substantial environmental impact.

In *Spain*, regional governments levy taxes on air pollution emissions, disposable plastic bags, industrial waste, environmental damage caused by large commercial establishments, and the storage of spent nuclear and radioactive waste. They also levy a fee paid by enterprises applying for the granting, modification, extension, and renovation of the European Ecolabel.

In *Sweden*, local governments can levy an excavation charge and a license fee for exploitation of peat.

In the *United States*, many states have introduced their own green taxes. For example, California has introduced an electronic waste recycling fee and hazardous substances taxes; the state of Illinois has a dry-cleaning license tax and an electricity excise tax; and in Indiana, there is an aircraft license excise tax, a hazardous chemicals inventory fee, an underground storage tank fee and a waste tire management fee. In addition, many of the federally-levied green taxes are shared with state governments.

5. Redesign and innovations in transfer systems to combat climate change

From a first look, intergovernmental fiscal transfers appear to be the most suitable public finance instrument for internalizing spatial externalities associated with conservation and preservation policies against climate change as well as for financing adaptation programs, especially those showing inter-jurisdictional externalities. Transfers, subsidies, and direct performance contracts and agreements between the central and subnational governments represent the most versatile and direct set of tools to influence the subnational policies to fight climate change.

As in the case of expenditure and revenue assignments, in order to assess the potential

role that transfers, subvention and agreements between different levels of government may play in devising more effective policies for climate change, it is helpful to briefly review the general theoretical principles for transfer design as well as the most common challenges observed in actual practice.

Basic principles of transfer design

Transfers and grants are important components of the revenue architecture for subnational governments. They are necessary to help close vertical fiscal gaps due to the inadequacy of own tax sources in revenue assignments and horizontal fiscal imbalances stemming from the different fiscal capacities and expenditure needs across subnational governments at any level. Transfers are also important for pursuing national objective priorities through subnational government actions, addressing different types of externalities which otherwise subnational governments would not take into account, financing certain expenditure programs on behalf of the central government and specific investment programs, incentivizing better subnational expenditure performance, and so on.

The most common mistake made in transfer design is to pursue multiple—sometimes contradictory—objectives with a single instrument. This results in confusion about the objectives pursued and make monitoring actual performance of the transfer hard or impossible. The best international practice is to follow the general rule of using one separate instrument (transfer) for each distinct objective.

The most commonly used types of intergovernmental transfers include revenue sharing, equalization transfers, conditional block and specific grants (including capital grants), conditional block and specific subventions, and performance-based grants. The latter utilize ex-

post type conditionalities, as opposed to the ex-ante conditionalities used in the case of conventional conditional grants. Next is a review of the basic structure and objectives of each of those main categories.

Revenue sharing arrangements provide subnational government with a percentage of certain central tax revenues. Their allocation is generally implemented on a derivation basis (shared with the jurisdiction where the central revenues are collected), although other allocation formulas are also used, such as by population or per a weighted index with several variables. The two most important objectives pursued with revenue sharing are that of helping to close existing vertical fiscal imbalances and that of "devolution" (i.e., to provide incentives to develop regional economies and a sense of national balance and cohesion rewarding economic activity).[66] Revenue sharing funds are typically provided unconditionally, so that recipient subnational governments can use them as part of their general discretionary budgets; it is in this sense that they are expected to help close existing vertical gaps.[67] This feature, the unconditional use of funds, reduces the attractiveness of revenue sharing as an instrument to pursue environmental and climate change objectives.

Equalization transfers are generally needed because the level of economic activity and wealth differs markedly across subnational units, and the assignment of own revenue sources and tax sharing result in horizontal fiscal imbalances. These horizontal imbalances can be enlarged when demographic composition and other circumstances create further disparities in expenditure

[66] Revenue sharing following devolution objectives clearly benefits the most economically dynamic regions of the country. But inequality or horizontal fiscal imbalances created can be addressed by a strong equalization grant, which recognizes the revenue sharing funds as part of the fiscal capacity of subnational governments, and in turn reducing, if not eliminating, the equalization funds eventually received by those areas favored by the revenue sharing arrangements.

[67] Nevertheless, there are countries (like Argentina, Brazil, or India), that attach multiple objectives – including equalization—to revenue-sharing grants. The multiple objectives are pursued through different variables and factors used in the sharing allocation formulas.

needs. Horizontal fiscal disparities are undesirable on both equity and efficiency grounds. If not addressed, citizens in different locations would have different access to basic services, which may lead to undesirable fiscal migration (as opposed to economic migrations for job opportunities, etc.).

The commonly accepted objective of equalization grants is to allow all subnational governments to provide similar access to all residents to a standard package of public services, exercising an average level of tax effort. The basic architecture of equalization grants includes the determination of the pool of funds and an allocation formula. The former determines the actual degree of equalization to be achieved, and the latter typically incorporate differences in fiscal capacity and expenditure needs across subnational governments. Equalization funds are also generally unconditional and part of general subnational revenues. This, and the general principle of one separate instrument for each separate objective, also makes equalization transfers generally unsuitable for the pursuit of environmental and climate change objectives.[68]

Conditional transfers are generally used to incentivize or mandate certain types of actions from, or spending by, subnational governments.[69] These transfers come in many different shapes and forms and because of their design flexibility are ideal instruments to pursue environmental and climate change objectives at the subnational level. The main types of conditional grants include block grants (with general ex ante conditions that the funds must be spent in some general functional area, for example, improving the environment) and specific grants (with much

[68] Still, adequate transferred equalization funds can be quite crucial to facilitates the financing of adaptation policies by less well-off subnational governments which lower fiscal capacity.
[69] They may also be known as conditional grants, subsidies, or subventions. Agreements between the central and subnational governments are also generally financed by conditional transfers. Conditionalities typically specify the function for which and how the funds are to be spent. These may involve—non-exclusively—financial conditions (like matching requirements), administrative conditions (like production and service delivery conditions), and informational conditions (like data on impact and effectiveness).

more detailed ex ante conditions for how the funds must be spent, for example, a sewage treatment plant in a particular location). Both types may or may not include a matching clause, requiring the simultaneous contribution of funds by the recipient subnational government. Finally, the type of conditionality attached can be ex ante or ex post—the latter as in the case of performance-based grants.[70]

Conditional grant design should always start with the fundamental question of what type of instrument would be best fit to achieve the goal being sought. From this perspective, it is important to recognize that there is no absolute dominance of one type of conditional grant over others, for example, of block grants over specific grants or performance-based grants over ex ante conditional grants. Because conditional grants limit the (spending) autonomy of subnational governments, from that perspective general block grants are generally preferable to specific grants. However, specific purpose grants (with ex ante conditionality or ex post performance-oriented conditionality) may be what is needed depending on the policy objectives being pursued. For example, when central governments try to address externalities (negative and positive) across subnational governments, a specific grant may be what is needed since it offers greater assurance that the central governments' preferences will be respected during implementation.

