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# Essays on Decentralization and Political Institutions

Kshitiz Shrestha
*Andrew Young School of Policy Studies*

**ABSTRACT**

ESSAYS ON DECENTRALIZATION AND POLITICAL INSTITUTIONS

BY

KSHITIZ SHRESTHA

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Committee Chair: Dr. Jorge Martinez-Vazquez

Major Department: Economics

This dissertation comprises two essays on decentralization and political institutions. The first chapter of the dissertation investigates how national levels of corruption are influenced by the interaction of two factors in political decentralization: the presence of local elections and the organizational structure of national parties. Previous studies have focused primarily on the role of fiscal decentralization on corruption and have mostly ignored the institutions of political decentralization. Using new data in a series of expansive models across multiple countries and years, we find that corruption will be lower when local governments are more accountable to and more transparent towards their constituents. This beneficial arrangement is most likely when local elections are combined with non-integrated political parties, where party institutions themselves are decentralized from national control. Such an institutional arrangement maximizes local accountability by putting the decision to nominate and elect local leaders in the hands of those best in a position to evaluate their honesty – local electors.

The second chapter analyzes how political institutions, and in particular party institutionalization, can mediate the impact of fiscal decentralization on climate change. Decentralization has remained an important shift in governance structure throughout the world in the past few decades. The economics literature, thus far, has not provided conclusive evidence regarding the impact of fiscal decentralization on combatting climate change. Decentralized

decision making may be seen as antagonistic to the large externalities that typically characterize climate change policies. However, the local under-provision of public goods with externalities may be mediated by the presence of "institutionalized political parties." These latter have a stable party organizational structure and strong linkage to voters, providing the incentives and capacity to shape the incentives of local elected officials. Using a large panel data set for 75 countries from 1971 to 2018, we find that the presence of strong party institutionalization significantly improves the functional role of fiscal decentralization in combating climate change, when the latter is measured by the reduction of CO2 emissions and the promotion of renewable energy consumption.

INDEX WORDS: Political decentralization, fiscal decentralization, corruption, climate change

# ESSAYS ON DECENTRALIZATION AND POLITICAL INSTITUTIONS

BY

KSHITIZ SHRESTHA

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ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economic in the Andrew Young School of Policy Studies of Georgia State University.

| | |
|---|---|
| Dissertation Chair: | Dr. Jorge L. Martinez-Vazquez |
| Committee: | Dr. Andrew Feltenstein<br>Dr. Charles R. Hankla<br>Dr. Mark Rider |

Electronic Version Approved:

Sally Wallace, Dean
Andrew Young School of Policy Studies
Georgia State University
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## DEDICATION

*To my parents, brother, and sister.*

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# INTRODUCTION

This dissertation consists of two essays on political and fiscal decentralization. Decentralization has remained an important shift in governance structure throughout the world in the past few decades. Fiscal decentralization involves devolution of authority to tax and spend from central to sub-national governments. Moreover, a core tenet of political decentralization is the presence of local election. As we know from the literature, the degree of decentralization largely depends on the extent of preference heterogeneity and the extent of externalities. An important implication, however, is that given the local focus, in the presence of large externalities, local government officials will tend to under-provide the public goods that carry those spillover effects. In this regard, Riker (1964), and recently Hankla et al. (2019), suggested that strong national political parties could achieve a balance between local and national interests. While decentralization can address local preference heterogeneity, national parties can shape the incentives for local politicians to consider national objectives for public services. In this dissertation, we draw on recent work on the role of political decentralization and the performance of fiscally decentralized systems to analyze how political institutions, and, in particular strong political parties, can mediate how decentralization impacts corruption and climate change.

The first chapter of the dissertation investigates how national levels of corruption are influenced by the interaction of two factors in political decentralization: the presence of local elections and the organizational structure of national parties. Previous studies have focused primarily on the role of fiscal decentralization on corruption and have mostly ignored the institutions of political decentralization. Using new data in a series of expansive models across multiple countries and years, we find that corruption will be lower when local governments are more accountable to and more transparent towards their constituents. This beneficial

arrangement is most likely when local elections are combined with non-integrated political parties, where party institutions themselves are decentralized from national control. Such an institutional arrangement maximizes local accountability by putting the decision to nominate and elect local leaders in the hands of those best in a position to evaluate their honesty – local electors.

The second chapter analyzes how political institutions, and in particular party institutionalization, can mediate the impact of fiscal decentralization on climate change. Decentralization has remained an important shift in governance structure throughout the world in the past few decades. The economics literature, thus far, has not provided conclusive evidence regarding the impact of fiscal decentralization on combatting climate change. Decentralized decision making may be seen as antagonistic to the large externalities that typically characterize climate change policies. However, the local under-provision of public goods with externalities may be mediated by the presence of "institutionalized political parties." These latter have a stable party organizational structure and strong linkage to voters, providing the incentives and capacity to shape the incentives of local elected officials. Using a large panel data set for 75 countries from 1971 to 2018, we find that the presence of strong party institutionalization significantly improves the functional role of fiscal decentralization in combating climate change, when the latter is measured by the reduction of CO2 emissions and the promotion of renewable energy consumption.

# CHAPTER 1: POLITICAL DECENTRALIZATION AND CORRUPTION: EXPLORING THE CONDITIONAL OF PARTIES

## 1.1 Introduction

Corruption, generally defined as the misuse of public resources for personal gain, has been found to hinder economic growth (Mo, 2001) and labor force participation (Cooray and Dzhumashev, 2018). More than that, controlling corruption is a key indicator of good governance and is closely tied to a country's basic political stability (Guerrero and Castaneda, 2019). Because of its importance, scholars have devoted considerable attention to identifying the key causes of corruption, pointing to such factors as development (Triesman, 2000) and economic freedom (Buehn and Schneider, 2009).

One institutional feature which has received considerable attention in the corruption literature is fiscal decentralization, by which we mean the devolution of authority to tax and spend from central to sub-national governments (Oates, 1972). Decentralization has become, among other things, a primary vehicle to increase government accountability through the distribution of powers to regional and (especially) local governments. One might expect that corruption should be lower when the local governments are empowered. After all, corrupt acts should be more visible at the local level, and voters can more easily filter out corrupt candidates. On the other hand, decentralization implies many more public transactions and a larger government size, which may create opportunities and incentives for corruption (Goel and Nelson, 1998; Goel and Nelson, 2010; Arvate et al., 2010).

Thus, the relationship between decentralization and corruption is not a simple one. Many scholars do find that decentralization improves government accountability and reduces corruption (Seabright, 1996; Fisman and Gatti, 2000; Arikan, 2004). Others, however, contend

that corruption increases with the number of tiers of government (Triesman, 2000; Fan et al. 2009), since the opportunity for misuse of public resources becomes, in a sense, democratized.

In this paper, we endeavor to move this deadlocked debate forward by incorporating the institutional structures through which decentralization (and indeed corruption) operate. Such an approach has not yet been applied to the question of sub-national governments and corruption, but it is very much in keeping with recent research in fiscal decentralization. In the "second generation" fiscal federalism literature, scholars have shifted their focus from normative and technical issues such as the design of the vertical fiscal system to identifying which political and institutional conditions are necessary for decentralization to improve governance.

In this spirit, we draw on recent work on the role of political decentralization and the performance of fiscally decentralized systems to analyze how political institutions, and in particular local elections and integrated versus non-integrated political parties, can mediate how decentralization impacts corruption. We build especially on the arguments of Hankla et al. (2019), who develop and test an expansion of Oates' (1972) decentralization theorem. They find that the combination of democratic decentralization and party integration is especially conducive to the efficient provision of local public goods even in the presence of large externalities. For these authors, democratic decentralization means that local government officials are chosen through local elections, while integrated party systems occur when power (such as local nomination authority) flows upward through well-structured institutions towards the national party headquarters. The basic idea is that local elections create incentives for subnational leaders to provide quality public goods, while integrated parties introduce strong incentives for them to efficiently provide even those public goods with interjurisdictional spillover effects. The result is

the achievement of a "fine balance" between the benefits of local accountability and the exigencies of national coordination.

In this paper, we explore the role that these critical institutional features -- local elections and party integration -- play in incentivizing or deterring corruption among local officials. Following much of the previous literature, we argue that local elections are critical to promoting the accountability necessary to penalize corrupt officials. But we also emphasize the role of party integration in mediating the actual functioning of decentralized institutions.

How party integration – predicated as it is on greater centralized control of candidate nominations – impacts corruption will depend on the answers to two critical questions. Are voters in a small constituency in a better position than national party leaders to identify candidates who may be inclined to abuse their office, or to penalize elected officials who engage in corruption? Or are the benefits that familiarity may provide trumped by the incentives of integrated national parties to punish members who sully the party name with their corrupt behavior.

On the one hand, the presence of corruption in any locality can be thought of as producing negative externalities for an entire integrated national political party through loss in voter support in other localities. Thus, it would be in the interest of the national party to be vigilant and repress any corruption among its affiliated local public officials. On the other hand, when parties are non-integrated and candidates to local public office are therefore nominated and selected by way of local mechanisms, those candidates may be subject to greater scrutiny for corruption potential than when they are nominated by the national party headquarters. These observations give us every reason to suspect that such a critical institutional feature as party

integration, one which ties central and subnational governments together, will matter for the relationship between decentralization and corruption. The only question is how.

Bearing all of this in mind, we hypothesize, first, that democratically decentralized countries -- those with local elections -- will experience lower levels of corruption. Second, among such democratically decentralized countries, we explore whether those with integrated or non-integrated parties will have lower level of corruption, other things equal. As we have noted, the previous literature suggests that party integration may be beneficial for public goods distribution by promoting national coordination and the provision of goods with interjurisdictional spillovers. In such systems, national parties have the power and incentive to force local officials to provide the efficient level of public goods even when the benefits of those goods spill outside local constituency boundaries.

Similarly, in the domain of corruption, integrated parties are motivated to preserve their national reputation for probity; they may therefore use their power to punish local officials for corrupt practices. It may well be, however, that maximizing accountability is more critical than internalizing spillovers for combatting corruption. Non-integrated parties make local officials even more dependent on the votes of their constituents, who can then reward and punish them for their honesty in office. For this reason, it may be that decentralized systems with non-integrated parties are more likely to enjoy the benefits of honest government. Ultimately, this is an empirical question, one that we seek to resolve in this paper.

We test the impact of both our key institutions on corruption using a large cross-national time-series model that considers 135 countries over 24 years. We make use of the new dataset developed by Hankla et al. (2019) to measure party integration and decentralization, while we use six different corruption indices as our indicators of corruption. Our results show that

democratic decentralization -- the presence of local legislative and executive elections -- is more conducive to lowering corruption than democratic centralization. Furthermore, when local elections are combined with non-integrated parties, corruption drops significantly to even lower levels. This finding is important not only for our understanding of the roots of corruption, but also as a warning that political institutions can have disparate impacts. The same institutions that may promote public goods distribution may also be associated with higher levels of corruption. Scholars and policymakers will need to be more sensitive to the complex and contradictory ways in which institutions can mediate specific policy outcomes.

We structure the rest of the paper as follows: section 2 provides the literature review and discusses the decentralization theorem, section 3 lays out our theory and hypotheses, section 4 discusses the data, section 5 presents our estimation strategy and results, section 6 provides additional checks, and section 7 concludes.

## 1.2 Literature Review

### *1.2.1 Decentralization and Corruption*

The literature on fiscal decentralization has evolved in two primary waves. While the first-generation assumed a benevolent government (Oates, 1972), second-generation scholars recognized that government officials do not always maximize the welfare of their constituents (Weingast, 1995; Seabright, 1996; McKinnon, 1997; Tommasi and Weinschelbaum, 2007). Efforts to understand corrupt behavior within the context of decentralization emerge from this second scholarly tradition.

Corruption has attracted significant attention in the literature, with most scholars seeing it as a significant impediment to good governance. In general, corruption fosters an environment of

distrust towards public officials and uncertainty in business activities, and it generates negative externalities in the allocation of resources between firms. Moreover, corruption stifles the entry of new actors into the economy, including through foreign direct investment (FDI), and its negative effects disproportionally fall on small firms (Giannetti et al., 2021). Evidence also indicates that corruption hurts economic growth (Mo, 2001) and increases income inequality (Gupta et al., 2003).

While scholars are mostly united in their belief that decentralization has an impact on levels of corruption, there remains some disagreement as to the direction of the effect. For instance, Shleifer and Vishny (1993) contend that decentralization leads to a lack of coordination between bureaucrats due to the greater dispersion of government decision-making powers. This can result in local officials seeking bribes as part of rent-seeking behavior. Furthermore, they argue, local governments might have to rely on low-quality, potentially corrupt bureaucrats because the rewards for working in the central government are generally higher. Along the same lines, Triesman (2000) shows that an increase in the total size of government, which may accompany decentralization, can lead to a higher level of corruption. Compatible with this argument is Fan et al. (2009), who find that an increase in the number of government tiers also increases the level of corruption. As the number of public officials increases, so the argument goes, there is more potential for bribery.

One of the few papers that has considered how politics might interact with decentralization and corruption is Lessmann and Markwardt (2010). They find that decentralization is beneficial in reducing corruption only when effective monitoring is in place. Using freedom of the press as a proxy of effective monitoring, they provide cross-country evidence that decentralization reduces corruption in countries with high degrees of press

freedom. Another is Gerring and Thacker (2004), who argue that "unitary and parliamentary systems" are more conducive for reducing corruption. They identify multiple causal mechanism that could influence corruption from both a unitary and federalist point of view.

A prominent set of decentralization skeptics has argued that devolving power to lower tiers could lead to the elite capture of local governments, a position with clear implications for the study of corruption. These scholars contend that local governments are more susceptible to pressures from local elites who can mobilize resources for their own benefit at the expense of the community (Bardhan and Mookherjee 2000; Lucas 2016). Additionally, they have argued, corruption tends to thrive when politicians are engaged in clientelism, seeking to stay in office by offering material incentives to their voters. Even when there is no grassroots clientelism, special interest groups may curry favor with bribes, and politicians in return may offer them public work contracts. The penalty for corruption, unfortunately, declines over time due to receding memories and as politicians consolidate power and make it difficult to remove them from office (Bicchieri and Duffy 1997).

Taking the opposite position, other scholars have pointed to decentralization's ability to enhance the accountability of local governments as a force against corruption (Seabright 1996, Weingast 1995). For example, Lockwood (2005) posits that greater local accountability can be achieved through decentralization, while Hankla (2009) and von Braun and Grote (2000) emphasize the critical role of local elections in promoting this accountability. The logic is that, in their efforts to be reelected, local officials have reason not to engage in behavior that hurts their constituents, and, moreover, local officials should be easier to catch and sanction than those at higher tiers.

Decentralization may also limit the extent of rent extraction. On this question, Arikan (2004) examines the relationship between decentralization and corruption under a tax competition framework. She finds that, as jurisdictions try to reduce capital flight by lowering taxes, corruption becomes less remunerative. Such a political competition framework likewise suggests that when multiple politicians are competing to win office, corruption is lower under decentralization than under centralization (Albornoz and Cabrale 2013). And, more broadly, several papers have provided empirical evidence of a negative relationship between fiscal decentralization and corruption (Fisman and Gatti 2000; Arikan 2004; Ivanyna and Shah 2012).

Some recent studies have focused on examining the effect of decentralization on corruption in specific countries. Generally, these studies use the number of corruption cases as their dependent variable. Alfada (2019) has examined the causes of corruption in Indonesia, finding that a higher degree of expenditure decentralization yields an increase in the number of corruption cases. Similarly, Fatima et al. (2016) use water theft from irrigation basins in Pakistan as a proxy for corruption. They find that delegating the irrigation authority to locally elected leaders, in fact, increased the level of corruption. The results from Ferraz and Finan (2011) suggest the possibility that re-election serves as a significant incentive for corrupt politicians to lower their rent extractions. These findings highlight the importance of re-election as an incentive to fight corruption, and Gamalerio (2020) lends further supporting evidence from Brazil.

Furthermore, it is plausible that corruption exhibits cross-boundary spillover at the subnational level, as neighboring regions tend to have higher degree of economic, political, and sociocultural exchange (Borsky and Kalkschmied, 2019). Such regions are also more likely to engage in trade and are closer with respect to shared history, language, ethnic diversity, and

culture (Limao and Venables, 2001; Disdier and Head, 2008). In this context, one can presume that exchange of ideas happens at greater frequency at the subnational level than at the cross-national level. If the level of externality is high, then decentralization alone might not produce effective results. If we consider heterogenous jurisdictions, however, decentralization is effective, as an empowered central government could over or under allocate resources to fight corruption (Villalonga, 2018).

### *1.2.2 Corruption and Ballot choice*

A final area of research relevant to our argument concerns the relationship between corruption and different electoral systems. Most of the debate in this area has focused on national governments. For example, Sung (2004) and Kolstad and Wiig (2016) have shown that democracy is effective in decreasing corruption, while Drury et al. (2006) have presented evidence that elections provide an incentive for government officials to lower corruption for the sake of their political survival. Though temporary upsurges in government corruption may occur during the early stages of the process of political liberalization (Sung, 2004). Additionally, Kunicova and Rose-Ackerman (2005) have made the argument that monitoring for corruption by voters is easier under the plurality rule. This is because, in a plurality system, there is less possibility of coalition governments, so political opponents have more incentives to keep other parties in check.

In his seminal work Myerson (1993) argues that while voters prefer honest candidates, they might vote a dishonest candidate into office if they could not find a good substitute candidate. Following this argument, Persson et al. (2003) provide empirical evidence that a larger district magnitude is associated with lower corruption. Having more seats per district, they

argue, lowers the *barrier to entry* and increases the representation of the voters. Thus, an increase in the number of players in the election field leads to lower rent extraction and lower corruption.

More than that, how candidates are nominated for the ballot may also make a significant difference in the resulting corruption. Verardi (2004) distinguishes between the effects of different forms of candidate selection on corruption. He shows that a larger district magnitude is associated with lower corruption and that the closed-list nomination process is associated with higher corruption. In a plurality electoral system, voting over individual candidates gives the elected officials strong incentives to perform well while in office. However, when the nomination list is closed, and voters cannot choose their preferred candidates, a government official's chance of re-election depends on other factors that could be uncorrelated to her competence, such as party loyalty (Persson and Tabellini 2003). This could dilute the incentives for the elected officials to perform well while in the office.

Past research suggests that political institutions are likely to matter in mediating the relationship between decentralization and a variety of outcomes, especially local public goods provision (Riker, 1964; Enikolopov and Zhuravskaya, 2007). Notably, Enikolopov and Zhuravskaya (2007) argue that strong political parties can influence the incentives of local political actors through campaign finance and political support for their re-election. Our argument, however, is distinct. While Enikolopov and Zhuravskaya (2007) use party age as a proxy for national party strength, we make use of an original dataset to measure party integration at the sub-national level more directly. Moreover, Enikolopov and Zhuravskaya (2007) interact party age with fiscal and administrative decentralization while we are interested in the joint effects of party integration and democratic decentralization.

Though some debate persists, past research has broadly shown that political institutions – especially particular electoral systems – can also dampen, or exacerbate, levels of corruption. The link between decentralization and corruption, however, remains uncertain, with scholars finding effects in both directions. Moreover, there is little work considering how political institutions might mediate this relationship.

One important exception is Ivanyna and Shah (2012), who create a decentralization index which considers both the political and fiscal independence of low government. They use this index to predict corruption levels in nearly every country in the world and find clear evidence that decentralization reduces corruption. This is an important finding, but our paper takes the analysis a step further. We make use of a variable measuring whether local governments are elected, which Ivanyna and Shah (2012) also considered, but we interact it with a new variable measuring party integration. Moreover, while the role of political parties is missing from Ivanyna and Shah (2012), we emphasize how party structures can influence the incentives of local government officials to reduce corruption. Using an interactive approach with the new and important institutional variable of party cohesion allows us to better consider the conditions under which political decentralization might promote or impede corruption.

### 1.3 Theoretical Framework

It is our hope to resolve, at least partially, the mixed findings produced by past studies examining how decentralization impacts corruption. One possibility may be that the mixed findings we highlight above are due to the omission of critical institutional variables that affect how unethical public behavior plays out in centralized versus decentralized systems. When we

consider the institutional context of decentralization in more detail, we may find clearer relationships.

We argue here that an incorporation of political institutions – and especially party integration – can shed light on the decentralization-corruption nexus, as it has already on the connection between decentralization and local public goods. As we have discussed, the literature on decentralization has recently expanded to include an analysis of the political conditions necessary for the provision of public goods with spillovers. In particular, Hankla et al. (2019) provide a theoretical framework that incorporates increased accountability through democratic decentralization with the role of political parties in internalizing the externalities of public goods.

For these authors, democratic decentralization occurs when sub-national governments are popularly elected[1]. Party integration, for its part, is present when the following three conditions are met: i) national parties are the primary competitors in sub-national elections, ii) they are institutionalized and have coherent decision-making structures, and iii) national party leaders have authority over the nomination of candidates for subnational office. With these definitions in mind, Hankla et al. (2019) argue that local leaders want to win the next election and so must provide their constituents with the local public goods that they desire. But local officials – when operating in the context of integrated parties -- are also answerable to national party leaders, who have the power to nominate them for local office and to make or break their careers at higher tiers. Under the assumption of free and fair competition in the elections, national parties have the incentive to provide optimal levels of local public goods with spillovers because they want to win local elections in multiple jurisdictions. The dual loyalties of local elected officials mean that they will provide local public goods that meet the local preferences even when their benefits

[1] Note that we focus our analysis here on local governments, but that the theoretical arguments should apply to other sub-national tiers as well.

spillover outside their jurisdictions. Hankla et al. (2019) formalize this concept with what they call the "strong" decentralization theorem, which suggests that, even in the presence of interjurisdictional spillovers, decentralization is more efficient than centralization when parties are integrated. Ponce-Rodriguez et al. (2018) empirically show that democratically decentralized countries with integrated parties provide more efficient levels of health and education services.

Our current paper parallels this discussion to investigate the impact of democratic decentralization and party integration on corruption. Democratic decentralization gives local constituents a greater role in monitoring the performance of elected officials. It incentivizes the government officials to improve their chances of getting re-elected by tending to the needs of local constituents. Therefore, we argue, a democratically decentralized system leads to lower corruption than a democratically centralized system, *ceteris paribus.*

The question is how party integration might interact with democratic decentralization to impact corruption. First, it is worth pointing out that when there are no local elections (and countries are therefore democratically centralized), the issue of party integration across tiers in meaningless since there are no lower tier candidate nominations. Among democratically decentralized countries, as noted above, we define non-integrated parties as those where central party leaders do not have the authority to nominate candidates for sub-national elections. Instead, local constituents nominate a candidate for each political party. In addition, when a national party does not win a majority of seats in the local assembly, we categorize it as a non-integrated party as well. Indeed, non-integrated parties are generally regional parties that compete in specific regions and do not compete outside their regions.

On the other hand, we define integrated parties as national parties that dominate local elections, with central party leaders -- concerned about improving their electoral chances in

multiple jurisdictions -- having the authority to nominate local candidates. For their part, candidates seeking reelection to local office must get nominated by the party leaders and get elected by the constituents. Thus, elected officials under an integrated party system serve both their constituents and also their party leaders.

How do these different forms of party integration play into levels of corruption? From one perspective, corruption may be understood as a "public bad," which damages institutions and outcomes in the specific place where it occurs, but which may also generate (negative) spillover effects in other jurisdictions. With this in mind, we can argue that integrated parties have strong incentives to combat any localized corruption within their ranks. After all, a bad reputation for probity may negatively affect a party's electoral outcomes throughout the country (Graetz and McAllister, 1987; Davies and Mian, 2010). That is, the electoral costs of localized corruption could be more extensive when political parties are integrated and national. Therefore, party leadership or party reputation could potentially serve as a strong motivation to improve subnational fiscal performance and combat any resource abuse (Benton, 2018).

Another perspective, however, would emphasize that under party non-integration, there is a direct link between an individual candidate's re-election and performance in office. Furthermore, as non-integrated parties are limited to specific regions, they may have more at stake in terms of electoral outcomes and the local nomination process of candidates. Therefore, they have the incentive to nominate a less corrupt candidate to the office to improve their chances of re-election, especially when national parties are also competing in local elections.

Additionally, a considerable literature suggests that there exists an information gap between voters and party elites (Hertel-Fernandel et al., 2018). Even if party leaders care about voters' preferences, this information gap could lead to the selection of less-than-ideal candidates

at the local level. New democracies are more susceptible to such problems, as the party linkage with voters are not well-established (Schneider, 2019; Gulzar et al., 2021). Evidence for the United States also shows that advanced democracies may also suffer from the information-gap problem between voters and party leaders (Hertel-Fernandez et al., 2018).

With this perspective in mind, it could be that, in contrast to public goods provision (where local accountability and national coordination carry equal weight), efforts to deter corruption will lean more heavily on the strength of local accountability. It is true, as noted above, that integrated parties that operate in democratically decentralized settings have an incentive to protect their reputations by nominating honest local candidates. It is also true that local elections can promote effective local accountability even in the presence of integrated parties and strong central control. But all the same, such coordination across tiers may be less critical in combatting corruption than in providing public goods.

If what is needed to minimize corrupt incentives on the part of local leaders is strong accountability to constituents, that is produced first and foremost by elections. If these conjectures are right, non-integrated parties, whatever their negative repercussions for public goods, would tend to generate stronger local accountability than integrated parties. That may be correct for three primary reasons. First, in the absence of central nomination, local candidates in non-integrated systems must be selected locally, often through a primary election, nomination by a local party, or the collection of signatures. Such a selection process creates additional local checks on candidate suitability for office that may more than offset the additional scrutiny by national party officials in the case of integrated parties.

Second, candidates for local office in systems with non-integrated parties are more likely to be local. When parties are integrated, national party leaders may reward non-local loyalists

with nomination tickets to local office. But when these central leaders lack power over candidate selection, notables with local reputations are more likely to present themselves for office. Again, this dynamic would allow voters to weed out candidates known in advance as corrupt.

Last, in non-integrated party systems, strong national parties do not play a central role in local elections. For this reason, party identification is less likely to be determinative of local voting decisions. Instead, local personalities and issues will play a larger role. Of course, less programmatic and more personalistic elections may be costly for many elements of governance quality, but they could make it more likely that voters will withhold their support from candidates with a history of corrupt behavior.

These considerations lead us to these two hypotheses:

H1: Democratically decentralized countries (i.e., those with local elections) will have lower levels of corruption than democratically centralized countries, other things equal.

H2: Among democratically decentralized countries, party-integration versus non-integration will likely constitute another layer of corruption control, although it is a priori unclear the direction of the effect.

## 1.4 Data

### *1.4.1 Measure of corruption*

Measurement of corruption has remained a difficult task since it tends to be clandestine and rarely leaves a paper trail. Thus, it is virtually impossible to have a precise and objective indicator, and even subjective data can be mired with noise or measurement error. Nevertheless, several methods of measuring corruption in a relatively precise way have been developed.

One relatively direct way of operationalizing corruption is to measure the payment of bribes. However, a simple measure of bribe payments ignores a whole range of corrupt acts that are not accompanied by bribe payments (Tanzi, 1998). Another method of measuring corruption is to investigate the financial audits of specific projects to compare spending with the physical outputs of projects. These measurements, however, tend to be limited to specific projects and are not suitable for cross-country comparisons.

Another widely used approach to measuring corruption are perception-based indices. They include surveys of firms, public officials, country experts in think tanks, NGOs, multilateral donors, and other outside observers. In the absence of direct measurements of corruption, the perception of government institutions and their corrupt tendencies matters. For instance, higher corruption can lead to entrepreneurs choosing to operate in the informal sector (Choi and Thum, 2005; Dutta et al, 2011). Moreover, perceptions of corruption from country experts tend to be highly correlated with perceptions of corruption of from domestic firm surveys (Kaufmann et al., 2007), and these indices also use multiple data sources to reduce measurement errors.

### *1.4.2 Corruption indices*

As discussed above, different corruption measures cover different aspects of corruption, and each has its own weaknesses. Therefore, we make use of several corruption indices to provide greater robustness for the corruption measurement, rescaling them, when necessary, to reflect a low score for low corruption and a high score for high corruption. We discuss these measures below:

Our first corruption measure is the 'Corruption index', coded as part of the International Country Risk Guide (ICRG) by Political Risk Services, is based on surveys of country experts and measures actual and potential corruption in the form of favors and patronage to politicians. The ICRG index considers both "actual or potential corruption in the form of excessive patronage, nepotism, job reservations, 'favor-for-favors', secret party funding, and suspiciously close ties between politics and business." The ICRG corruption indicator is a good proxy based on two assumptions: i) corruption negatively affects foreign investment and ii) corrupt officials do not discriminate between foreign and domestic firms to extract bribes (Swaleheen, 2011). In addition, the variable not only covers a longer time period than other available indexes but is also highly correlated with them. We use the data covering the period 1984 to 2017.

Second measure of corruption is 'Control of corruption (CforC)' from World Governance Indicators. It measure captures perceptions of the degree "to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests" (Kaufmann et al., 2009). It is an aggregate indicator that is based on over 30 underlying data sources and covers 215 countries from 1996 to 2019.

Third measure of corruption is the 'corruption perception index (CPI)' provided by Transparency International. It provides scores based on the perceived level of public sector corruption by business leaders and experts. It is a composite index that pools sources from 13 surveys and assessments of corruption, and its methodology was updated in 2012 with a new scale of 0-100. Following this update, the CPI scores before 2012 became incompatible over time, and so we only use the CPI scores from 2012 to 2019.

Our next three measures of corruption comes from the 'Variety of Democracy' database. The variety of democracy database provides aggregate measures based on coding by multiple country experts. It considers potential disagreements and measurement errors and produces a probability distribution over country-year scores on a standardized interval scale. Following this method, V-Dem offers several corruption measures, three of which are relevant to our research. One such measure is the 'public sector corruption index (PSCI),' a composite that measures the extent to which the "public sector employees grant favors in exchange for bribes, kickbacks, or other material inducements, and how often do they steal, embezzle, or misappropriate public funds or other state resources for personal or family use" (V-Dem).

The 'political corruption index (PCI)' is another composite index that covers different political institutions, distinguishing between executive, legislative, and judicial corruption. Within the executive branch, the measure includes both bribery-related corruption and embezzlement-related corruption. Furthermore, the measure distinguishes between corruption at the top levels of the executive and corruption in the public sector as a whole. The index, thus, includes several differentiated types of corruption, including "petty" and "grand", bribery and theft, and corruption aimed influencing at lawmaking as well as at affecting implementation.

Finally, the 'regime corruption index (RCI)' measures the extent to which "political actors use political office for private or political gains" (V-Dem). It is closely related to the political corruption index above; however, it focuses on a more specific set of actors – those who occupy political offices. Furthermore, it is concerned with a specific set of corrupt acts that relate

more closely to clientelist relationships between office holders and their patrons. Data for corruption indices from the V-Dem database are available from 1975 to 2019[2].

The six indices described above are highly corelated with each other, as shown in Table 1.1 below.

Table 1.1: Correlation among corruption indices

| | ICRG | CPI | CofC | PCI | PSCI | RCI |
|---|---|---|---|---|---|---|
| ICRG | 1 | | | | | |
| CPI | 0.875 | 1 | | | | |
| CofC | 0.872 | 0.975 | 1 | | | |
| PCI | 0.719 | 0.871 | 0.906 | 1 | | |
| PSCI | 0.706 | 0.852 | 0.883 | 0.942 | 1 | |
| RCI | 0.704 | 0.846 | 0.885 | 0.979 | 0.914 | 1 |

### *1.4.3 Decentralization and political institution variables*

Our main independent variables is related to 'Democratic decentralization and party (non) integration. The data for local elections and legislative-executive relations are based on Hankla et al. (2019) and cover 135 countries from 1975-2019. We code dummy variables *DDPI* for "Democratic Decentralization and Party Integration" and *DDPN* for "Democratic Decentralization and Party Non-integration." *DDPI* is coded "1" when (1) municipal elections are held, (2) municipal executives are not appointed by a higher tier, (3) at least half of parties have a permanent organization, (4) more than 75 percent of municipal council seats are held by national parties, and (5) national party leaders have the authority to nominate candidates in local elections. Our other variable, *DDPN* is coded "1" when (1) municipal elections are held, (2)

[2] Apart from the three indices from the V-Dem dataset, we also ran regressions with other three corruption indices from the same dataset – the judicial, executive, and legislative corruption. While we do not present those in the paper, the results are similar to the ones we present.

municipal executives are not appointed by a higher tier, and when any one or more of the following conditions are met (1) fewer than half of the political parties have a permanent organization, (2) national parties hold 75 percent or fewer seats in municipal councils, or (3) central party leaders do not have the authority over party nomination in local elections. The reference category for this analysis are democratically centralized countries, i.e., those countries which do not hold local elections.

The coding rule for the democratic decentralization and party integration variables does not allow for a disaggregated analysis with separate variables for democratic decentralization and party integration. Party integration is only coded for countries that are democratically decentralized. Thus, we use alternative measures of democratic decentralization and political party integration in this section of our empirical analysis. We employ the 'local government index' and the 'party institutionalization index' from the V-Dem dataset as a substitute for democratic decentralization and party integration, respectively. Additionally, we also created another party integration proxy variable that mimics the requirements of party integration from Hankla et al. (2019) as closely as possible. We discuss these three indices below.

The 'local government index' measures the extent to which elected local governments can operate without interference from unelected bodies at the local level. Thus, a country that has no elected local governments gets the lowest score. Countries that have elected local governments, but those governments are subordinate to unelected officials, generally appointed by higher-level body, are given a medium score. A high score is given to countries where elected local governments can operate without restrictions from unelected actors at the local level with the exception of judicial bodies.

The ‘party institutionalization index’, on the other hand, captures various features of political parties in a country. These features include level and depth of organizational structure, links to civil society, coherence of party platforms and ideologies, and party-line voting among representatives within legislation. A high score indicates more institutionalized party system.