It is worth highlighting two types of conditional transfers with relevance to climate change policies: capital transfers and performance-based transfers.

[70] Conditional grants are also used to finance delegated functions (central authorities are still responsible for the service but use the subnational government as an agent for its delivery). These are known as "pass through" or "agency" or "cost reimbursement" grants. Overall, given the many forms of fund transfers, the types of distribution approaches and the types of control that can be imposed, there may be over 60 types of possible transfers. As a reaction to the overuse of specific grants (often small, costly to administer, with high compliance costs and often with contradictory objectives), there has been an international trend over the past several decades towards the simplification of transfers systems, by increasing the share of general purpose block grants over specific grants.

Regarding *capital grants*, the international practice is generally to use distinctive separate capital grants or transfers in support of subnational governments' needs to build public capital infrastructure, including climate change adaptation efforts. Even though all budget priorities should be considered simultaneously in the allocation of scarce fiscal resources, given their "lumpiness" and non-recurrent nature, the needs for capital infrastructure typically require specialized instruments, different from (recurrent) equalization transfer or ordinary conditional grants. Capital grants generally complement operating surpluses and borrowing as the financing sources of the capital infrastructure needs of subnational governments.

In terms of objectives, capital transfers may seek to close differences in infrastructure stocks across subnational governments, support central government's specific sectoral objectives, or help address externalities across subnational governments. In terms of design, capital grants can either be specific project-based grants, or categorical or block grants, which give more discretion on how the funds can be spent.[71] And in terms of their distribution, capital grants can be allocated by ad hoc decisions and negotiations, by using pre-established formulas, or by competitive processes with defined application procedures. Finally, as in the case of most other transfers, incentives matter in the design of capital grants. One overriding common concern is that of achieving "additionality," or that the grant does not simply substitute for subnational government funds. Matching fund arrangements are used for this purpose. But the concept of additionality should not be erroneously interpreted to mean that that transfers funds would only be made available if the project is not completely or entirely viable or cannot be financed by any

[71] Two common design biases are to believe that capital expenditures are always more efficient than recurrent expenditures and to ignore the future maintenance requirements of new infrastructure. Matching arrangements are frequently used to induce subnational ownership and proper maintenance of existing infrastructure.

other means.[72]

Performance-based grants use ex-post conditionality and are increasingly used by central authorities to incentivize improvements in service delivery and overall subnational government performance. The amount of funding is linked to performance according to predetermined criteria. Incentives can be provided by: 1) granting access to the grant scheme based on performance; 2) increasing/decreasing the grant amount based on performance; and 3) allowing more discretion in the use of the grant resources also based on performance. The most crucial design area in this type of grant lies in the specification of the performance criteria. Often, the performance measures—which should always be linked exclusively to actions for which subnational governments are genuinely responsible—are related to institutional dimensions, such as in revenue collection effort, planning, financial management and reporting, or governance issues. Performance can also relate to service delivery as measured by outputs and outcomes. Typically, access to the program is linked to meeting some minimum conditions. Many intergovernmental agreements or contracts, as used in countries like Australia and the United Kingdom, can be interpreted as a variation on performance-based grants, since the payment under contract is typically tied to delivery or performance criteria.

Applying basic principles and best practices of transfer design for climate change policy action

The generally desirable unconditional use of funds in equalization grants and revenue sharing make these types transfers generally not well-suited for coordinated climate change policy action among central and subnational governments.[73] This does not mean that it cannot be

[72] See the World Bank (2018) for a discussion of this issue.
[73] An entirely different issue, somewhat already addressed above, is whether the expenditure needs of subnational government for mitigation and adaptation policies related to climate change should be considered in the formulas of utilized for the distribution of existing equalization grants. The answer to this question is decidedly affirmative if those responsibilities have been assigned—as is commonly the case—to subnational governments. For further discussion, see Ring (2002).

done, but rather that is much more desirable to utilize separate instruments for each objective, so that the effectiveness of each instrument as well as the policy impact are more transparent and easier to evaluate. In contrast, conditional grants, for recurrent or capital purposes and with ex-ante or ex-post conditionality, are generally well-equipped for designing and implementing climate specific transfers to subnational governments.[74]

Despite the general desirability of the design principle of "one objective per transfer," the embedding of climate considerations in transfers which are targeted primarily at other purposes may not always be a bad idea. Under what circumstances may embedding of climate issues be desirable? Given the extensive expenditure assignments that subnational governments have in many countries in areas such as housing and transport, it would seem that designing those existing transfers in climate-sensitive ways may have significant net climate impacts. The "one objective per transfer" principle of transfer design can still be largely respected if transfers are designed to in addition encourage or further incentivize the use of green means of transportation or house building—altering *how* the objective is achieved, not the objective itself. On the other hand, there could be cases in which embedding climate considerations in the transfers design may just go too far and pervert the main objective of the transfer. This may have been the case India's equalization grant design (discussed further below) when it included the "forest tree coverage" as an important additional expenditure need in the equalization formula. In this case, preserving the wholeness of "true" expenditure needs and fiscal capacity calculations would be primordial for equity and fairness in the design of the equalization grant. Introducing "forest tree coverage" —a worthwhile objective in itself—as an expenditure need of the state governments

[74] One question to ask is when to use transfers versus when to use taxes to address climate change issues at the subnational level. Although for simple political economy reasons, subnational jurisdictions may prefer transfers, levying green taxes and the like has the additional benefit of generating higher subnational government accountability.

likely distorted the true fiscal needs balance and led to unfair results for poorer states. That policy also may have had less merit because using other conditional grants outside the equalization grant was certainly possible in that country.