Finally, we created a separate ‘party integration proxy index’. In addition to the components of the party institutionalization index, it includes two important components of party integration. The first one is party competition across regions, which measures how common is it for major parties to have electoral support in multiple regions. A low score suggests major parties are competitive in only one or two regions of the country, while a high score means major parties are dominant in most regions of the country. The second component reflects the authority of national party leaders over candidate selection for legislative elections. After adding these components, the index is converted to its CDF in order to range from 0 to 1, where a high score suggests strong party integration.

### *1.4.4 Control variables*

In our empirical analysis, we include control variables measuring institutional, economic, and demographic factors. First, we include the level of fiscal autonomy of local governments. The data for fiscal autonomy comes from the ‘Regional Authority Index’ by Marks et al. (2008) and measures the extent to which subnational governments can independently tax their population. The level of authority of local governments over fiscal decisions can affect the opportunities and incentives for corruption. For instance, local politicians can extract bribes and misuse public funds with smaller costs because of their abundant knowledge of local interest

groups (Dincer et al., 2010). Local-level bureaucrats are more vulnerable to fall under the influence of private corporations and special interests (Shon and Cho, 2020).

Next, we include a series of controls for economic factors: GDP per capita (logged), trade openness, and government consumption. Richer countries are likely to enjoy lower rates of corruption, while the net impact of trade openness is ambiguous. Trade openness can increase competition and reduce the ability of domestic firms to pay bribes (Majeed, 2014). Moreover, international firms can divert their businesses from one country to another relatively more easily than domestic ones. Thus, trade can encourage a nation to allocate resources to building good governance and lower corruption. At the same time, trade can also create more opportunities for corruption. For instance, Tanzi (1998) finds that paying bribes to politicians can help firms gain advantage in obtaining foreign contracts or for obtaining imports authorization. Corruption can also be transmitted as a learned behavior. Hisamatsu (2003), for example, argues that countries that trade with corrupt countries also import corruption.

Government consumption measures total government expenditure as a percentage of the economy. One might expect higher government spending to increase corruption, but some of the least corrupt governments, such as Canada and the Netherlands, have large government sectors (Lash and Batavia, 2013). In previous research, Tanzi and Davoodi (1997) have identified a positive relationship between corruption and government spending, while Elliot (1997) and Graeff and Mehlkop (2003) have found the opposite result.

Additionally, we control for the natural resource dependence of nations. Greater dependence on natural resources such as oil and minerals can create economic opportunities as well as foster rent-seeking behavior by government officials (Franke et al., 2009; Caselli and Michaels, 2013). State-controlled resource sectors can lead to resource windfalls in the hands of

government officials and encourage corrupt behaviors (Ross, 1999). Finally, we include population size, world region dummies, and decade dummies. Summary statistics of all variables are reported in Table A1 in the appendix

### 1.5 Estimation Strategy and Results

We use the following estimation specification:

$$y_{it} = \beta_0 + \beta_1 ddpi_{it-1} + \beta_2 ddpn_{it-1} + \beta_3 \boldsymbol{X}_{it-1} + \epsilon_{it} \quad 1.1$$

Where, $y_{it}$ is the corruption index for country 'i' in year 't', $ddpi_{it-1}$ and $ddpn_{it-1}$ are lagged values of 'democratic decentralization and party integration' and 'democratic decentralization and party non-integration', respectively. $\boldsymbol{X}_{it-1}$ includes the control variables discussed in previous section. Finally, this model includes world region dummies and decade dummies. In the robustness section, we present results with country and time dummies as well.

We include the results with one-year lags to account for the potential delayed effect of the independent variables on corruption. Our results also hold for three- and five-year lagged values of the independent variables. Corruption indices are rescaled to represent low scores as low corruption and high scores as high corruption. Therefore, a negative sign should be interpreted as negative relationship to corruption.

Table 1.2 presents the regression results where both *Democratic decentralization and party integration (DDPI)* and *Democratic decentralization and party non-integration (DDPN)* are included as independent variables. The reference category is countries with no democratic decentralization. Results from table 2.2 show that both of our independent variables (DDPN and DDPI) are negatively related with the corruption indices and are consistent to using multiple

corruption indices. These results suggest that, regardless of the party structure, democratic decentralization may be more effective in reducing corruption than democratic centralization.

Table 1.2: Panel estimation results (Base category: Democratic centralization)

| | (1) ICRG | (2) CforC | (3) PCI | (4) PSCI | (5) RCI | (6) CPI |
|---|---|---|---|---|---|---|
| DDPI (Lagged) | -0.169** | -0.228*** | -0.009 | -0.040*** | -0.024** | 2.639 |
| | (0.076) | (0.055) | (0.011) | (0.011) | (0.011) | (1.989) |
| DDPN (Lagged) | -0.166** | -0.120** | -0.022** | -0.037*** | -0.041*** | 2.192 |
| | (0.077) | (0.058) | (0.010) | (0.012) | (0.011) | (2.117) |
| Fiscal autonomy (Lagged) | -0.054*** | 0.014 | 0.007** | 0.006** | 0.011*** | 0.337 |
| | (0.018) | (0.013) | (0.003) | (0.003) | (0.003) | (0.411) |
| GDP Per Capita (Lagged) | -0.620*** | -0.686*** | -0.174*** | -0.173*** | -0.169*** | -14.585*** |
| | (0.026) | (0.021) | (0.004) | (0.004) | (0.005) | (0.939) |
| Government Consumption (Lagged) | -0.040*** | -0.034*** | -0.011*** | -0.005*** | -0.011*** | -0.722*** |
| | (0.005) | (0.003) | (0.001) | (0.001) | (0.001) | (0.136) |
| Trade Openness (Lagged) | -0.001*** | -0.002*** | -0.001*** | -0.001*** | -0.001*** | -0.037** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.015) |
| Oil Rent (Lagged) | 0.017*** | 0.045*** | 0.012*** | 0.011*** | 0.012*** | 1.142*** |
| | (0.006) | (0.004) | (0.001) | (0.001) | (0.001) | (0.192) |
| Mineral Rent (Lagged) | -0.002 | -0.021*** | -0.010*** | -0.009*** | -0.007*** | -0.610** |
| | (0.009) | (0.007) | (0.002) | (0.002) | (0.002) | (0.239) |
| Population size (Lagged) | -0.001 | 0.002*** | -0.001*** | -0.003*** | -0.001*** | 0.002*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Decade dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| World Region dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 7.909*** | 5.602*** | 1.854*** | 1.754*** | 1.846*** | 193.635*** |
| | (0.211) | (0.117) | (0.032) | (0.031) | (0.035) | (4.269) |
| Obs. | 2300 | 1641 | 3047 | 3047 | 3047 | 620 |
| R-squared | 0.603 | 0.804 | 0.720 | 0.680 | 0.684 | 0.825 |
| F-test | 204.179 | 416.053 | 432.591 | 357.458 | 363.670 | 429.03 |

Robust Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Next, we examine the effectiveness of party integration versus non-integration in reducing corruption. Table 1.3 limits the data to democratically decentralized country-years and presents the regression results where the independent variable is *Democratic decentralization and party non-integration,* and the reference category is countries with *Democratic decentralization and party integration.* The results show that, compared to party integration, party non-integration (under a democratically decentralized setting) is negatively associated with corruption. This highlights an important distinction between the political party structures and their impact on corruption. When local candidates are nominated by local constituents or local parties, corruption tends to be lower. Corruption is more visible at the local level, which allows local voters to filter out corrupt candidates.

Table 1.3: Panel estimation results (Base category: Democratic decentralization and party integration (DDPI))

| | (1) ICRG | (2) CforC | (3) PCI | (4) PSCI | (5) RCI | (6) CPI |
|---|---|---|---|---|---|---|
| DDPN | -0.017 | -0.145*** | -0.029*** | -0.015** | -0.032*** | -1.572* |
| | (0.040) | (0.028) | (0.007) | (0.007) | (0.008) | (0.882) |
| Control Variables | Yes | Yes | Yes | Yes | Yes | Yes |
| Decade dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| World region dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 3.513*** | 3.461*** | 1.193*** | 1.026*** | 1.192*** | 153.186*** |
| | (0.505) | (0.301) | (0.081) | (0.077) | (0.091) | (9.602) |
| Obs. | 1973 | 1443 | 2422 | 2422 | 2422 | 547 |
| R-squared | 0.629 | 0.815 | 0.743 | 0.702 | 0.698 | 0.843 |
| F-test | 245.398 | 561.098 | 607.915 | 448.618 | 473.408 | 395.93 |

Robust Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In summary, democratically decentralized systems with either kind of party structure are effective in reducing corruption compared to democratically centralized systems. Within the decentralization framework, however, party non-integration is more effective than party

integration at reducing corruption. In the next section, we present estimation results from alternative identification strategies to ensure the robustness of these results.

## 1.6 Robustness checks

### *1.6.1 Quantile Regressions*

We use quantile regression as a robustness check on our main party results (again limiting the dataset to democratically decentralized observations). Conventional OLS regression reports the conditional mean (E(y|x)) of the dependent variable. Unlike OLS estimation, quantile regression does not require a normally distributed error term. Rather, it estimates the parameter at multiple points in the distribution of the dependent variable (Billger and Goel 2009). Thus, quantile regression examines the impact of the covariates on the entire distribution of the dependent variable. It allows us to assess whether the relationship between the independent variables and corruption varies over different quantiles, for example whether it is present in both highly corrupt and less corrupt countries (Saha and Su, 2012; Goel and Ram, 2013; Jetter et al. 2015).

The quantile regression for $\theta$th quantile minimizes the weighted sum of absolute deviations of the error terms by appropriately weighting the residuals as shown in the following objective function:

$$Q(\beta_\theta) = \sum_{i:y_i \geq x'_{i\beta}}^{N} q|y_i - x'_i\beta_\theta| + \sum_{i:y_i < x'_{i\beta}}^{N} (1-q)|y_i - x'_i\beta_\theta| \qquad (1.2)$$

Where, $\theta \in (0,1)$, y is the corruption index, and x is the vector of control variables. We use the robust standard errors to account for the heteroskedasticity that might be present in the data. We present these results in Table A3 in the appendix.

A Bruesch-Pagan / Cook-Weisberg test for heteroskedasticity yields a large and statistically significant chi-square value indicating the presence of heteroskedasticity. Thus, we report robust standard errors. The reference group for the quantile regressions is *Democratic decentralization and party integration.* The results confirm earlier findings from table 1.3 where party non-integration is more effective in lowering corruption compared to party integration. These results hold true at different levels of corruption and are consistent with the quantile regression of multiple corruption indices. The results further indicate that the effects of party structure are greater in countries with higher levels of corruption. This is a result that requires further explanation, but it seems likely that low levels of corruption are driven by broader structural factors such as income-level, and also that low levels of corruption may be less visible or salient in local politics. It is precisely when these constraints are absent that factors such as greater accountability through party structures are likely to matter most.

### *1.6.2 Using data on sub-national corruption*

While our arguments are primarily about corruption at the subnational level, we use national corruption data for our primary analyses. We make this choice because national data are available for a much broader range of countries and years. At the same time, for robustness, we present here our models estimated with the best subnational data on corruption available, coded as a cross-section for the year 2005. More specifically, in these models, we use the subnational corruption index from Borsky and Kalkschmied (2019), which uses survey data to capture corruption perception at the local government level[3].

[3] Higher values of the subnational corruption index indicate higher levels of corruption. For more details on how the sub-national corruption index is created, see Borksy and Kalkschmied (2019). Data available at: https://www.sciencedirect.com/science/article/pii/S0176268018304415

We present our results in table A4 in the appendix. These models reinforce the earlier results where party non-integration is associated with lower corruption compared to party integration, within democratic decentralization. They suggest that, when using a local level corruption indicator, party non-integration remains more potent in its effect on reducing corruption than party integration.

### *1.6.3 Disaggregated measures of democratic decentralization and party integration*

Additionally, we use alternative measures of democratic decentralization and party integration for our estimation. As we discuss earlier, our alternative measure of democratic decentralization is 'local government index.' Similarly, we use 'party institutionalization index' as an alternative measure of party integration. Data for both variables come from the V-Dem database. Finally, we create a proxy index of party integration including components that reflect party competition in subnational elections and the local candidate nomination authority of central party leaders. We use the following estimation for this part of the analysis:

$$y_{it} = \theta_0 + \theta_1 locgovindex_{it-1} + \theta_2 partyindex_{it-1} + \theta_3 \boldsymbol{X}_{it-1} + \mu_{it} \qquad (1.3)$$

Where, $locgovindex_{it-1}$ is the lagged 'local government index' for country 'i' and $partyindex_{it-1}$ is the lagged value of party indices. The control variables are the same as in equation (1.1) above.

The regression results with disaggregated independent variables suggest that greater autonomy of local governments over political decision making is associated with lower corruption (Table A5 and A6). Similarly, higher party institutionalization and party integration is associated with lower corruption.

### *1.6.4 Further lagged independent variables*

We use one-year lagged independent variables in our estimations to address potential endogeneity resulting from reverse causality. The use of lagged explanatory variables to sidestep the potential issue of simultaneity and reverse causation is a common practice in applied economic research (Reed, 2015; Islam, 2018). Moreover, we run a Granger causality test to identify the direction of causality between our independent and outcome variables. The results show that causality runs one way from the independent variables to the corruption indices, but not the other way around. Additionally, we use Driscoll-Kraay standard errors that are robust to serial correlation, heteroskedasticity, and cross-sectional dependence (Driscoll and Kraay, 1998; Hoechle, 2007). Finally, we use country and year fixed effects.

To further ensure the robustness of our findings, we present in table A7 results with further lags of the independent variables. The results hold for both 3 year- and 5 year-lagged variables and further bolster our initial findings.

## 1.7 Conclusion

In this paper, we test the impact of political institutions, in particular local elections and sub-national party integration, on corruption. We argue that locally elected officials have incentives to behave honestly in office, lest they be voted out by their constituents. We also test whether this local accountability is augmented when national parties are non-integrated, meaning that candidate selection for local office also happens at the sub-national level, versus when local candidates are nominated by the national party structure. We use sub-national data to test our theory on a vast dataset of more than 100 countries, and the statistical results robustly show that democratically decentralized countries have less corruption. We also find evidence in most of

our models that, among such democratically decentralized countries, corruption will be further minimized by the presence of non-integrated parties with local candidates selected by local mechanisms.

This result suggests that the ability of local voters to choose among potential candidates allows them to select those who are more honest. It also indicates that this advantage of party non-integration trumps any benefit derived from the incentives that national party leaders possess to choose honest candidates when they are empowered to do so.

Our findings, in additional to their policy relevance, have three important implications. First, they provide further evidence that political institutions, and in particular party structures, matter for governance outcomes at the local level. Second, they indicate that the "perfect" local institutions may not exist, since party structures that are best for public goods delivery and those that reduce corruption may be different. Finally, they point clearly to the important role played by information in combatting corruption. While both national party officials and local voters possess incentives to minimize corruption, it is local voters who know which candidates are likely to abuse their positions. Empowering these voters, our results suggest, will reduce the risk that corruption will undermine good governance.

In the final analysis, we hope that this paper can contribute to resolving entrenched theoretical disputes and mixed empirical findings around the impact of decentralization on corruption. Our results show that scholars must consider the specific political and institutional features of decentralized systems to understand their impact on complex outcomes such as corruption.

# CHAPTER 2: FISCAL DECENTRALIZATION AND CLIMATE CHANGE: HOW POLITICAL INSTITUTIONS MEDIATE THE IMPACT OF FISCAL DECENTRALIZATION ON CLIMATE CHANGE

## 2.1 Introduction

The Sixth Climate change report by the 'International Panel on Climate Change' is unequivocal on its assessment that – "human influence has warmed the atmosphere, ocean, and land" (IPCC, 2021). Moreover, climate change is also hindering the efforts to meet 'Sustainable Development Goals' (IPCC, 2022). The economic impacts of climate change are expected to be severe (Mukhi et al., 2020). According to Sterns Review (2006), global GDP will fall by at least 5 percent per year under "Business as usual". The efforts to address climate change at the international and domestic levels have remained underwhelming (WDR, 2010; Gupta, 2010).

Decentralization has remained an important shift in governance structure throughout the world in the past few decades (Arzaghi and Henderson, 2005). It is an effective tool for a more efficient delivery of public services (Simatupang, 2009; Faguet and Sanchez, 2014; Escaleras and Register, 2012)[4]. As we know from the literature, the degree of decentralization largely depends on the extent of preference heterogeneity and the extent of externalities (Oates, 1972). Not surprisingly, most climate change challenges and the policies to address them carry significant externalities (Stern, 2008) - for instance, curbing air pollution (Banzhaf and Chupp, 2012) or addressing water pollution (Sigman, 2005, 2014; Lipscomb and Mobarak, 2011). This raises an important question – What role do (and also could) subnational governments play in combatting climate change?