Perhaps the general rule on the potential embedding of climate consideration in transfer design is the following: Embedding climate change considerations in the design of fiscal transfers is desirable when there is complementarity and no distortion with the goals of the transfer (as, for example, in the case of the urban transportation conditional grant discussed above), but it is not desirable when the goals or objectives of the transfers may be distorted (as in the case of the equalization grant in India and the insertion of "forest tree coverage" as an additional expenditure need).

Decarbonization activities. How to incentivize subnational governments to spend on climate decarbonization? Conditional transfers can be used to encourage subnational governments to introduce protective land-use restrictions and to incentivize different conservation activities within their jurisdictions. Conditional transfers are also suitable to compensate local jurisdictions for internalizing different types of externalities, such as the UNCDF Local Climate Adaptive Living Facility conditional grant program.

In particular, matching transfers can be used by central governments to incentivize subnational governments to provide more adequate levels of environmental protection, even in situations where inter-jurisdictional competition for geographically mobile resources may coerce subnational governments to ignore emissions and keep their green levies low (Oates 1999; Alm and Banzhaf 2012).[75] Subsidies from the central government to incentivize specific actions by

[75] See also Silva and Caplan (1997) and Nagase and Silva (2000) for formal discussions of how central governments can incentivize subnational government to take inter-jurisdictional externalities into account even when central authorities have limited information on the pollution processes and abatement costs but can observe pollution

subnational governments are just another form of conditional transfer and are used, for example, in the Netherlands to improve municipal buildings, increase sustainable energy usage, smooth traffic flows, and so on.[76] Performance–based grants can be designed for a variety of decarbonization activities, for example, to promote green procurement practices.[77] In Germany the federal funding scheme "Municipal Directive for Climate Protection in Social, Cultural and Public Institutions" targets local governments and institutions under their jurisdiction, such as schools, to improve energy efficiency in municipal buildings, in transport and mobility, in water, in sewage and in the management of municipal enterprises.[78]

Adaptation activities. How to incentivize subnational governments to spend on climate adaption? Conditional transfers can be used to compensate local governments for introducing environmentally cautious zoning. Capital block grants can be designed for promoting other climate adaptation policies like investing on large projects such as seawalls and flood prevention landscaping and infrastructure.

In the United States, the federal government has a subsidy program to help local governments (implemented through a federal agency, the Army Corps of Engineers) combat and prevent the damaging impacts of climate change. The Army Corps subsidizes local governments to purchase homes highly prone to flooding and have them torn down. In recent years, the federal government has imposed a condition that local governments must use "eminent domain" to force people out of flood-prone homes, or otherwise forfeit the funds the federal government would

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outcomes.

[76] Some types of green subsidies, especially to businesses, have the potential of running afoul of WTO rules, as discussed by Charnovitz (2014).

[77] ***See, for example, Kollner et al. (2002) for a discussion of how conservation performance measures regarding biodiversity can be inserted in the distribution formula of already existing transfers in Switzerland.***

[78] Up to now, more than 11,500 projects in roughly 3,000 German municipalities (out of approximately 12,000 in total) have been subsidized with around €525 million from the National Climate Initiative (GIZ et al. 2017).

allocate locally to combat climate change. Some local government have agreed to these new terms and some others have not.[79] Federal transfers appear to play an important role in how subnational governments respond to natural disasters. Miao et al. (2018) analyzed data covering over forty years and found that the response by US states following natural disasters is fundamentally determined by the size of federal relief transfers received.[80]

What are current promising (and unhelpful) practices in transfer design in different countries?

This discussion begins with the example of the inclusion of environmental measures in the design of India's equalization grant.[81] The current weighted index formula for the equalization grant in India uses a couple of variables (population and land area), which can be interpreted as approximating the states' expenditure needs, one variable approximating fiscal capacity (the deviation from the highest per capita income), and additionally one variable encouraging environmental conservation (the extent of forest areas in the states). This last criterion of "forest cover" was introduced by the 14th Finance Commission in 2015, because it was mandated by the Union government to give consideration to the ecology, environment, and climate change in the sharing of federal revenues with the states.[82] The issue in this approach,

[79] Part of the official mission of the Army Corps of Engineers is to offer protection from flooding and coastal storms by building levees, seawalls etc., and typically it takes responsibility for two thirds of the costs, while local governments have to assume one third. In order to decide what houses to condemn for demolition, the Army Corps of Engineers compares the estimated cost of flood damage over the next five decades to the cost of tearing the house down, plus other expenses such as moving the owners (Flavelle 2020).

[80] The Federal Emergency Management Agency (FEMA) in the United States coordinates the response to disasters that overwhelm the resources of local and state authorities. The governor of the state in which the disaster occurs must declare a state of emergency and formally request federal assistance. Other countries have similar arrangements. For example, if an event in Indonesia is declared a national disaster, there will be direct funds from central government to the affected region and the funds are managed by the National Disaster Relief Agency (BNBP).

[81] See Martinez-Vazquez (2019).

[82] The weight given to forest area in the formula was 7.5%. This measure had been recommended at different times in India (see, for example, Kumar and Managi 2009). Similar proposals have been made for other countries. For example, for Indonesia, Mumbunan et al. (2012) argue that changing the current general-purpose fiscal equalization transfers by incorporating "protected areas" as a criterion would benefit one-third of the Indonesian provinces with

however, is that even though distributing resources to encourage forest conservation is clearly a positive measure against climate change, it is doubtful that it really belongs in an equalization grant, as opposed to a separate conditional transfer.[83] In this last respect, India's Finance Commission already designs grants for disaster management from the National Adaptation Fund on Climate Change (NAFCC) and could design an additional one for forest conservation. However, from a political economy angle, the attraction in India, and elsewhere, of using the equalization grant or other large existing transfers as a vehicle to pursue environmental and climate change objectives is that the pool of funds involved is indeed large and probably much larger than those funds potentially available for climate-oriented transfers.[84]

Overall, the international experience offers a wide array of other types of intergovernmental transfers pursuing, for the most part, decarbonization objectives and, perhaps surprisingly, much less so in terms of established transfer programs in support of adaptation objectives, as opposed to ad hoc aids following catastrophic events

Conditional grants are being used in some countries for forest conservation programs and, complementarily, considerable research has been conducted analyzing the role of intergovernmental transfers for local deforestation and forest degradation management; much less work appears to have been conducted on the role of conditional transfers regarding other

an increase of the transfers from 4.2 to 12.6% (the transfer is weighted by the protected area relative to the general area).