[4] For a detailed survey of fiscal decentralization see Martinez-Vazquez et al. (2016)

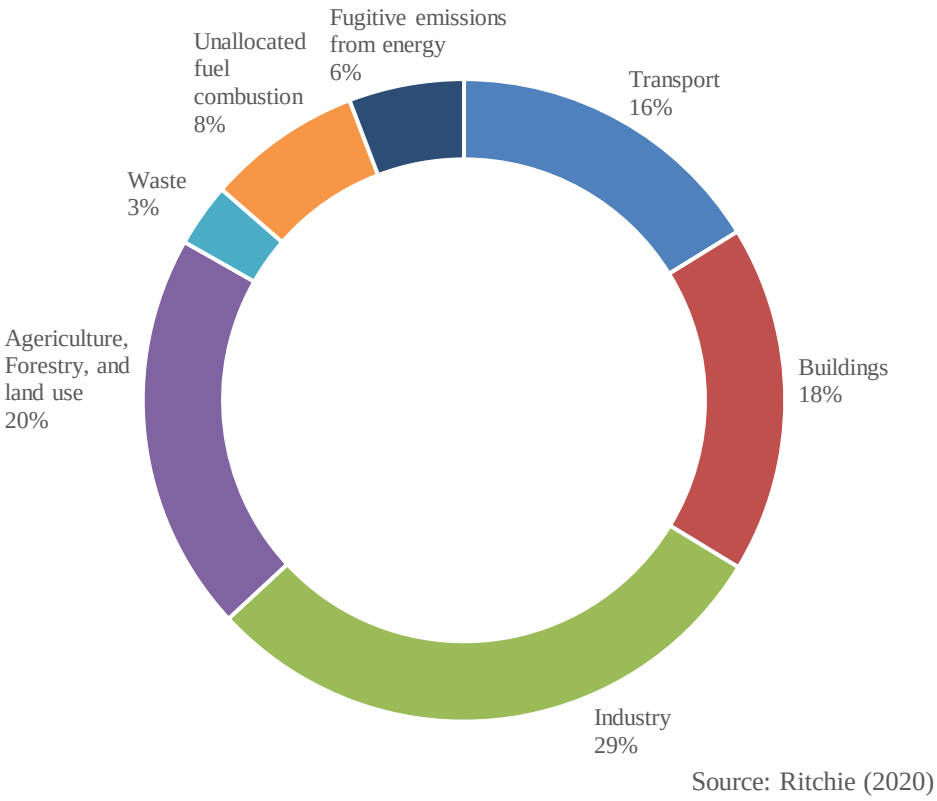



Figure 2.1: Sources of Greenhouse gas emissions in 2016

Carbon emissions are a major source of climate change with relatively large spillovers effects. Nevertheless, if we consider the source of the emissions subnational governments may have responsibility over more than 40 percent of the sources (Martinez-Vazquez, 2021). For instance, subnational governments are generally responsible for land use and waste management regulations. And these activities are responsible for 20 percent and 3 percent emissions of greenhouse gases, respectively. Moreover, subnational governments also play important role in maintaining building codes, reducing waste and energy use in the provision of public services, and improving vehicle emission standards (Danida, 2009). As figure 2.1 shows, energy use in transport and buildings are responsible for 16 and 18 percent of the global greenhouse gas emission,

respectively. Typically, these sectors are regulated by regional and local government (Martinez-Vazquez, 2021). From this perspective, it makes sense for subnational governments to have more control of policy making when it comes to the environmental effect on climate change.

Yet, to this point, the economics literature has not provided any conclusive evidence regarding the relationship between fiscal decentralization and climate change (Millimet, 2003; Farzanegan and Mennel, 2012). This harkens back to the issue of the potentially large externalities that climate change policies typically carry. As the degree of externality increases, fiscal decentralization might yield under-provision of local public goods with externalities, but which are provided strictly from a local lens (Martinez-Vazquez, 2021). In this regard, Riker (1964) suggested that strong national political parties could achieve a balance between local and national interests. While decentralization can address local preference heterogeneity, national parties can shape the incentives for local politicians to consider national objectives for public services including climate change (Enikolopov and Zhuravskaya, 2007; Hankla et al., 2019).

Particularly, when parties are institutionalized, which is the focus of this paper, they have the incentive and the capacity to influence the local policymaking. Institutionalized parties have well-defined organizational structure, have their pulse in local preferences and have the capacity to incentivize local party members to care about issues that carry varying degree of externalities (Bizzaro et al., 2018). In this way, the organizational structure political parties can be effective player to the fight against climate change in fiscally decentralized countries.

In this paper, we study the joint effect of fiscal decentralization and party institutionalization on climate change using a large panel dataset of 75 countries over from 1971 to 2018. Our data for fiscal decentralization comes from IMF's 'Government Finance Statistics' and data for party institutionalization comes from 'V-Dem dataset.' Our dependent variables

proxying climate change are – Co2 emission per capita, organic water pollutant (BOD) emissions, and renewable energy consumption. Our empirical findings show that strong party institutionalization improves the functional role of fiscal decentralization in combating climate change. Party Institutionalization and fiscal decentralization, together, help lower Co2 emission and promote renewable energy consumption.

Rest of the paper is organized as follows: section 2 provides a literature review of fiscal decentralization and climate change and the role of political institutions, in particular the role played by political parties. Section 3 develops a simple theoretical framework, section 4 discusses the data, and section 5 outlines the empirical methodology. We present the empirical results in section 6 and robustness checks in section 7. Section 8 concludes.

## 2.2 Literature Review

### *2.2.1 Fiscal Decentralization and Climate change*

From a theoretical standpoint, decentralization is a preferable system for delivering local public services when preference heterogeneity exists across jurisdictions, and no significant externalities (and/or economies of scale) are present in the delivery of public services (Oates, 1972). This model has been extended to environmental decentralization (Oates, 2001). However, the theoretical models on environmental decentralization provide results that are often contradictory, such as the "race to the top" vs. "race to the bottom" (Garcia-Valinas, 2004).

A "race-to-the-bottom" occurs when sub-national governments competing over capital lower their taxes and environmental standards to attract more capital. Local governments are typically faced with tight budget constraint and may find it hard to adequately invest in environmental protection. Moreover, often, the externalities from pollution can be passed onto

the neighboring counties or states, so the polluting jurisdictions can relax their own environmental standards (Woods, 2006). Conversely, a "race to the top" occurs when states prioritize a “clean” environment and raise their environmental standards. This could be due to pollution costs being too high and therefore states wanting to limit pollution-intensive activities States may also want to highlight a “clean” environment to attract new firms from non-polluting sectors. Additionally, the introduction of strict environmental laws could also be in response to similar laws set by neighboring states. These behavior patterns are in line with the “race-to-the-top” type of arguments (Konisky, 2007; Ferganegan and Mennel, 2012).

A sizable number of scholars have investigated the possible "race-to-the-bottom" phenomenon of environmental decentralization. Evidence, so far, appears to be mixed (List and Gerking, 2000; Fredriksson and Millimet, 2000; Fomby and Lin (2003). In particular, Millimet (2003) examined the devolution of environmental policymaking during the Reagan era and found that the results are consistent with a "race-to-the-top." In contrast, Farzanegan and Mennel (2012) found support for a "race-to-the-bottom" under decentralized policy environments, although the nefarious effects decline with improvements in the quality of institutions.

Other researchers have emphasized the possible efficiency improvements derived from environmental decentralization (Oates, 1997; Oates and Schwab, 1988). In this regard, List and Mason (2001) developed a game-theoretic model that shows that decentralization has a greater payoff than centralized control when there is a larger degree of pollution heterogeneity (flow of emissions/stock of pollution) across jurisdictions. In the context of inter-jurisdictional capital mobility, Fredriksson and Gaston (2000) argue that competition for capital in a decentralized setting has an equivalent effect on environmental policymaking as capital owner lobbying in a centralized system. More recently, Khan et al. (2021) provides evidence for a positive relation

between fiscal decentralization and environmental quality in seven OECD countries. This relation is further strengthened by improved institutional quality and the development of human capital.

Individual country empirical findings also tend to be mixed. For example, the results for China, the largest and most polluting country in the world and which is also highly fiscally decentralized but not at all politically decentralized, show positive, negative, and non-significant effects of fiscal decentralization on different measures of environmental pollution. For example, Liu et al. (2017) and He et al. (2012) find a positive relationship between fiscal decentralization and environmental pollution. On the other hand, He (2015) finds that fiscal decentralization has no significant effect on environmental pollution, while Kuai et al. (2019) show that fiscal decentralization has a positive effect on environmental regulations leading to emission reduction. Increases in both revenue and expenditure decentralization enhance local governments' administrative powers, which translate into more funding towards improving environmental quality. A similar conclusion is reached by Song et al. (2018). Several other papers have found a non-linear relationship between fiscal decentralization and environmental pollution (Hao et al. 2020; Liu and Li, 2019, Liu et al. 2019; Cheng et al. 2020); fiscal decentralization increases environmental pollution up to a certain point, after which, further levels of fiscal decentralization result in local governments encouraging firms to use environmentally friendly methods of production because of pressures from civil society.

Other researchers have emphasized the difficulties of decentralized governance in inter-jurisdictional externality settings. For example, Sigman (2005, 2014) has highlighted the drawbacks of environmental decentralized policymaking due to coordination failures and the free-riding of the states; specifically, water pollution is greater when the rivers cross state/county

borders as well as international borders. Similar results are found by Helland and Whitford (2003) using toxic release inventory (TRI) data from 1987 to 1996. Also related, states with stricter environmental policies tend to strategically locate their more polluting firms near the state boundaries (Monogan III et al., 2017, Helland and Whitford, 2003).

Fewer papers have studied the relationship between fiscal decentralization and renewable energy consumption. Su et al. (2020) finds a positive relationship between fiscal decentralization and renewable energy consumption based on panel data for seven OECD countries from 1990 to 2018. Elheddad et al. (2020) also study the relationship between fiscal decentralization and energy consumption along with the role of urbanization in China and find a non-linear relationship. At an early stage of fiscal decentralization, energy consumption increases and deteriorates environmental quality. After a certain point, local governments tend to increase environmental regulations to improve the environmental quality. This case signifies a negative relationship between fiscal decentralization and energy consumption. Thus, their results provide evidence for an inverted U-shaped relationship between fiscal decentralization and energy consumption.

Since decentralization allows for the catering of local needs and preferences, thus making the provision of public goods more efficient, decentralization may have an advantage over the provision of some climate-change-related functions, especially when these functions need to respond to localized effects of environmental damage (Oates, 1997). For instance, subnational governments are commonly responsible for land-use planning and enforcement, solid waste management, water, and power utilities. Subnational governments may also be generally more accountable for the provision of those services. For example, Bedner (2010) finds that local governments in Indonesia are more responsive towards complaints about water pollution levels.

On the whole, many climate-change-related damages, such as in the case of greenhouse gas emissions, carry externality spillover effects that could affect from neighboring jurisdictions to the whole world. In those cases., the conventional decentralization theorem (Oates 1972) may not hold. However, in such cases, the role of fiscal decentralization may be mediated by the presence of certain political institutions (Harrison and Sundstrom, 2007), and in particular political parties, might have a strong role to play (Robbins, 2010; Hankla et al., 2019).

### *2.2.2 Role of Political Parties*

Political parties are ubiquitous regardless of the political system, democratic or autocratic. Scholars have studied the significant roles parties play in strengthening the political system and delivering public services (Mainwaring and Scully, 1995; Bizzarro et al., 2018; Hicken, 2018; McMann et al. 2017). In his seminal work, Riker (1964) argued that strong political parties could have a significant influence on local politics, especially through their influence on the careers of local politicians. Strong parties are well-funded and have stable linkages to the voters. This is important for local politicians as they depend on the party to fund their (re)election campaign, and perhaps in being nominated to do so. Additionally, local politicians may find more powerful and lucrative roles in central government and may want to move to the party-central leadership role. One prominent measure related to those political party strengths is "*party institutionalization*" typified in the 'V-Dem Dataset.'

Party institutionalization considers several facets of political parties. In a broad sense, institutionalization is "the process by which organizations and procedures acquire value and stability" (Huntingon, 1968). Huntington further identified four dimensions of party

institutionalization – adaptability, autonomy, complexity, and coherence.[5] In addition, Panebianco (1988) introduced two essential features of party institutionalization – autonomy and systemness. Autonomy refers to the autonomy of the party over decision-making and not to be influenced by veto actors. Systemness captures the strong and stable organizational structure of political parties. An institutionalized political party must be stable and be able to survive for a relatively long period of time. Similarly, it should also prioritize long-term goals that are closer to its ideals and be willing to sacrifice short-term objectives. This latter feature has been termed *value-infusion* (Levitsky, 2003).

In addition to stable organizations, institutionalized parties also have strong linkages to voters (Rasmussen and Knutsen, 2017). They have a local presence through party branches which gives them the ability to identify voters' preferences. They are also well connected with various interest groups. When parties can identify and aggregate voters' preferences, they have the incentives to act on it as they want to have broader support to win the elections nation-wide. Political parties with such characteristics have the incentives to be concerned about policies with nation-wide impact and a longer time span and have the capability to adopt such policies.

Strong political parties can also shape the political incentives of local politicians. Institutionalized parties are focused on the long-term gain for the party rather than the short-term gain of any individual party member. They are also better positioned to filter candidates and avoid the influence of any veto players due to their "well-functioning organizational apparatus" (Rasmussen and Knutsen, 2017). Hankla et al. (2019) have also argued that local politicians might aspire to move up the rank to the national government. When parties are institutionalized

[5] Party institutionalization is strongly related to party system institutionalization. While party institutionalization is concerned with the internal decision-making structure of political parties, party system institutionalization deals with the “the system of interaction resulting from inter-party competition” (Sartori, 1976).

within a democratically decentralized system, local elected leaders serve both the voters and the party leaders. They have the incentive to meet the need of local constituents to ensure their re-election. At the same time, they are also answerable to the central party leaders to secure their renomination. They argue that such a combination of democratic decentralization and the level of party institutionalization is conducive to providing optimal local public goods with spillovers. In a similar vein, Enikolopov and Zhuravskaya (2007) have argued that strong political parties can influence the political incentives of local politicians through political and financial support for their re-election. This is particularly important in a decentralized environment where local politicians might favor regionalist policies.

There are relatively fewer papers that have studied the impact of party institutionalization on policymaking. Hankla (2006) argues that strongly institutionalized parties have stable voter base and are less worried about electoral volatility. Therefore, these parties prioritize issues that have a longer time horizon. Conversely, weakly institutionalized parties do not have secure voting support, and they are more likely to be short-sighted in their policymaking. Similarly, Robbins (2010) shows that strong party system institutionalization, in general, is associated with larger spending on public goods and of a less parochial nature.

Last, there has been much less research on the role that party institutionalization may play in mediating the impact of fiscally decentralized governance on climate change. One exception is Fredriksson and Wollscheid (2014) who empirically studied the joint impact on environmental policy stringency of environmental decentralization and political centralization. They use a dummy for federal systems as a proxy for environmental decentralization and use party age as a proxy for political centralization for their cross-sectional data of 110 countries. They find that political centralization increases the policy stringency under decentralized

regimes. In the current paper, we will also use party age as a robustness check for our measure of party institutionalization. Instead of using dummy variable for fiscal decentralization, we use the expenditure and revenue decentralization data from the IMF database (discussed below).

### 2.3 A Simplified Theoretical Framework

Subnational governments generally play an important role in climate change-related policies such as regulation, emission controls, promotion of renewable energy consumption, and some forms of carbon taxation (Martinez-Vazquez, 2021). Some of the decarbonization/adaptation activities such as urban transport, housing construction codes, and land use regulations are well within the usual functional reach of local governments. For instance, state and local governments could adopt energy efficient building codes, preserve, and promote green area and forests, promote water conservation and crop diversification, and improve vehicle emission standards (Danida, 2009). How much of these policies will subnational governments implement efficiently largely depends to a large extent on the externalities associated with such policies.

For example, carbon emissions generally exhibit large negative externalities (Liu and Li, 2019). The presence of such externalities makes it difficult for decentralized governments to undertake efficient levels of climate-change related policies. In fact, as discussed earlier, the empirical evidence for the impact of fiscal decentralization on CO2 emission and renewable energy consumption so far has been mixed. These conditions strongly hint that those policies involving larger externalities will need strong institutions providing the right incentives so to attain effective results.

A core tenet of fiscal decentralization is that local government officials have the political incentives to fulfill the local population's needs and preferences. However, the fundamental implication of this is that given the local focus, in the presence of such large externalities, local government officials will tend to underestimate if not ignore them, and therefore under-provide the public goods that carry those spillover effects (Musgrave, 1959; Oates, 1972). However, recently Hankla et al. (2019) have posited that in democratically decentralized systems, when national parties are strongly institutionalized or integrated, local government officials will provide the efficient levels of public goods with spillovers (discussed above). Similarly, Enikolopov and Zhuravskaya (2007) have argued that the nature of national political parties is crucial in shaping the political incentives of local politicians.

Following this line of argument, our basic hypothesis to be empirically tested in this paper is that in the presence of strong institutionalized parties, fiscally decentralized systems will be effective on combating climate change, where effectiveness is approximated by several climate-change related outcomes including CO2 emissions and the promotion of renewable energy consumption.

The basic theoretical premise, as has been expounded above, is that institutionalized parties are in a better position to have a wide-economy and long-term view regarding policy formulation as well as to providing incentives to subnational government officials to take into account the externalities associated with public policy decisions. We further provide empirical evidence in support of those arguments in the following sections.

## 2.4 Data

### *2.4.1 Dependent Variables*

We use several separate variables measuring pollution levels, as proxies for effectiveness in combating climate change. First, we have yearly data on $CO_2$ emission per capita for each country. The emission of $CO_2$ is classified as a transboundary pollutant; it is a by-product of energy consumption, specifically from the burning of fossil fuels. It is also the largest contributor to the greenhouse gases in the atmosphere. Data for CO2 emissions are extracted from the World Bank's *World Development Indicators.*

Second, organic water pollutant (BOD) emission (mg/l) data are taken as an indicator of the water pollution level. It provides an approximation of the amount of total oxygen needed to decompose the organic and inorganic matter present in the water sample. BOD has a slower attenuation rate and is an appropriate indicator for inter-jurisdictional spillovers (Lipscomb and Mobarak, 2011; Sigman, 2007). The data on BOD emissions are taken from the GEMStat database of the Global Environment Monitoring System for Freshwater (GEMS/Water) Programme.

In addition, we also use 'renewable energy consumption' as an alternative outcome variable. This variable is calculated as renewable energy consumption as a share of total final energy consumption and the data comes from World Bank's *World Development Indicators.*

### *2.4.2 Explanatory Variables*

Our main independent variables are related to 'Fiscal Decentralization measures.' The level of fiscal decentralization is measured alternatively by revenue decentralization and expenditure decentralization. These variables capture the share of own revenue/expenditure of

sub-national governments (local and regional) as a share of general government revenue/expenditure. These measures exclude any transfer payment received from other government units. The data come from the Government Finance Statistics (GFS) provided by IMF, supplemented from the OECD decentralization database. Figure 2.2 contrasts the level of expenditure decentralization in 1975 versus 2016.

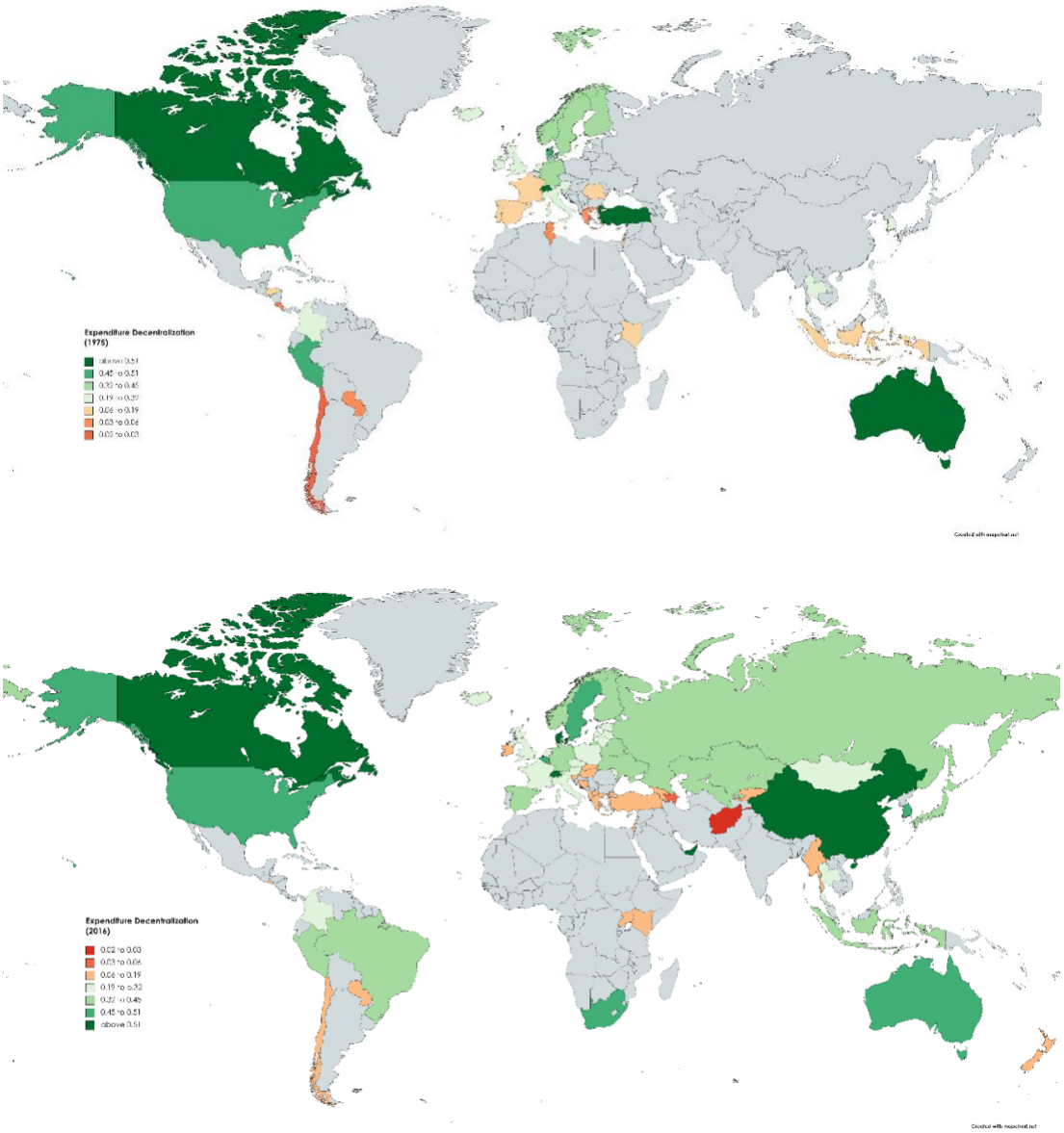



Figure 2.2: Expenditure decentralization in 1970 (top) and 2016 (bottom)

However, while the GFS data on decentralization measures are commonly used in the literature, these measures have been often criticized in the literature because of their inability to capture multiple aspects of decentralization, in particular the level of autonomy exercised by subnational governments (Martinez-Vazquez and Timofeev 2009). For these reasons, we will also use the regional authority index (RAI) as an alternative measure of fiscal decentralization. Developed by Hooghe et al. (2016), the RAI measures the authority of regional governments to exercise explicit rules that are not necessarily written in constitutions and other legislation. The indicator is disaggregated into two components: 'self-rule' and 'shared rule'. Self-rule measures the capacity of the regional government to function autonomously within its territory; more specifically, it evaluates the following five different institutional aspects: institutional depth, policy scope, fiscal autonomy, borrowing autonomy, and representation. Shared rule captures the co-dependence of regional governments to shape national policies. It indicates the influence subnational governments have over central decision making, and it covers four areas: normal legislation, executive control, fiscal control, and constitutional reform (Hooghe et al., 2016).

Next, for our analysis, we use the *party institutionalization index (PI index)* from the V-Dem dataset. The PI index captures the scope of party institutionalization in a country focusing on two important dimensions – organizational stability (routinization) and prioritization of long-term interests (value infusion). Furthermore, it also captures the linkages between parties and voters. It is calculated from five indicators that describe various features of political parties:

A. How many political parties for national-level office have permanent organizations?

B. How many parties have permanent local party branches?

C. How many parties have publicly available party platforms and relatively distinct platforms?

D. Is it normal for members of the legislature to vote with other members of their party on important bills?

E. Among the major parties, what is the main or most common form of linkage to their constituents? (Bizzarro et al. 2017)

The first three items capture the internal dimension of party institutionalization, specifically the organizational stability of political parties. The fourth item asks how often political elites vote in line with their parties' position. It captures the extent of party discipline and whether legislatures follow the party line in policymaking. The last item considers the linkages between parties and voters. The links range from clientelistic (signaling low degree of party institutionalization) to programmatic (high degree of party institutionalization). Together these variables adopt the core concepts of institutionalization – stability and long-term dynamics (Bizzaro et al., 2017). The PI index is available for 170 countries from 1789 to 2018 from V-Dem database.

As figure 2.3 shows, the average level of party institutionalization is lower in autocratic countries. China is an example where the regime is autocratic, but the Chinese communist party (CCP) is highly institutionalized (0.855). However, average party institutionalization in autocratic regimes (polity iv <-5) is much lower at 0.57 than parties in democratic regimes (polity iv > +5) at 0.813. In our empirical estimation, we control for this variation with polityiv scores.

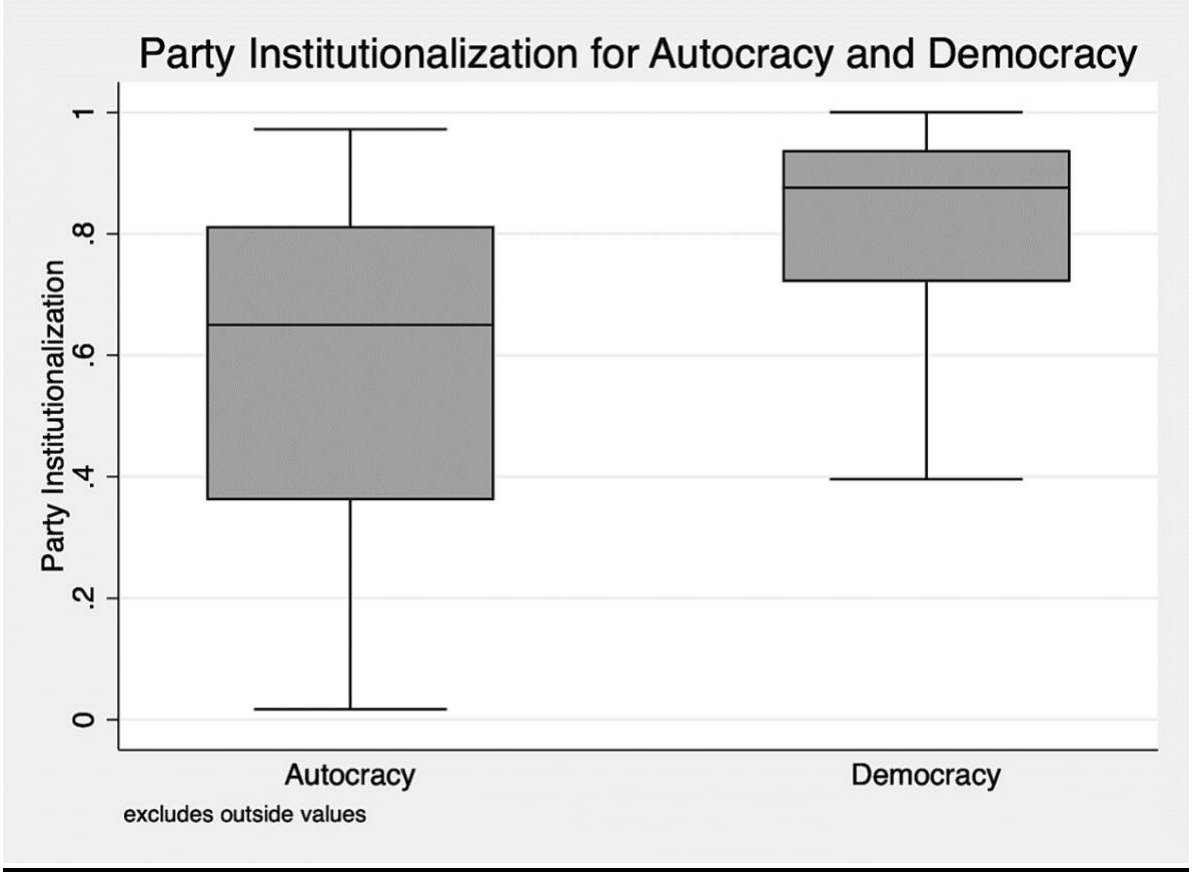



Figure 2.3: Party Institutionalization for Autocracy and Democracy

Figure 2.4 shows the examples of PIs for four countries from each of the corresponding world regions. Belgium has a high party institutionalization index, and it has remained stable over the years. El Salvador, on the other hand, experienced lower party institutionalization prior to the 1992 accords, after which a democratic transition occurred. We see a sharp rise in the index when the transition occurred between 1992 and 1994. Thailand saw a gradual rise in the index since the early 90s. Following the military coup in 2014, we see a decline in the index. In South Africa, after the end of apartheid in 1994, there's been a rise in the number of active political parties. Particularly, African National Congress (ANC), founded in 1912, is one of the oldest political parties in Africa. It played a major role to end the apartheid regime and, since

1994 it is the country's dominant party securing more than 60% of the seats in national and provincial elections.

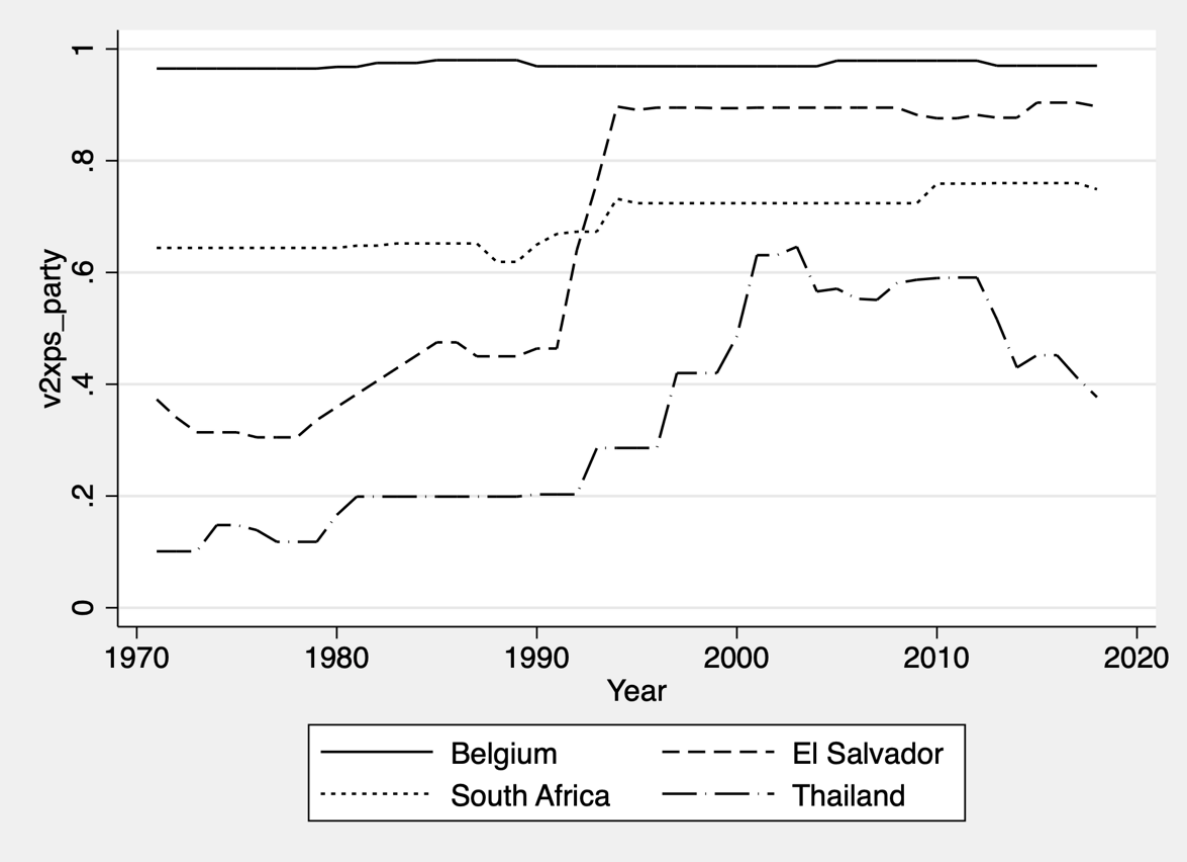



Figure 2.4: Party Institutionalization index of selected countries

We also use the average age of parties as an alternative measure for party institutionalization. The higher age of the parties indicates stronger political parties and a stable party system, and the latter can influence the career-concern of local politicians (Huntingon, 1968; Enikolopov and Zhuravskaya, 2007). This measure comes from the 'Database of Political Institutions' and is defined as the average age of the two largest government parties and one opposition party.

Another alternative measure of the independent variables is taken from the recent dataset of political decentralization from Hankla et al. (2019). They provide a measure for 'party integration' at the subnational level more directly. Party integration considers the dominance of national parties in subnational election. Moreover, central party leaders have the authority over the nomination of candidates in local elections. The authors combine party integration with democratic decentralization, where democratic decentralization is coded "1" when municipal elections are held, and municipal executives are not appointed by a higher tier. Party non-integration, on the other hand, present when regional parties are dominant. Also, central party leaders do not have the authority over candidate nominations in local elections. Rather, they are nominated through local mechanisms, either by local party members or by collecting signature. Their data covers 135 countries from 1975 to 2019.

Our final measures of decentralization come from the V-Dem dataset. They are 'Regional government index' and 'Local government index.' These indices measure the extent to which the elected government at regional/local level can operate without interference from the unelected body at the corresponding levels. Furthermore, these measures enable us to examine how party variables interact with decentralization at various levels of governments, and how this interaction affects the outcome variables to diverse degrees.

### *2.4.3 Control Variables*

*Democracy* – The first of our control political variables captures the presence of democracy/autocracy. We use the 'Polity-IV' data for this purpose. It ranges from -10 (autocracy) to +10 (democracy) (Beck et al., 2001). Previous studies have found a negative relationship between democracy and environmental pollution (Bernauer and Koubi, 2009).