[83] The question fundamentally is how equalizing this variable (forest cover) may be in comparison to other variables that for example, and as reported by the 14th FC, some states had been pushing for their inclusion in the devolution formula such as: The Human Development Index (HDI), poverty measures, an index of social and economic backwardness, lack of infrastructure and communication facilities, and so on. Those states with greater ability to implement forest conservation may not be those that need more equalization in fiscal capacity and general expenditures needs.

[84] And is there any evidence of this policy change in India? As Busch and Mukherjee (2018) note, India's equalization grant or tax revenue distribution reform in 2014 created the world's first ecological fiscal transfers (EFTs) for forest cover. In a preliminary analysis, these authors did not find any as yet increased forest cover across Indian states, probably due to the short period of time the measure has been in effect.

dimensions of climate change policy. In Brazil, the ecological "ICMS"[85] was introduced in the 1990s by several states as part of their revenue sharing formula with their local governments based on ecological indicators. States in Brazil are under the federal mandate of sharing 25% of the ICMS collections with their municipalities, with three-fourths shared on derivation basis and the other one-fourth according to any specific state rules. In 1989, the state of Paraná introduced the ecological ICMS by distributing that one-fourth of resources according to the percentage of preserved land that the municipality had set aside. Other states followed suit: São Paulo (1993), Minas Gerais (1995), Amapá (1996), and so on. Currently, 18 of the 26 Brazilian states have adopted the ecological ICMS.[86] One good practice aspect of the ecological ICMS is that it keeps the different objectives—devolution via destination basis and land preservation—in different transfer instruments. [87]

Portugal introduced an ecological fiscal transfer for land conservation in its 2007 Portuguese Local Finances Law (LFL). The transfer provides significant incentives for those local governments that set aside a large proportion of their land under protected status (Santos et al. 2012). Other European countries (such as Germany and Poland) have discussed the introduction of similar transfers but only France has to some extent also implemented them (Schroter-Schlaak et al. 2014).

As a different modality of assistance, in some circumstances it can be useful for higher-

[85] The ICMS (Imposto sobre Circulação de Mercadorias e Serviços) works in Brazil as a state level VAT (Faria 2020).
[86] See Ring (2008) for further discussion of Brazil's ecological "ICMS."
[87] Not many other developing countries appear to have introduced land conservation transfers despite the availability of international funds. In this regard, Irawan et al. (2014) analyze the design of intergovernmental fiscal transfers to channel REDD+ (reducing emissions from deforestation and forest degradation) international funds to local governments in countries where this level of government has authority over forest management. Two design approaches are considered: cost-reimbursement and derivation. With the former, subnational governments with more degraded forests—which have higher opportunity costs—would receive a higher payment per unit of carbon emission reduction; the latter approach sets a fixed percentage and rate to distribute the funds.

level governments to enter into contracts with local governments to undertake "climate services." Most often, contracts between governments are based on performance indicators, and as such contracts have large similarities with performance-based grants. Several countries implement this type of contract.

In *Australia*, the Federal Government uses four types of intergovernmental agreements for the pursuit of climate change objectives: (i) the Intergovernmental Agreement on Federal Financial Relations (IGA-FFR) is an envelope agreement which includes the distribution of federal transfers, including GST revenues, among the states as well as funding for natural disasters; (ii) National Agreements which set out policy objectives and performance measures in many sectors but through which no funding is provided;[88] (iii) National Partnerships with time-limited funding agreements in a variety of sectors including the environment (examples include disaster risk reduction; grants assistance to primary producers impacted by the north Queensland floods; and the National Water Infrastructure Development Fund); and (iv) Project Agreements with simpler time-limited funding for low cost and/or low risk service or projects including the environment (for example, Improving Great Artesian Basin Drought Resilience). At the state-local level, New South Wales has established by itself a Climate Change Fund that supports programs by local councils, schools, and community groups to plant 5 million trees by 2030. Similarly, the Queensland government provides grants to local government/councils over 12 months to monitor, act on, and prevent illegal dumping activities.

In the *Democratic Republic of Congo*, a large share (40%) of forest area fees is

[88] One such example is the Reef 2050 plan, which is a joint effort of the federal government and the State of Queensland. In 2016, the Australian government and the Queensland government jointly funded the plan. An independent expert panel consisting of scientists and experts and a Reef 2050 Advisory Committee has been established to advise the Australian and Queensland governments on implementation and review of the Reef 2050 plan. Another example is the federal *20 Million Trees Program*, which pursued the goal of planting 20 million trees by 2020 by involving local councils and private organizations.

transferred to subnational governments (provinces and territories).

In *Mexico*, many states implement decarbonization projects, and some assist their municipalities to also do that. For example, the state of Jalisco has created a framework to provide funds to municipalities as well as to associations of municipalities to implement climate protection projects, often in matching arrangements (GIZ et al. 2017).

In *Niger*, the National Environment Fund allocates resources to support the actions of local communities in protecting and improving the environment.

In the *United Kingdom*, performance-based grants have been used in "Local Public Service Agreements" with significant additional funds provided for good performance on previously agreed indicators related to climate decarbonization targets and adaptation outcomes.

In the *United States*, like in many other countries, the federal and state government have a plethora of green subsidies to businesses and households for reducing emission, saving energy, and introducing green types of energy production; the intergovernmental subset of transfers is the one relevant to the current work. In this regard, the federal government grants environmental subsidies to state and local governments in various forms, including those to rural communities experiencing high energy costs. Also, with the Low-Income Home Energy Assistance Program, federal funds are distributed to the state governments for the latter to implement assistance to low income households. Among the states, California, for example, provides local governments grants and low-interest loans for drainage water projects that, if discharged untreated, would pollute or threaten to pollute the waters of the State. Eligible applicants include cities, counties, districts, etc., involved with water management, grants to local governments for used oil recycling, subsidies to all levels of governments for safe household hazardous waste management, and subsidies to school districts for lower-emission school buses. As another

example, the state of Illinois allocates funds to local recycling grants, school greening grants, subsidies for ecosystems protection and land preservation, and zero-waste schools grants.

There are also cases of international transfers pursuing environmental and goals. One example is Amazon Fund in Brazil. It was created to raise donations (international and domestic) to prevent, monitor, and combat deforestation and to promote the conservation and sustainable use of forests in the Amazon Biome. Activities supported include: management of public forests and protected areas; environmental control, monitoring, and inspection; sustainable forest management; ecological and economic zoning; territorial arrangement and agricultural regulation; preservation and sustainable use of biodiversity; and recovery of deforested areas. Although the Amazon Fund was created by the government, it is managed by a public bank, the Brazilian Development Bank (BNDES), and it functions as a private fund. As part of the same objectives, the federal Ministry of Environment periodically publishes a list that identifies municipalities responsible for the greatest share of deforestation in the region. Once included in the list, municipalities become prioritized for environmental and land control actions executed by the states and federal governments. In addition to becoming subject to intense surveillance, these municipalities are prohibited from obtaining new land clearing authorizations, apart from special cases described by the decree (Amazon Fund 2013; Ferreira Levy 2019).

6. Adapting subnational borrowing and other fiscal rules to facilitate effective policies for climate change

Borrowing represents a powerful resource for enabling subnational governments to invest in infrastructure projects for decarbonization and adaptation activities in combatting climate change. However, subnational borrowing also carries potential threats to macro stability and fiscal sustainability which need to be heeded. As in the case of the other three pillars of fiscal decentralization, in order to assess the potential role that borrowing may play in devising more

effective policies for climate change in a multilevel government context, it is helpful to briefly review the general principles for subnational borrowing and how best to regulate it.

Basic principles of subnational borrowing and other fiscal rules

The last pillar of the fiscal decentralization architecture is subnational borrowing. All decentralized systems need to address the issue of long-term financing for the capital infrastructure expenditure needs of subnational governments. This is so because, typically, a considerable share of capital infrastructure investment responsibilities must be assigned to the subnational level.[89] But, how is this financed? Beyond the use of subnational governments' current savings and capital transfers received from the central government, the best practical solution is for subnational governments to borrow the necessary funds

Borrowing is efficient because it allows subnational governments to make large lump-sum payments to acquire the necessary infrastructure in a way that is not generally possible by using current savings. Borrowing is also equitable because it allows subnational governments to match the timing of consumption of the services with periodic debt service payments. Having one generation of taxpayers pay for capital equipment, with later generations consuming the services that equipment provides, would not be fair.

The two general common forms of credit-based financing are bond issuance and borrowing from financial intermediaries. There is no intrinsic superiority to either of these approaches to financing subnational government long-term capital investment needs. Direct borrowing from private commercial banks and other financial institutions, international lending programs, bond issues, and the creation of local government development funds are all valid and

[89] For example, in OECD countries subnational governments represent about two thirds of all public expenditure on capital infrastructure.

desirable alternatives.

On the other hand, subnational borrowing often is seen as an activity full of fiscal risks. A number of factors create adverse incentives for subnational governments not only to overspend and under-tax, but also to borrow excessively, which all can lead to fiscal imbalances and macroeconomic instability.[90] Such factors include the common pool problem, moral hazard risk, and vulnerabilities of weak decentralization structures with low tax autonomy and large vertical imbalances. There are also simple but powerful political economy incentives at work: borrowing allows subnational officials to increase spending and engage in ribbon cutting, while it postpones most payments to future officials and generations of taxpayers.

Thus, ensuring disciplined and responsible subnational borrowing behavior generally requires more than good decentralization design. It also requires explicit rules, monitoring, and oversight regarding subnational debt. Most countries adopt or issue fiscal rules which can be understood as institutional constraints on policymakers' decision-making discretion. The objective is to allow subnational government flexibility with responsible borrowing and at the same time prevent undisciplined or irresponsible behavior. Borrowing and fiscal rules used internationally range from the most restrictive, as in the "administrative approach"—with central authorities controlling subnational borrowing through debt ceilings, prohibitions on external borrowing or prior approval of conditions for any new debt—to the least restrictive, the "market-based approach" where central authorities rely on financial markets to regulate and restrict subnational borrowing. In between those two extremes, there are several other approaches including: the "cooperative approach," where rules are determined through negotiations and dialog between the central and subnational governments; the "rule-based approach," which relies

[90] See, for example, Ter-Minassian (2007).

on clearly stated ex-ante rules that subnational governments need to follow when they borrow regarding debt ceilings or limits on total borrowing or ceilings on debt service expenditure (for principal and interest); the "golden rule" (funds can only be used to finance investment on infrastructure); rules on who can be a lender; rules on whether or not lenders can be foreign entities; and so on. In practice, the "rule-based approach" is the most used.

Applying basic principles and best practices in borrowing and rules for climate change policy action

As just shown, borrowing to finance subnational capital infrastructure is desirable from both efficiency and equity perspectives. Generally, those conclusions apply equally to infrastructure investment for decarbonization and adaptation to climate change, but two additional questions must be asked regarding climate investment. First, is there a case for subsidizing or facilitating subnational borrowing for climate change? Second, is there a case for specially structuring subnational access to national and international climate finance?

Regarding the first question, the most important innovation has been the introduction of "green bonds." Green bonds (also known as climate bonds) are a special type of bond or fixed-income instrument for which the raised funds are earmarked for environmental and climate change investment projects.[91] Very often green bonds offer tax advantages, such as exemptions and credits, making them more attractive to investors vis-à-vis other types of bonds, although the price advantage logically depends on demand. These bonds are backed by the full faith and credit of the issuing government, as in the case of other bonds, and so they carry the same credit ratings. Even though green bonds are typically linked to investment in specific assets, the investments themselves do not aim to generate earmarked revenue streams, as in the case for

[91] See, for example, IBRD and World Bank 2015.

example of “revenue bonds.” The green bond status may be granted by an independent board, like the Climate Bond Standard Board (part of the Climate Board Initiative), which verifies the funds will be used for green projects and certifies that the bond will fund projects that include benefits to the environment.[92] The European Union’s *Technical Expert Group on Sustainable Finance* has recently published a report on the issuance of green bonds funding climate change-mitigating projects, the so called EU Green Bond Standard, giving the public, investors, and industry a definition of what is “green.”