*Type of electoral system* –Recent research by Ponce-Rodriguez and Rodriguez-Hernandez (2020) argues that environmental policies are likely to be more polarizing in majoritarian electoral system than in proportional electoral system. In proportional representation systems certain parties and coalition can attract the electorates that have special interest in climate or environmental issue (Harrinson and Sundstorm, 2007). We use the variable *pr* from the 'Database of Political Institutions' to control for the presence proportional electoral system.

*Party ideology*-- Party ideology may matter in environmental policymaking. Particularly, when left-leaning parties are in power, environmental policies are stricter than under right-leaning parties (Forgas and Jolliffe, 1994; Nawrotzki, 2012; Hamilton, 2011). We use the variable *gov1rlc* from the 'Database of Political Institutions' to control for the ideological leaning of the largest party in government.

*Economic Control variables* – We also consider several economic and demographic variables as additional control variables. To control for the level of income we use GDP per capita. The rationale is that there is considerable consensus in the literature that there is an inverted U-shaped relationship between GDP per capita and environmental pollution (Stern and Common, 2001; Chimeli and Braden, 2005; Brock and Taylor, 2010; Liu and Li, 2019; Hao et al.,2020). We also control for the level of globalization in the economy through trade openness. Antweiler et al (2001) suggests three possible channels for how trade openness can influence the environment. First, greater economic activity via increase in trade openness entails environmental costs, i.e., scale effect. Second, countries that have comparative advantage in products that are pollution-intensive may specialize in the production of that commodity. This is referred to as the composition effect. Third, higher income induced by increased trade openness can provide greater ability and willingness to implement strict environmental regulations. This is

known as the technique effect. Next, we control for urbanization level (expressed as the urban population as a percent of the total population). Previous studies have shown that higher urbanization is related to higher pollution levels (Panayotou, 1997).

We also control for the overall economic structure of countries. For this purpose, we use the relative size of the manufacturing and service sectors in the economy. The data corresponds to the value added as a percent of GDP for each sector. Value added is calculated as the total output from a sector minus intermediate inputs. Moreover, countries over-reliance on natural resources could lead to a rise in carbon emission and energy consumption (Kwakwa et al., 2020; Badeeb et al. 2020). We control for natural resource rents as a proxy for natural resource dependence (Badeeb et al. 2017). We further disaggregate the total natural resource rents and use rents from coal, and oil. These data are available from World Bank's 'World Development Indicators.'

*Demographic Control variables*, First, we use the 'Historical index of Ethnic Fractionalization' as a measure for ethnic diversity. An ethnically diverse society can suffer from poor communication and lower social cohesion, potentially making it more difficult to achieve long-term environmental goals (Das and DiRienzo, 2010). Data for ethnic fractionalization comes from Drazanova (2020). They are available for 162 countries from 1945-2013. The ethnic fractionalization index for country 'c' is calculated by a decreasing transformation of the Herfindahl concentration index measured by: , where $S_i$ is the proportion of the population in country 'c' at time 't' belong to ethnic group in the (i=1,….,n). In addition, we control for total population size.

*Institutional Quality Control variables*– Our first institutional-quality variable is the "civil participation index." Civil society can play an important role when it comes to

environmental protection (Khondker, 2001). We use the *civil society participation index* from the V-Dem dataset as a measure for the active participation of civil society in policymaking. This index is broad in its implications as it considers not only the participation of civil society in policymaking but also a general participatory environment for civil society organizations, including female participation in civil society organizations. The index is constructed by taking the point estimates from a Bayesian factor analysis model of the following indicators: i) candidate selection – national/local, ii) Civil society organization (CSO) consultation, iii) CSO participatory environment, and iv) CSO women participation.

We also use corruption and government stability as alternative controls for institutional quality. Corruption has shown to have a negative effect on the environment – i.e., it exacerbates environmental pollution (Welsh, 2004; Habib et al., 2018; Akhbari and Nejati, 2019). Government stability measures the ability of the government to carry out its declared programs and its ability to stay in office. We use government stability as a proxy for political stability. Political instability has been found to negatively affect the stringency of environmental regulation (Fredriksson and Svensson, 2003; Purcel, 2019).

Finally, in the estimation using political decentralization data, we control for potential confounding factors by including three additional controls. The first one is clean election. It controls for any election related irregularities such as registration fraud, government intimidation of the opposition, vote buying and election violence. Second, we control for judicial independence. It measures the extent to which the courts are not subject to undue influences from other branches of government. Our next variable controls for whether elected officials are subordinate to non-elected officials in local governments. Rather than the relative power of local

offices to higher tier of government, it controls for the relative power of local elected offices to each other.

Table 2.1 shows the summary statistics for all variables used in the empirical estimation.

Table 2.1: Summary Statistics

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| (Logged) CO2 emission (Metric ton per capita) | 3,013 | 1.331 | 1.286 | -3.321 | 4.352 |
| (Logged) BOD emission (mg/l) | 558 | 0.832 | 0.822 | -1.386 | 5.333 |
| (Logged) Renewable energy consumption (% of total energy consumption) | 1,936 | 2.410 | 1.350 | -2.738 | 4.573 |
| Revenue Decentralization | 2101 | 0.171 | 0.145 | 0.003 | 0.892 |
| Expenditure Decentralization | 2076 | 0.259 | 0.161 | 0.002 | 0.816 |
| Regional Authority Index | 2413 | 11.1414 | 10.227 | 0.000 | 37.722 |
| Party Institutionalization | 3124 | 0.743 | 0.230 | 0.017 | 1.000 |
| Average Age of Parties | 2585 | 42.870 | 35.447 | 1.000 | 183 |
| Self-rule | 2413 | 9.173 | 7.469 | 0.000 | 26.336 |
| Shared rule | 2413 | 1.967 | 3.583 | 0.000 | 14.951 |
| Democratic dec. and party integration | 2,872 | 0.368 | 0.482 | 0.000 | 1.000 |
| Democratic dec. and party non-integration | 2,872 | 0.369 | 0.483 | 0.000 | 1.000 |
| Regional government index | 3,214 | 0.429 | 0.418 | 0 | 0.998 |
| Local government index | 3,187 | 0.735 | 0.351 | 0 | 0.996 |
| Polity IV | 2944 | 4.954 | 6.706 | -10.000 | 10.000 |
| Proportional Representation (1=Proportional rep. electoral system) | 2455 | 0.794 | 0.405 | 0.000 | 1.000 |

Table 2.1: Summary Statistics (continued)

| | | | | | |
|---|---|---|---|---|---|
| Largest Government Party Orientation (1=Right, 2=Center, 3=Left) | 2770 | 1.607 | 1.161 | 0.000 | 3.000 |
| GDP per Capita (logged) | 3041 | 8.581 | 1.514 | 4.372 | 11.685 |
| Urbanization rate | 3285 | 62.522 | 18.788 | 7.040 | 98.001 |
| Trade Openness | 2993 | 77.249 | 45.718 | 0.167 | 408.362 |
| Population (logged) | 3581 | 16.135 | 1.671 | 10.859 | 21.055 |
| Civil Society Participation Index | 3223 | 0.670 | 0.292 | 0.041 | 0.99 |
| Corruption - ICRG | 2042 | 3.536 | 1.439 | 0.000 | 6.000 |
| Government Stability - ICRG | 2020 | 7.735 | 1.802 | 1.000 | 12.000 |
| Ethnic Fractionalization Index | 2625 | 0.351 | 0.244 | 0.000 | 0.888 |
| Manufacturing sector (% of GDP) | 2,459 | 15.58 | 6.22 | 0.000 | 44.59 |
| Service sector (% of GDP) | 2,471 | 53.25 | 10.97 | 18.81 | 88.72 |
| Total natural resource rent (% of GDP) | 3,042 | 3.51 | 6.42 | 0.000 | 60.45 |
| Oil rent (% of GDP) | 3,015 | 1.74 | 5.18 | 0.000 | 60.01 |
| Coal rent (% of GDP) | 3,010 | 0.24 | 0.97 | 0.000 | 25.96 |
| Clean election | 2,872 | 0.665 | 0.331 | 0.000 | 0.987 |
| Judicial Independence | 2,526 | 0.586 | 0.220 | 0.000 | 1.000 |
| Local relative power | 2,812 | 2.218 | 1.373 | 1.000 | 5.000 |

## 2.5 Empirical Methodology

### *2.5.1 Base Specification*

For our main estimation, we use the following regression model:

$$Y_{it} = \beta_0 + \beta_1 Dec_{it} + \beta_2 Party_{it} + \beta_3 Dec_{it} \times Party_{it} + \beta_4 X_{it} + \varepsilon_{it} \qquad (2.1)$$

Where, $Y_{it}$ is one of the three outcome variables – Co2 emission per capita, BOD emission, and renewable energy consumption - for country 'i' and year 't.' All outcome variables are in logged format.

*Dec* is the decentralization variable; *Party* is our party institutionalization variable. And $X_{it}$ stands for the set of control variables listed above. In the estimations we also control for year and country fixed effects.

Our main coefficient of interest is $\beta_3$ which is the coefficient of the interaction between decentralization measures and party institutionalization index. We use the natural logarithms of the outcome variables to reduce the skewness.

Before we run the regressions, it is important to identify any potential issue that might yield biased and/or inefficient estimation. We run several tests to identify these problems.

### *2.5.2 Estimation issues*

We first check the potential 'multi-collinearity' issue in our data. The presence of (near perfect) multi-collinearity results in coefficients with large standard errors and makes the estimation less precise (Gujarati and Porter, 2009). We use "Variance-Inflation Factor (VIF)" to check the presence of multi-collinearity. As a general rule, VIF higher than 10 indicates severe multicollinearity in the data. Table B2 shows the results for multi-collinearity. The VIF values are below ten, indicating that there is no severe multi-collinearity in the data.

Prior to estimating the models, we conduct panel data diagnostics regarding the presence of serial correlation, heteroskedasticity, and cross-sectional dependence. Serial correlation causes the standard errors to be biased and produces less efficient results. We use the Wooldridge test for serial correlation. Wooldridge's method uses the residuals from a regression in first-

differences and tests for Corr($\Delta\varepsilon_{it}, \Delta\varepsilon_{it-1}$) = -0.5. In Stata, *xtserial* implements the Wooldridge test for serial correlation in panel data. The Null hypothesis of the test is no serial correlation.

The assumption of homoskedasticity is violated if the conditional distribution of the error term given $X_i$ is non-constant for i = 1,2,…n, i.e., $E(u_i^2) \neq \sigma^2$ instead $E(u_i^2) = \sigma_i{}^2$. In this case, the estimators will still be unbiased, but they will no longer have the minimum variance in the class of unbiased estimators. Furthermore, in panel data, it is possible that the disturbance term is homoscedastic within a group but is different across the panel or groupwise heteroskedasticity (Baum, 2001). We employ modified Wald test statistic for groupwise heteroskedasticity in fixed-effects models. The null hypothesis of the test is of no heteroskedasticity. In Stata, it is done through *xttest3*. The results show the presence of serial correlation and heteroskedasticity (Table B3).

Cross-sectional dependence occurs when the error terms are correlated across panels, i.e., Corr($\varepsilon_{it}$, $\varepsilon_{jt}$) ≠ 0. The presence of cross-sectional dependence could be due to common shocks such as recessions, financial crises, spatial dependence, and other unobserved components. Ignoring cross-sectional dependence will yield biased estimates and spurious inference (Beyene and Kotosz, 2020). Pesaran (2004) test is used to determine the presence of cross-sectional dependence. This test can be used with balanced and unbalanced panels. The null hypothesis for the test is of no cross-sectional dependence. The Pesaran test statistics were significant at the 1% level, indicating cross-sectional dependence in the data. Stata code for this test is *pescadf*.

After detecting cross-sectional dependence, we use the Pesaran Cross-sectional Im, Pesaran-Shin (CIPS) test, and Maddala and Wu unit root test to check the stationarity of the data.

Pesaran CIPS test uses a cross-section average of lagged levels and first-differences of individual series. The standard Dickey-Fuller regression becomes:

$$\Delta y_{it} = \propto_i + \rho_i y_{it-1} + c_i \bar{y}_{it-1} + d_i \overline{\Delta y_t} + \varepsilon_{it} \quad (2.2)$$

Where $\bar{y}_{it-1} = \frac{1}{N}\sum_{i=1}^{N} y_{it-1}$ and $\overline{\Delta y_t} = \frac{1}{N}\sum_{i=1}^{N} \Delta y_{it}$

The CIPS test statistics is given by: $\widehat{CIPS} = \frac{1}{N}\sum_{i=1}^{N} CADF_i$. The Pesaran's test is based on the individual cross-sectionally augmented ADF statistics or CADF. The null hypothesis is of no unit root (Su et al. 2020, Hurlin and Mignon 2007). The IPS tests allow for heterogeneity in the value of $\rho$, under the alternative hypothesis, in the following model (Hurlin and Mignon 2007).

$$\Delta y_{it} = \propto_i + \rho_i y_{it-1} + \sum_{z=1}^{p_i} \beta_{iz} \Delta y_{t-z} + \varepsilon_{it} \quad (2.3)$$

Under the assumption of cross-sectional independence, Maddala and Wu (1999) use the following statistics: $P_{MW} = -2\sum_{i=1}^{N} log(p_i) \sim \chi^2_{2N}\ when\ T \to \infty$. The null hypothesis supports the presence of unit root (Table B4).

The unit root test shows that some of the variables are Integrated at order one or I(1). Next, we employ Kao (1999) and Westerlund (2005) co-integration tests to determine if there is a relationship between the variables. Kao (1999) test assumes a cointegrating vector that is the same across all panels, while Westerlund (2005) makes use of error correction approach and is appropriate in the presence of cross-sectional dependence (Baltagi and Kao 2000; Pesrysn and Westerlund 2008; Hashmi and Alam, 2019; Su et al., 2020; Haseeb et al. 2018). The presence of co-integration means that there exists a long-term relationship among the variables and the regression results are not spurious (Hashmi and Alam, 2019). Table B5 shows that the null hypothesis of no co-integration is rejected at a 1% significance level, establishing that the regression is not spurious.

Since the data consists of heteroskedasticity, autocorrelated, and cross-sectionally dependence. We use Driscoll-Kraay standard errors that are robust to autocorrelation, heteroskedasticity, and cross-sectional dependence. Newey and West (1987) built on White (1980) and developed Heteroskedasticity-Autocorrelation consistent (HAC) standard errors. Driscoll and Kraay (1997) applied a Newey-West type correction to the sequence of cross-sectional averages of the moment conditions (Hoechle, 2007). Their method assumes that the error structure is heteroskedastic, autocorrelated up to some lag and also correlated between the cross-sections. It produces standard errors that are not only heteroskedasticity consistent but also robust to general forms of cross sectional and temporal dependence (Sarkodie and Strezov, 2019). In Stata, *xtscc* provides the Driscoll-Kraay standard errors.

Last, we employ the Hausman test to determine whether a random effect or fixed effect model is appropriate for the estimation purpose. Under the null hypothesis, Random effects is preferred. Cameroon and Trivedi (2005) recommend using the *sigmamore* option in Stata because this option specifies that both covariance matrices are based on the same estimated disturbance from the efficient estimator. The test rejects the null hypothesis, and the fixed effects model is selected.

### *2.5.3 Addressing potential endogeneity*

An important concern regarding our model specification is that decentralization measures could be endogenous (He, 2015; Liu and Li, 2019; Sigman, 2014). For example, an increase in environmental pollution could lead to a government response of decentralizing further as subnational governments could better match the environmental need. Conversely, it could also lead to less decentralization and central government policy response, especially when negative

externality is deemed large. While the direction of externality is unclear, endogeneity might be an issue.

In the estimation we use two different instrumental variables for decentralization. First, we use the surface area of countries. Arzaghi and Hendersson (2005) and Jilek (2018) suggest that the land area of a country is an important determinant for decentralization. Additionally, we use the "Geographic Fragmentation Index (GFI)", developed by Canavire-Bacarreza et al. (2020). The GFI considers two important dimensions of geography – elevation and country size. It measures the weighted probability that two randomly picked individuals do not reside in similar altitude zone, with the weight matrix calculated as the average distance between altitudes. It is calculated as: $1 - \sum_{j=1}^{J} \sum_{i=1}^{N} (w_{ij} \frac{n_i}{N})^2$, where $\frac{n_i}{N}$ is the share of population by elevation and $w_{ij}$ measures the distance between altitude *i* and altitude *j*. It ranges from zero to one. Zero indicates that all the population reside in same altitude zone, and one indicates that none of the population reside in the same altitude.

Additionally, we use further lag of independent variables to account for the potential endogeneity. The use of lagged independent variables to address the potential simultaneity and reverse causation is a common practice in applied economic research (Reed, 2015; Islam, 2018). In our estimation, we use one year-, three year-, and five year-lagged independent variables for this purpose.