What are current promising (and unhelpful) practices in borrowing design in different countries?

A number of developed countries have been experiencing with the use of “green bonds” by subnational governments. For example, over the past five years, states in Australia have been issuing green bonds to finance projects with environmental and anti-climate change objectives, with certification by the Climate Board Initiative. In Australia, the state governments have the authority to generate funds by issuing green bonds. The State Government of Victoria issued AU$300 million of the worth of Green Bonds in July 2016. Green bonds are used to finance new and existing projects that offer climate and environmental benefits. The Climate Board Initiative (CBI), a London-based not-for-profit organization, verifies all projects funded by Victoria’s Green Bonds. In France, subnational governments (regions, departments, and municipalities) also have the authority to raise revenue by issuing green bonds (Frandon-Martinez and Filkova 2018). So far, the Ile-de-France region, Hauts-de-France region, Essonne department, and city of Paris have issued green bonds. In the cases of in Denmark, Finland, Norway, and Sweden, green bonds are intermediated through Local Government Funding Agencies (LGFAs). These are well-

[92] The Climate Bond Standard Board reports to the Governors of the **Climate** Bonds Initiative which is a London-based not-for-profit organization which specializes in the verification of the green credentials of proposed projects.

established financial institutions specialized in financing local governments of the region. For example, KommuneKredit accounts for almost all subnational public sector lending in Denmark (Filkova and Frandon-Martinez 2018). Similar arrangements exist in Finland. Subnational governments are also using green bonds in other developed countries, such as Canada, Iceland, and the United States.[93]

International agencies, like the World Bank, also frequently issue green bonds. There has been international interest in promoting this type of instrument. For example, recently, the OECD (2018) has recommended adjusting the regulatory framework to provide subnational governments with the ability to mobilize external funding, including the ability to borrow and access to capital markets for subnational governments by issuing green and climate bonds.

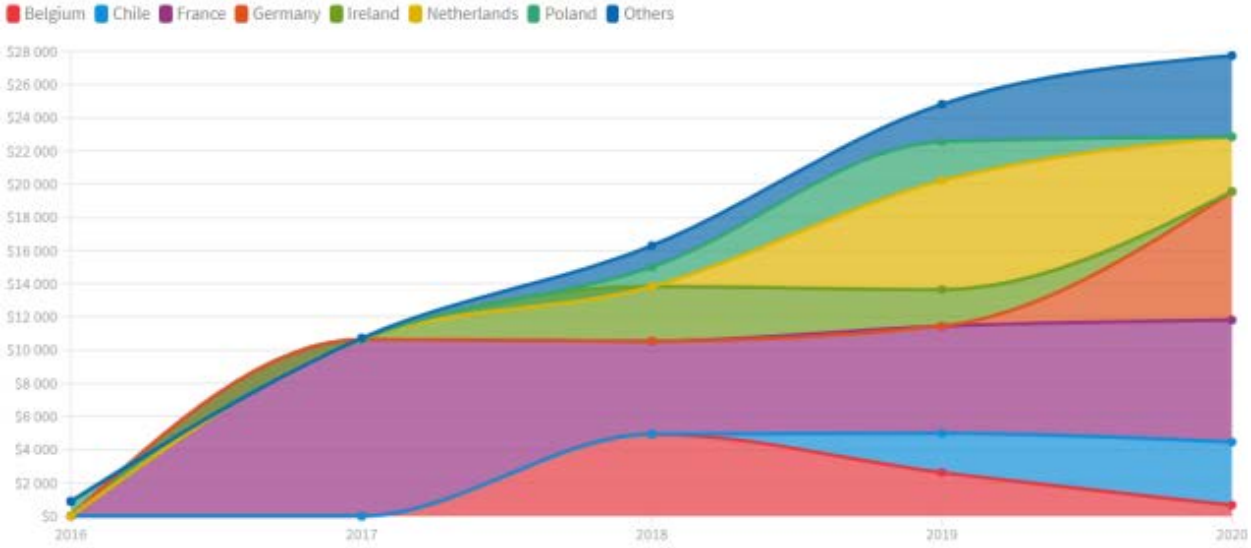
In the case of developing countries, green bonds are much less utilized. Perhaps the big exception here is China, where many provincial and local governments have issued green bonds. The Chinese government strongly promotes "Green Finance," meaning that many provincial and local governments have issued green finance guidance documents. In 2018 alone, Chinese local government entities issued at least $5.9 billion in green bonds (Sandalow 2019). Other developing countries that have used green bonds at the subnational levels include Colombia, Estonia (Tallinn), Mexico (Mexico City) and South Africa (Johannesburg and Cape Town). The less frequent use of green bonds by subnational governments in developing countries is largely explained by the many factors which severely constrain their access to debt finance in general; after all, in order to issue a green bond, a subnational government has first to be able to issue a

[93] Similarly, to the green bonds' idea, in the United States, the federal government exempts interest on state and local bonds issued to support water, sewer, and hazardous-waste facilities.

bond at all.[94]

In closing, green bonds still remain a small source of finance. As most recently reported by the OECD (OECD 2020), up to sixteen countries have issued sovereign green bonds to finance green projects in governments' budgets, exceeding USD 80 billion (Figure 3, reproduced from the OECD report). However, despite its recent growth, the size of the sovereign green bond market is still quite small; for example, among OECD countries, sovereign green bonds account for only 0.1% of all government debt securities.

Figure 3. Total Sovereign Green Bond Issuance in Millions of Dollars USD



Note: Data as of July 2020. "Others" include Fiji (2017), Hong Kong (China) (2019), Hungary (2020), Indonesia (2018, 2019 and 2020), Lithuania (2018), Korea (2019), Nigeria (2017), Seychelles (2018) and Sweden (2020). Source: OECD (2020), OECD Business and Finance Outlook 2020.