### 2.6 Results

Table 2.2 presents the baseline panel estimation results. Column (1) – (3) shows results for expenditure decentralization, and columns (4) – (6) shows results for revenue decentralization. Overall, the results show that the interaction of strong institutionalized parties

with decentralization work in favor of reducing CO2 emissions and promoting renewable energy consumption in fiscally decentralized settings. Specifically, party institutionalization has a significant effect on reducing CO2 emission with higher levels of expenditure decentralization. Also, party institutionalization has a significant effect on reducing BOD emission and improve the renewable energy consumption with higher levels of revenue decentralization

On the other hand, decentralization in the absence of part institutionalization appears to have a strong negative effect on climate change, increasing CO2 and BOD emissions and reducing renewable energy consumption. This is in line with the theoretical predictions of under provision of public goods with large externalities (Oates, 1972) and previous empirical findings (Banzhaf and Chupp, 2012; Liu and Li, 2019; Sigman 2005 and 2014). On average, in the absence of party institutionalization (i.e., without the interaction effect), a 10-percentage point increase in expenditure decentralization is associated with a 24.8 percent increase in CO2 emissions.[6] For a full estimation of the effects of decentralization on CO2 emissions, however, we must take into account the coefficient of the interaction term. Let's take three cases to clarify the impact of party institutionalization further – i) Party institutionalization = 0.5 (which is approximately one standard deviation below the sample mean); ii) Party institutionalization = 0.75 (which is approximately equal to the sample mean); and iii) ii) Party institutionalization = 1.0 (which is the maximum of party institutionalization in our sample). In the first case, a 10-percentage point increase in expenditure decentralization leads to an increase of 9.7 percent in

[6] $\%\Delta y = \frac{y_1 - y_0}{y_0} = \frac{y_1}{y_0} - 1 = exp(log(y_1/y_0)) - 1 = exp(\beta_1 \Delta Dec + \beta_1 \Delta party + \beta_1 \Delta(Dec \times party) + \beta_1 \Delta X) - 1$

In the absence of party institutionalization and holding everything else constant: $\%\Delta y = exp(\beta_1 \Delta Dec) - 1$. For expenditure decentralization, $\hat{\beta} = 2.218$. A 10 pp increase in expenditure decentralization leads to $\%\Delta y = exp(2.218 * 0.1) - 1 = 0.248 \; or \; 24.8\%$.

Co2 emission, holding everything else constant.[7]In the second case, a 10-percentage point increase in expenditure decentralization still leads to an increase in CO2 emission by 2.8 percent, with higher party institutionalization, fiscal decentralization still leads to deleterious effects on climate change causes, but those negative effects are greatly reduced. In fact, with higher levels of party institutionalization, as shown in the third case those deleterious effect practically disappears: with the highest level of party institutionalization, a 10-percentage point increase in expenditure decentralization yields a decrease by 3.5 percent in CO2 emissions.

The results for water pollution also exhibit similar patterns. However, the results are significant only for revenue decentralization. The effect of revenue decentralization, ignoring the interaction effect, is positive i.e., higher level of revenue decentralization increases water pollution (BOD emissions). A 10-percentage point increase in revenue decentralization increases BOD emission by 0.21 percent. However, in the presence of party institutionalization those deleterious effects are swiftly eliminated and reversed. An increase in revenue decentralization of 10 percent with party institutionalization index at 0.5 yields a decrease of 12.45 percent in BOD emissions. At higher levels of party institutionalization index of 0.75 and 1, a 10-percentage point increase in revenue decentralization results in decreases of 18.2 percent and 23.5 percent in BOD emissions, respectively.

Additionally, greater degree of party institutionalization improves the effect of fiscal decentralization on renewable energy consumption. Here, we describe the impact of revenue decentralization on renewable energy consumption. In the first case, where party institutionalization is at 0.5, a 10-percentage point increase in revenue decentralization leads to a negative 7.8 percent decline on renewable energy consumption. Similar increase in the

[7] $\%\Delta y = exp(\beta_1 \Delta Dec + \beta_1 \Delta party + \beta_1 \Delta(Dec \times party) + \beta_1 \Delta X) - 1$. When party=0.5 and $\Delta Dec = 0.10$, holding everything else constant, $\%\Delta y = exp(2.218 * 0.10 - 2.583 * 0.10 * 0.50) - 1 = 0.971 = 9.7\%$

decentralization measure in the second case, where party institutionalization index is at 0.75, leads to a negative 1.1 percent change in the renewable energy consumption. Notice that the while the overall impact has improved (from negative 7.8 percent to negative 1.1 percent), total impact is still negative. When the party institutionalization index is at the maximum i.e., 1.00, overall effect of a 10-percentage point increase yields a positive impact of 6.24 percent on renewable energy consumption, holding everything else constant.

Overall, the estimates in Table 2.2 show that party institutionalization acts as a strong mitigating factor for the impact of decentralization on environmental outcomes.

Table 2.2: Panel Estimation results

| VARIABLES | (1) CO2 emission per capita | (2) BOD emission | (3) Renewable Energy Consumption | (4) CO2 emission per capita | (5) BOD emission | (6) Renewable Energy Consumption |
|---|---|---|---|---|---|---|
| Expenditure Decentralization | 2.218*** | -3.320 | -1.249 | | | |
| | (0.634) | (3.353) | (0.819) | | | |
| Revenue Decentralization | | | | -0.451* | 0.021 | -2.246** |
| | | | | (0.250) | (0.508) | (0.854) |
| Party Institutionalization | 0.810*** | 2.696 | -0.652** | 0.453*** | 3.526** | -0.848*** |
| | (0.165) | (1.687) | (0.280) | (0.132) | (1.664) | (0.268) |
| Interaction (Decentralization and Party Institutionalization) | -2.583*** | 0.836 | 0.812 | 0.413 | -2.702** | 2.851** |
| | (0.767) | (3.621) | (1.265) | (0.249) | (1.063) | (1.094) |
| Polity IV | 0.013*** | 0.045** | -0.023*** | 0.015*** | 0.038** | -0.024*** |
| | (0.003) | (0.020) | (0.005) | (0.003) | (0.017) | (0.006) |
| Population (logged) | 0.423*** | 3.741*** | -1.688*** | 0.474*** | 4.231*** | -1.678*** |
| | (0.118) | (0.938) | (0.153) | (0.124) | (0.995) | (0.181) |
| GDP per Capita (logged) | 0.358*** | 0.271* | -0.293*** | 0.340*** | 0.244 | -0.296*** |
| | (0.042) | (0.154) | (0.053) | (0.044) | (0.160) | (0.052) |
| Urbanization rate | 0.016*** | -0.037* | -0.004 | 0.016*** | -0.026 | -0.002 |
| | (0.003) | (0.021) | (0.007) | (0.003) | (0.022) | (0.005) |
| Trade Openness | -0.001* | -0.011*** | 0.003*** | -0.001 | -0.009*** | 0.004*** |
| | (0.001) | (0.003) | (0.001) | (0.001) | (0.003) | (0.001) |
| Largest Government Party Orientation = 1, Right (Base Group) | | | | | | |
| Largest Government Party Orientation = 2, Center | -0.039* | -0.098 | -0.012 | -0.035 | -0.061 | -0.021 |
| | (0.020) | (0.106) | (0.046) | (0.021) | (0.091) | (0.049) |
| Largest Government Party Orientation = 3, Left | -0.005 | 0.119*** | -0.012 | -0.001 | 0.067 | -0.022 |

Table 2.2: Panel Estimation results (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.013) | (0.041) | (0.030) | (0.014) | (0.044) | (0.028) |
| Proportional Representation = 1 | 0.207*** | -0.241 | -0.084 | 0.193** | -0.192 | -0.075 |
| | (0.068) | (0.216) | (0.093) | (0.073) | (0.206) | (0.097) |
| Country and Year Dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.000 | -64.364*** | 0.000 | 0.000 | -74.415*** | 33.873*** |
| | (0.000) | (15.150) | (0.000) | (0.000) | (16.102) | (2.560) |
| Observations | 1,660 | 379 | 1,209 | 1,669 | 382 | 1,217 |
| Number of groups | 67 | 34 | 65 | 67 | 35 | 66 |
| R-Squared | 0.43 | 0.43 | 0.41 | 0.44 | 0.45 | 0.42 |

Driscoll-Kraay Robust Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In table 2.3, we present a scenario analysis of the main estimation results. Panel A shows the impact of a 10-percentage point increase in expenditure decentralization on CO2 emission at different levels of party institutionalization. In the absence of any party institutionalization, a 10 pp increase in expenditure decentralization yields a positive 24.83 percent increase on CO2 emission. This result is drastically lowered when party institutionalization is at 0.5. When party institutionalization index is at 0.75, which is approximately equal to the sample mean, we see the total net impact is positive 2.85 percent. While the net impact is still positive, we see a downward trend in the impact with higher levels of party institutionalization.

In panel B, we present similar results for a 10-percentage point increase in party institutionalization. In the absence of any expenditure decentralization, a 10 pp increase in party institutionalization yields a positive 8.44 percent net impact on CO2 emission. When the level of decentralization is at 0.25, which is approximately equal to the average in the sample, the net impact of CO2 emission is lowered to a positive 1.66 percent only. When expenditure decentralization is increased by one standard deviation to 0.42, a 10 pp increase on party institutionalization index yields a negative 2.71 percent impact on CO2 emission. Taking it further, when expenditure decentralization is raised by two standard deviations at 0.58, similar increase on party institutionalization yields a net impact of negative 6.65 percent on CO2

emission. Overall, the result shows that similar level increment on either of the variable yields a fruitful result when the other variable is also high.

Table 2.3: Scenario analysis of the impact on CO2 emission

| Panel A: 10 pp increase in exp. Decentralization | | | | |
|---|---|---|---|---|
| Levels of Party institutionalization | 0 | 0.5 | 0.75 | 1 |
| Change in CO2 emission | 24.83% | 9.71% | 2.85% | -3.85% |
| Panel B: 10 pp increase in Party institutionalization | | | | |
| Levels of exp decentralization | 0 | 0.25 | 0.42 | 0.58 |
| Change in CO2 emission | 8.44% | 1.66% | -2.71% | -6.65% |

### *2.6.1 Marginal Effects*

From the main estimation equation, we can derive the marginal effects of party institutionalization and decentralization index. The marginal effect of decentralization index is given by the following partial derivative:

$$\frac{\partial(Y_{it})}{\partial Dec_{it}} = \beta_1 + \beta_3 Party_{it} \tag{2.4}$$

Similarly, the marginal effect of party institutionalization is:

$$\frac{\partial(Y_{it})}{\partial Party_{it}} = \beta_2 + \beta_3 Dec_{it} \tag{2.5}$$

Next, we derive stationary points for each of the indices, where the marginal effects of decentralization and party institutionalization are zero. We set the right-hand side of (2.4) and (2.5) to zero. Therefore, the stationary point for decentralization index is $\left({}^{-\beta_1}/_{\beta_3}\right)$ and the stationary point for party institutionalization index is $\left({}^{-\beta_2}/_{\beta_3}\right)$.

Figure 2.5 provides graphical interpretation of the marginal effect of expenditure decentralization on Co2 emission at different levels of party institutionalization. The stationary point for decentralization is 0.31 in our sample, where the Co2 emissions at any level of party institutionalization are equal. Similarly, the stationary point for party institutionalization index is 0.86. At this level of party institutionalization index, Co2 emissions at any level of expenditure decentralization are equal, i.e., the marginal effect of decentralization index is zero. Beyond this point, higher level of decentralization is associated with lower level of Co2 emission. The opposite is true for party institutionalization below the stationary point.

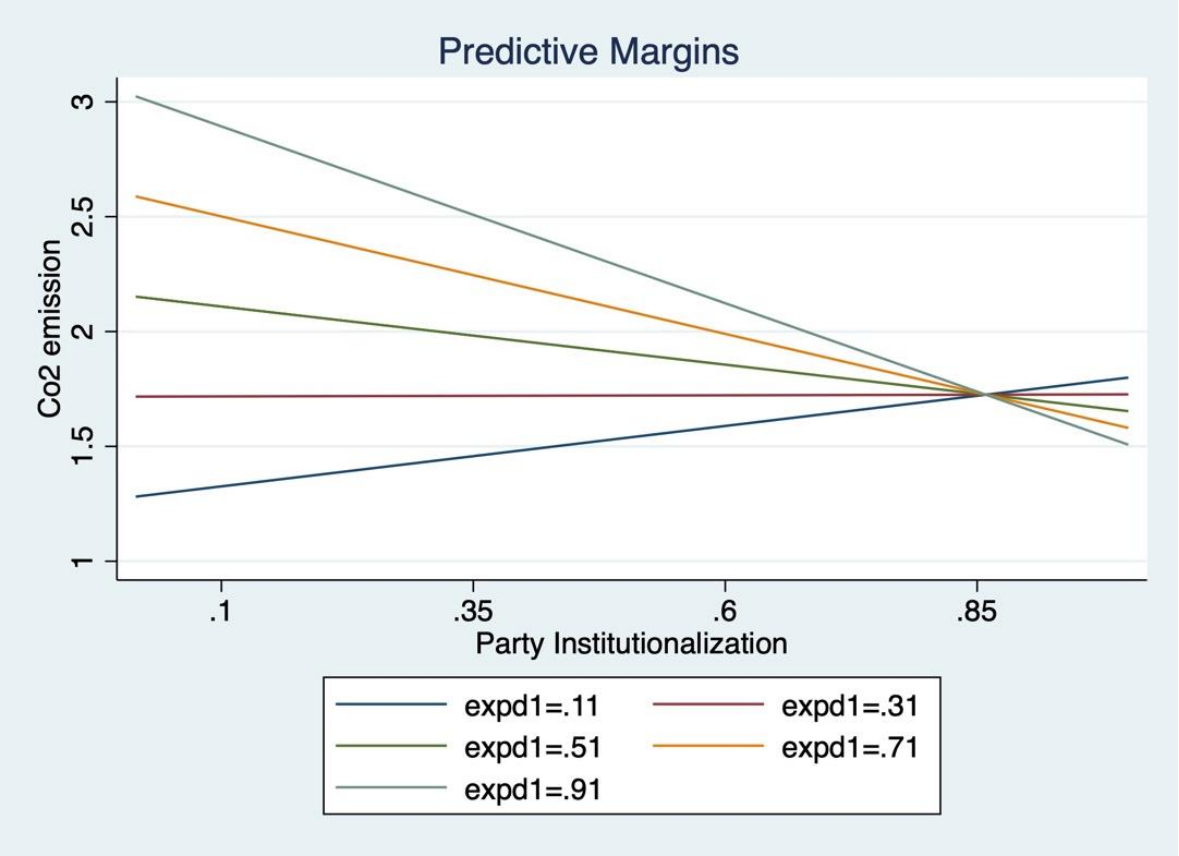



Figure 2.5: Marginal effect of party institutionalization on Co2 emission on different levels of expenditure decentralization

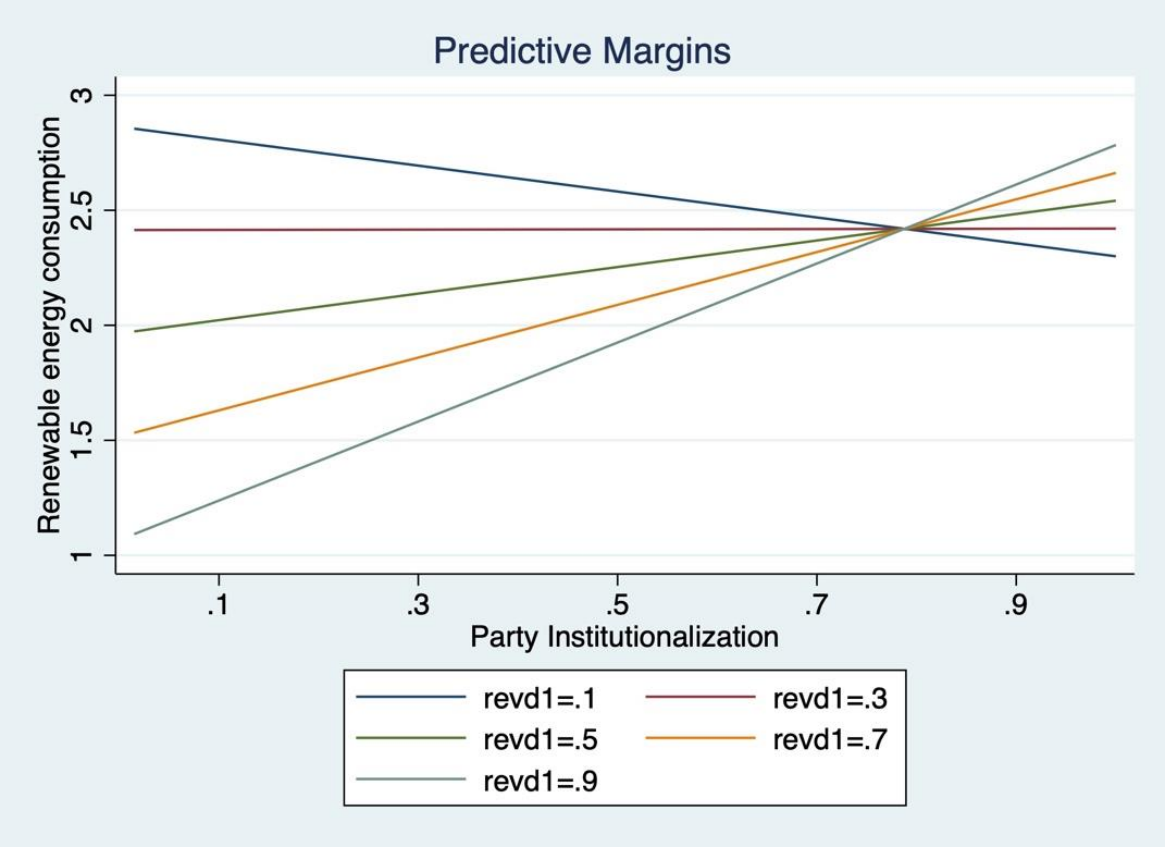



Figure 2.6: Marginal effect of party institutionalization on renewable energy consumption on different levels of revenue decentralization

Figure 2.6 shows the marginal effect of revenue decentralization on renewable energy consumption for different levels of party institutionalization. The stationary points for the decentralization measure and party institutionalization are 0.30 and 0.79, respectively, in our sample. Higher level of decentralization is positively associated with renewable energy consumption as the level of party institutionalization index increases. However, beyond the decentralization level of 0.30, the relationship is the opposite.