7. Summary and conclusions

The main objectives of this paper have been to re-examine the basic principles of fiscal decentralization from the perspective of fighting climate change and critically review the

[94] See White and Wahba (2019) for a recent discussion for why green bond financing still poses very limited opportunities for climate financing in most developing countries and for the factors which should be addressed if the scope for subnational borrowing (for climate purposes or otherwise) is to be significantly improved.

international practices for engaging subnational governments in climate-change mitigation. Even though the theory of fiscal decentralization provides clear guidelines for redesigning fiscal decentralization architecture from the perspective of fighting climate change, and international good practices are available for replication across many other countries, still many countries around the world so far have not effectively engaged their subnational governments in their climate change policy frameworks. This frequent failure to explicitly account for the role that subnational governments could and should play in the design and implementation of national strategies to combat climate change is the most significant finding of this review paper and also a clear call for action.

The scientific consensus is clear that the stock of greenhouse gases (GHG) in the earth's atmosphere is causing global warming and other changes in the climate. Even though there are differences of opinion on how to quantify and aggregate the damages, it is widely accepted that the economic impact of climate change has been estimated to be quite severe in terms of losses to GDP, health, and food security and increases in poverty.

From the main sources of GHG emissions identified in the Stern (2007) report, an estimated over 40% come from activities over which subnational governments typically exert regulatory and taxing powers, meaning subnational governments potentially have a big role to play in fighting climate change. The role of subnational governments becomes even stronger in terms of adaptation policies, given the smaller importance of externalities and economies of scale in this dimension of fighting climate change.

Still, the role to be played by subnational governments has some natural limits. While decentralized governments can better cater to differences in needs and preferences and provide a laboratory setting for incubating innovations and testing effectiveness, their big disadvantages

are their potential lower effectiveness in dealing with large externalities and taking advantage of economies of scale. Thus, it is mainly the former, the presence of significant externalities and how they can be handled in decentralized settings, that becomes the central consideration for the role that subnational government can play in decarbonization policies. Nevertheless, climate change policies in practice take many forms and many of those activities indeed can be implemented by subnational governments.

Thus, in many countries, subnational governments do play significant roles on certain types of decarbonization actions, such as managing land use, housing codes, water and power utilities, waste disposal, or transport systems. On the side of adaptation actions, subnational governments have also been, in many countries, on the front line of disaster response and climate adaptation programs. However, measuring actual subnational government involvement has proven difficult with the information that is currently available.

One way to measure such involvement is to look at the share of environmental expenditures of subnational governments in each country. Clearly, this provides only a limited view, since it disregards other subnational decarbonization activities like in transportation or sanitization and ignores expenditures in adaptation projects. Overall, this type of measure provides very low numbers, even when subnational governments have more of a presence than central governments, mainly because the overall share of environmental and climate-related spending and investment is very low with respect to GDP in most countries, rich and poor. An alternative measure, subnational government involvement in the Nationally Determined Contributions (NDCs) under the Paris Agreement, also yields modest indicators thus far. These preliminary findings provide further motivation for seeking venues through which subnational governments can become more engaged in the planning and implementation of decarbonization

and adaptation policies.

This paper has been structured around the four pillars of fiscal decentralization architecture: the assignment of functional expenditure responsibilities, the assignment of tax and other revenue sources, the systems of intergovernmental transfers, and subnational credit and borrowing. One of its foci has been to identify the best tools available within fiscal decentralization design to effectively engage subnational governments at the national level in the fight against climate change. The hope is that countries around the world will work to strengthen their policy frameworks by adapting their fiscal decentralization design to the best principles and practices, discussed in this paper. However, realistically speaking, those changes will not be easy to implement. Not only is institutional reform often slow and hard to implement, but fiscal decentralization design, as also shown in this paper, pursues many other significant worthwhile objectives, which in the eyes of policymakers may be as or more important than fighting climate change. Thus, a significant rebalancing of government objectives regarding decentralization will need take place over time.

On the practice of expenditure assignments, it is clear that the advantage of involving subnational governments on climate change policies is that in a decentralized setting, these governments are expected to be more responsive and accountable to residents. Working against this involvement is the common large scope of the externalities associated with activities causing climate change. Thus, how externalities manifest themselves in the different activities and policies related to climate change—the geographical scope of the externalities—becomes a critical linchpin to deciding the assignment of expenditure responsibilities for climate change policies.

For decentralized response to be operational and effective, it is also necessary that

subnational governments have the necessary administrative capacity and funding, and that they do not get involved in negative strategic behaviors (for example, competing with low standards in order to attract more economic activity). Furthermore, the assignment of responsibilities among different levels of governments is likely to differ for decarbonization and adaptation activities, with subnational governments playing a more important role with the latter. Even in the case of decarbonization policies, however, optimal assignments are likely to call for concurrent assignments involving two or more levels of government. In this case, clarity in the assignment of functional responsibilities requires identifying what level of government is responsible for the different attributes of the function (regulation, financing, and implementation). This discussion also highlighted the importance of intergovernmental coordination and cooperation for effective policymaking.

In practice, there are significant variations in how countries organize the division of responsibilities regarding designing policies and programs to fight climate change. While some countries provide the central government with exclusive responsibility for designing policies and targets and make subnational governments just implementation arms, other countries—the largest number—assign joint responsibility to the central and subnational governments for the designs of policies and targets, and at the same time provide subnational governments with varying degrees of flexibility to expand on national policies and exceed those targets programmed at the central level. Yet other countries, perhaps the smallest number but important for the size of their economies, practice a completely decentralized model, with much less coordination among the different tiers of government, and sometime with subnational units playing a leadership role in the absence of explicitly coordinated national policies and programs.

On balance, it appears that the second model, with shared responsibilities between central

and subnational authorities allowing subnational units to exceed national targets, is a superior approach because it is best adapted to the peculiarities of climate change policies in a multilevel government setting. Given the enormous economic externalities present in most climate change issues, it is important that the central authorities design national programs and coordinate actions throughout the entire national territory. However, the mixed or shared approach also takes advantage of the laboratory setting fiscal decentralization provides for experimenting with innovative subnational approaches. In this type of setting, subnational governments can innovate and compete in "a race to the top" in fighting climate change, while nationally-coordinated policies with explicit minimum national standards can ensure that geographical externalities are recognized and can avoid any possibility of a "race to the bottom." The first or centralized approach fails to take advantage of innovation and experimentation at the subnational level, while the third or decentralized approach risks not addressing externalities or allowing "race to the bottom" and free-riding subnational government behaviors.

In terms of revenue assignments, it is clear that a good revenue-raising tax and a good Pigouvian tax have different properties. While the former raises revenue with a low impact on economic activity, thus reducing excess burdens, in a Pigouvian setting, the goal is to maximize the elasticity of response, so that with small tax levels polluting activities are reduced as much as possible. Given the mobility of businesses and households and the fact that the benefits of climate change action are in many cases not localized, the most effective use of Pigouvian taxes may be at higher levels of government, such as regionally, nationally, or even (if feasible) internationally.

An important constraint for using green taxes at the subnational level is that in practice, for many reasons not related to climate change, subnational governments in many countries are

in fact devolved very low levels of taxation authority. In addition, some other factors may contribute to the low powers of green taxation at the subnational level. First, there is often the perception that many related subnational charges have a regressive incidence, penalizing lower income groups and so tying the hands of subnational governments which lack the ability to offset that regressivity with other policies. Second, there are also technical or administrative issues. Some green taxes can be quite complex to administer, especially when dealing with global multi-unit businesses. In addition, subnational governments may have lower ability to measure and monitor pollution emissions and other activities that constitute the tax bases of green levies; this is part of the capacity issue.

From the theory of revenue assignments, the question of what level of government is better equipped to levy different green taxes is answered by determining the extent of the externality present. If the externality is confined to a local area, the responsibility for the proper green tax should be local. As the area of the externality increases to the regional or national level, then the proper assignment of tax powers should be regional or national. An important advantage of green taxes emphasized throughout the paper is that they yield a double dividend, the decarbonization of activities and increased budget revenues, which could derive into more public services, including climate adaptation investment measures. These benefits will tend to offset any incentives to out-migrate because of the green taxes.

In the case of adaptation activities, to the extent that the consequences of climate change-related disasters tend to be more localized, there is more room for using the benefit principle for subnational financing. This calls for the use of fees and charges as well as traditional subnational instruments such as real estate property taxes, property transfer taxes, betterment levies, and other land value capture measures. These latter are especially attractive because most adaptation

activities will result in land-value increments.

In practice, regardless of the assignment of taxing powers to different levels of government, the most significant fact is the overall very low levels of green taxation in most countries around the world, which provides ample space for both central and subnational government to make much more extensive use of this type of levies. This fiscal space is even larger at the subnational level because of the large vertical fiscal imbalances most decentralized countries experience. Providing subnational governments with greater green tax autonomy becomes an additionally desirable way to close those vertical fiscal imbalances.

This review of country practices with green subnational levies uncovers a rich collection of different tax instruments, charges, and levies that subnational governments use in a little more than a handful of decentralized countries. The many other decentralized countries that so far have not introduced subnational green taxation—other than the usual charges for waste collection, etc.—could replicate some of those types of tax assignments to strengthen the role of their subnational governments in fighting climate change from the revenue side of the budget.

Intergovernmental fiscal transfers are likely the most suitable financing instrument for internalizing spatial externalities related to decarbonization and adaptation programs. They are also a versatile adaptable instrument. Beyond conventional conditional grants, central government funds can be also transferred via different types of subsidies and direct performance contracts or agreements between the central and subnational governments to fight climate change.

In general, these transfers are designed separately from other transfer policies such as unconditional equalization grants and revenue sharing of a derivation basis pursuing the objectives of equalization and devolution to subnational governments. In contrast, in cases where

the main objective of the conditional transfers is not diluted or confused, it may be feasible and desirable to imbed climate change objectives into transfers. More generally, conditional grants, for recurrent and capital purposes and with ex-ante or ex-post conditionality, are generally well equipped for designing and implementing climate-specific transfers to subnational governments. Conditional transfers can be used to compensate local jurisdictions for internalizing different types of externalities, to incentivize different conservation activities, to promote energy efficiency, or to introduce land-use restrictions to prevent flooding damages.

This paper has further identified a large variety of country practices in using intergovernmental transfers to engage subnational governments in the fight against climate change. Conditional grants are being used in some countries for forest conservation programs, as in the case of Brazil states' ecological "ICMS" or Portugal's ecological fiscal transfer for land conservation. In other countries like Australia and the United Kingdom, higher-level governments are entering into agreements and contracts with local governments to undertake determined "climate services."

Finally, this work highlights the ways that prudential borrowing can be a powerful financing complement enabling subnational governments to invest in infrastructure projects for decarbonization and adaptation activities in combatting climate change. Provided that borrowing is prudent and within bounds—as outlined for example by the country's fiscal rules—this form of financing subnational capital infrastructure is in general desirable from both efficiency and equity perspectives, and these conclusions hold even more so for such borrowing done to fund green infrastructure investments.

Whether subnational borrowing rules can be justifiably relaxed to some extent to further incentivize subnational governments' infrastructure spending in green projects is a more complex

issue; it is necessary to avoid moral hazard and keep subnational debt on a sustainable basis. The safest approach is to facilitate and subsidize green borrowing, an area which has seen some recent innovations. The most important development has been the introduction of “green bonds” (also known as climate bonds); these instruments often offer tax advantages, such as exemptions and credits, making them more attractive to investors vis-à-vis other types of bonds, while they are backed by the full faith and credit of the issuing government. An increasing number of developed countries are making use of “green bonds” by subnational governments, but their adoption has been slower in developing countries, in large part because most subnational governments still do not have access to capital markets. Despite their recent growth, the size of the sovereign green bond market is still quite small, even in developed countries.

There is much work to do at all levels to reduce the emission of greenhouse gases and implement climate-adaptive infrastructure. Currently, the relative GDP share of environment-targeted spending and effort even on the national level is low in many countries. The subnational levels, in federal or decentralized nations, generally still play a relatively small role. Nevertheless, there have been many innovative and exciting developments in this space, whether in the form of expenditure assignments, tax authority, funding transfers, or borrowing. Shared responsibility for policy and program design and implementation, fee- or charge-funded adaptation activities, objective-targeted intergovernmental transfers or conditional grants, and the use of green bonds are some of the most promising approaches profiled. Regardless of the methods chosen, however, what is clear is that there is ample space ahead for the further involvement of subnational governments across the world in combating climate change.

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