It is interesting to note that higher levels of party institutionalization yield positive results (in reducing pollution and increasing renewable energy consumption) at higher degree of fiscal decentralization. When the level of decentralization is low, higher degree of party institutionalization shows adverse effect. While this point might need further research, we

believe it underscores the central point of this research – undoubtedly, local governments are important players in their role to mitigate the effect of climate change. At the same time, party institutionalization provides appropriate incentives for policies with large externalities and long-term impact. In this regard, political parties also have crucial role in dealing with climate change related effects[8].

Results for the control variables indicate that population size (logged), GDP per capita (logged), and urbanization level positively affect pollution levels. These results are expected and in line with previous empirical findings in the literature. Trade openness has a negative relationship with CO2 emission and a positive one with renewable energy consumption. This latter may be explained by a higher degree of trade openness leading to more efficient use of resources due to trade-induced competition (WTO, 2011) and knowledge spillover (Madsen, 2007). Last, we note that "party ideology" does not yield any significant effect.

### *2.6.2 Additional Control variables*

In table 2.4, we estimate the baseline regression by employing several additional control variables – subnational government autonomy, ethnic fractionalization, and GDP per capita squared. We also use three separate institutional quality variables – civil society participation, corruption, and government stability. We present the results for expenditure decentralization with additional control variables in table 3. Columns (1) – (3) show the results with civil society participation as a control variable. Columns (4) – (6) include corruption, and columns (7) – (9) include government stability as an additional control.

[8] Figure B.4 and B.5 in the appendix shows the scatterplot of Co2 emission with Expenditure decentralization and Party Institutionalization. Figure B.6 shows the kernel density estimate of the residuals.

Our base results are robust to these additional control variables. Party institutionalization negatively affects CO2 emission and BOD emission for a given level of fiscal decentralization. For instance, in column (7), where government stability is a control variable when party institutionalization is approximately one standard deviation lower than the sample mean, at 0.5, a 10-percentage point increase in expenditure decentralization increases the net CO2 emission by 9.60% at the mean. When party institutionalization is at approximately the sample mean, at 0.75, a 10-percentage point increase in expenditure decentralization increases the net CO2 emission by 4.68%. Thus, these results further solidify our baseline regression results.

Moreover, the results shows that corruption has positive effect on CO2 emission lending support to past results in the literature (Habib et al., 2018; Akhbari and Nejati, 2019). Additionally, a negative sign on the GDP per capita squared term supports an inverted U-shaped relationship between income and Co2 emissions. It implies that as countries transit from low to middle income level, economic growth is preferred over environmental protection. As countries move from middle to high income level, however, there's more concern over environmental degradation (Coskuner et al., 2019). Ethnic fractionalization, on the other hand, is shown to exacerbate water pollution. At the same time, it improves renewable energy consumption. This diverging effect of ethnic fragmentation on climate-change-related outcome variables is intriguing and may need further investigation. Related research by Schuldt and Pearson (2016) show that, in the US, non-whites are just as concerned about the environment as whites. However, non-whites are less likely to consider themselves as "environmentalists." They suggest that greater inclusivity of non-whites in environmental policymaking can bolster the effort to shape climate change policies. Nevertheless, the relation between ethnic diversity and climate change related outcomes is an interesting topic that could provide avenues for future research.

Table 2.4: Panel estimation results with additional control variables

| VARIABLES | (1) CO2 emission per capita | (2) BOD emission mg/l | (3) Renewable energy consumption | (4) CO2 emission per capita | (5) BOD emission mg/l | (6) Renewable energy consumption | (7) CO2 emission per capita | (8) BOD emission mg/l | (9) Renewable energy consumption |
|---|---|---|---|---|---|---|---|---|---|
| Expenditure Decentralization | 1.295* | -3.780 | -1.251 | 1.898*** | 8.622** | -1.506 | 1.835*** | 7.892* | -1.507 |
| | (0.757) | (4.334) | (0.959) | (0.606) | (3.926) | (0.999) | (0.607) | (4.596) | (0.989) |
| Party Institutionalization | 1.040*** | 0.203 | -0.860** | 1.047*** | 4.298* | -1.155** | 1.025*** | 3.070 | -1.162** |
| | (0.254) | (2.525) | (0.314) | (0.236) | (2.254) | (0.450) | (0.231) | (2.546) | (0.451) |
| Interaction (Dec. measure and Party institutionalization) | -1.363 | 0.803 | 0.738 | -1.931*** | -12.580*** | 1.086 | -1.837** | -11.875** | 1.063 |
| | (0.817) | (4.740) | (1.370) | (0.683) | (3.942) | (1.425) | (0.682) | (4.648) | (1.404) |
| Polity IV | 0.003 | 0.033 | -0.005 | 0.002 | -0.002 | -0.019 | 0.004 | -0.006 | -0.018 |
| | (0.005) | (0.037) | (0.009) | (0.005) | (0.035) | (0.012) | (0.005) | (0.036) | (0.012) |
| Population (logged) | 0.554*** | 1.784 | -1.666*** | 0.492*** | 1.783 | -1.425*** | 0.500*** | 1.631 | -1.416*** |
| | (0.080) | (1.227) | (0.188) | (0.102) | (1.642) | (0.237) | (0.090) | (1.744) | (0.243) |
| GDP per Capita (logged) | 0.980*** | 4.003*** | -0.482** | 0.935*** | 3.528*** | -0.449** | 0.953*** | 3.561*** | -0.460** |
| | (0.163) | (0.909) | (0.173) | (0.163) | (0.814) | (0.210) | (0.174) | (0.819) | (0.208) |
| Urbanization rate | 0.008*** | -0.026 | -0.006 | 0.012*** | -0.029 | -0.005 | 0.011*** | -0.022 | -0.005 |
| | (0.003) | (0.019) | (0.006) | (0.003) | (0.033) | (0.006) | (0.003) | (0.032) | (0.007) |
| Trade Openness | 0.001** | -0.007* | 0.003** | 0.001* | -0.010*** | 0.004** | 0.001 | -0.010*** | 0.004** |
| | (0.001) | (0.004) | (0.001) | (0.001) | (0.003) | (0.001) | (0.001) | (0.003) | (0.001) |
| Largest Government Party Orientation = 1, Right (Base Category) | | | | | | | | | |
| Largest Government Party Orientation = 2, Center | 0.005 | -0.291** | -0.033 | -0.018 | -0.268* | -0.035 | -0.018 | -0.277* | -0.033 |
| | (0.022) | (0.123) | (0.029) | (0.016) | (0.135) | (0.029) | (0.017) | (0.153) | (0.029) |
| Largest Government Party Orientation = 3, Left | -0.002 | 0.123 | -0.001 | -0.016 | 0.132** | 0.002 | -0.015 | 0.143*** | 0.003 |
| | (0.011) | (0.073) | (0.023) | (0.011) | (0.048) | (0.023) | (0.012) | (0.047) | (0.023) |

Table 2.4: Panel estimation results with additional control variables (continued)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Proportional Representation = 1 | 0.206** | -0.598** | -0.064 | 0.185* | -0.403* | -0.065 | 0.184** | -0.467** | -0.072 |
| | (0.088) | (0.276) | (0.073) | (0.092) | (0.233) | (0.077) | (0.089) | (0.204) | (0.072) |
| GDP per capita square | -0.037*** | -0.215*** | 0.009 | -0.035*** | -0.199*** | 0.006 | -0.037*** | -0.202*** | 0.006 |
| | (0.009) | (0.048) | (0.014) | (0.008) | (0.042) | (0.015) | (0.009) | (0.042) | (0.015) |
| Self-rule | 0.006 | -0.005 | 0.003 | -0.003 | 0.030 | 0.005 | -0.004 | 0.032 | 0.005 |
| | (0.005) | (0.023) | (0.006) | (0.003) | (0.023) | (0.006) | (0.003) | (0.020) | (0.007) |
| Ethnic Fractionalization | 0.468 | 7.297** | 0.386 | -0.314 | 7.571** | 0.719** | -0.318 | 8.816*** | 0.724** |
| | (0.325) | (3.021) | (0.356) | (0.320) | (2.971) | (0.274) | (0.339) | (2.641) | (0.271) |
| Civil Society Participation Index | 0.066 | 1.175 | -0.448* | | | | | | |
| | (0.157) | (1.179) | (0.252) | | | | | | |
| Corruption | | | | 0.028*** | 0.056 | 0.002 | | | |
| | | | | (0.010) | (0.076) | (0.010) | | | |
| Government Stability | | | | | | | -0.005 | 0.050** | 0.006 |
| | | | | | | | (0.004) | (0.022) | (0.007) |
| Year and Country Dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.000 | -48.585** | 0.000 | -14.271*** | 0.000 | 31.429*** | -14.204*** | 0.000 | 31.314*** |
| | (0.000) | (18.111) | (0.000) | (1.733) | (0.000) | (3.881) | (1.664) | (0.000) | (4.027) |
| Observations | 1,228 | 312 | 910 | 1,001 | 251 | 873 | 1,001 | 251 | 873 |
| Number of groups | 51 | 28 | 50 | 48 | 26 | 48 | 48 | 26 | 48 |
| R-Squared | 0.63 | 0.50 | 0.49 | 0.63 | 0.57 | 0.49 | 0.62 | 0.57 | 0.49 |

Driscoll-Kraay Robust Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

### *2.6.3 Addressing endogeneity*

In table B6 shows the results for the instrumental variable approach. Column (1) shows the result with surface area as an instrumental variable. While column (2) shows the results for 'Geographic Fragmentation Index (GFI)' as IV. Both results are consistent with the main findings. Higher party institutionalization improves the effectiveness of expenditure decentralization for lowering CO2 emission.

Additionally, estimation results in table B7 accounts for the potential lagged effect of the independent variables on CO2 emission. The short run effect of decentralization could entail greater institutional uncertainty and overlaps of government functions in terms of spending. This could mean a higher information costs. With a higher influx of information and fine-tuning of decentralization, the long-term effect can be more stable (Fiorino et al., 2015). The findings indicate that the joint impact of party institutionalization and expenditure decentralization is negative on CO2 emission. This result holds with one-year and three-year lagged independent variables. After five years, however, the effects seem to wane.

## 2.7 Robustness checks

We conduct a series of robustness checks for our main results. First, in table B8, we control for the variation in economic sectors. We control for the manufacturing sector and service sector. In columns (1)-(3), we include total natural resource rents as a proxy for natural resource dependence. In columns (4) – (6), we further disaggregate the natural resource dependence into oil rent, and coal rent. Main estimation results for the CO2 emission are robust to the inclusion of economic sector and natural resource rents control variables. Both manufacturing sector and service sector are positively related to CO2 emission. This is in line

with previous literature that have expansion of the economic sector increases CO2 emission (Krackeler et al, 1998; Friedl and Getzner, 2003; Wang et al., 2020). Moreover, higher natural resource dependence is also associated with higher CO2 emission (Huang et al., 2021). Natural resource dependence strengthens the relationship between economic growth and CO2 emission (Badeeb et al., 2020). Among the disaggregated natural resource rents, oil rents show a positive effect on CO2 emission. Meanwhile, coal rent does not show a statistically significant effect.

Second, it is likely that countries within a certain world region, geographic or income, exhibit similar attributes. Some regions have experienced higher growth than others. Similarly, some regions tend to have high trade restrictions than others. For instance, Latin America and the Caribbean region is a highly regulated region compared to North America (Bolaky and Freund, 2006). We use the world region dummies and income region dummies to control for the variation owing to regional idiosyncrasies[9].

Results are also robust to the inclusion of both income group and world region dummies. In table B9, columns (1)-(3) shows results with decade dummies. Columns (4)-(6) shows results with income groups. The coefficient of the interaction term in column 1 is -4.087. The result suggests that when party institutionalization is at the one standard deviation below the mean (at 0.5), a 10-percentage point increase in expenditure decentralization leads to a 9.6 percent increase in CO2 emission. The effect declines to 4.68 percent when party institutionalization index is at the mean (0.75). When party institutionalization index is at 0.91, the marginal effect of decentralization is zero. Beyond this level, total effect on CO2 emission starts to decline as the party institutionalization index increases. Similarly, when expenditure decentralization level is at

[9] Regional categories are taken from World Bank's classification. World regions are East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, and Sub-Saharan Africa. Income groups are low income, lower-middle income, upper-middle income, high income.

0.08, the marginal effect of party institutionalization is zero. Decentralization levels higher than 0.08 are negatively sloped, i.e., as the level of party institutionalization increases, higher decentralization level lowers the CO2 emission. The opposite is true for decentralization levels lower than 0.08.

Third, we use alternative measures of decentralization as well as party institutionalization measures. In table B10, columns (1) – (3) includes alternative measure of decentralization and columns (4) – (6) shows results using alternative party measure. We use 'Regional Authority Index (RAI)' as an alternative measure for decentralization and we use the average age of parties as an alternative measure for party institutionalization (Enikolopov and Zhuravskaya, 2007). The overall results for both alternative measures support our main estimation results. The coefficient of the interaction term for CO2 emission has a negative sign and is statistically significant when using 'RAI'. Similarly, the interaction between average age of parties for measuring party institutionalization and the decentralization index also supports our main the interaction of these two variables is conducive towards improving climate change related governance and for improving renewable energy consumption.

Fourth, we employ the political decentralization data from Hankla et al. (2019). Results are presented in Table B11. In columns (1) – (3), the independent variables are 'democratic decentralization and party integration (DDPI)' and 'democratic decentralization and party non-integration (DDPN)'. The reference category is 'democratic centralization.' Overall, the results provide support to our main findings. The coefficient of 'Democratic decentralization and party integration' is statistically significant for all three outcome variables. Meanwhile, 'Democratic decentralization and party non-integration' is only significant for BOD emission. In columns (4) – (6), the regression estimation shows the results for 'DDPI', and the reference category is

'DDPN'. The results show a combination of democratic decentralization and party integration (DDPI) is effective in lowering Co2 emission and improving renewable energy as compared to a similar combination of democratic decentralization and party non-integration (DDPN).

Our final robustness check includes separate decentralization measures for regional and local level. The results are presented in Table B12. The findings suggest that the interplay of party institutionalization and decentralization reduces CO2 emissions at the regional and local levels. Furthermore, increased local government decentralization, combined with party institutionalization, is effective in promoting renewable energy consumption.

## 2.8 Conclusion

In this paper, we examine the role of political parties to mitigate climate change in a fiscally decentralized environment. Subnational governments tend to be responsible for several functions that are known to be the sources of detrimental environmental effect. Institutionalized parties have the capacity to influence the policymaking at the subnational level. Party institutionalization can incentivize local politicians to internalize the externalities from climate change related policies. With this approach, strong political parties can strike a balance between local preferences with national objectives.

To test our argument, we employ panel data estimation on three measures of climate change – Co2 emission, BOD emission, and renewable energy consumption. Our findings show that party institutionalization and fiscal decentralization, together, can help lower Co2 emission and promote renewable energy consumption. These results are robust to several additional checks including various alternative measures of decentralization and party institutionalization to

strengthen our results. Our results may provide better understanding of the joint importance of political parties and fiscal decentralization to address the growing concern of climate change.

# APPENDICES

## APPENDIX A: Appendices for Chapter 1

Table A1: Summary Statistics

| VARIABLES | (1) Obs. | (2) Mean | (3) Std. Dev. | (4) Min | (5) Max |
|---|---|---|---|---|---|
| Corruption (ICRG) | 4,302 | 3.072 | 1.345 | 0 | 6 |
| Control for corruption (CforC) | 3,331 | 0.142 | 1.026 | -2.470 | 1.869 |
| Corruption perception index (CPI) | 1,258 | 58.197 | 19.728 | 8 | 100 |
| Political corruption index (PCI) | 6,752 | 0.510 | 0.300 | 0.002 | 0.968 |
| Public sector corruption index (PSCI) | 6,782 | 0.488 | 0.304 | 0.001 | 0.979 |
| Regime corruption index (RCI) | 6,782 | 0.503 | 0.312 | 0.002 | 0.977 |
| Democratic decentralization and Party Integration (DDPI) | 6,782 | 0.295 | 0.456 | 0 | 1 |
| Democratic decentralization and Party Non-Integration (DDPN) | 6,782 | 0.261 | 0.439 | 0 | 1 |
| Party institutionalization index | 6,270 | 0.595 | 0.268 | 0.008 | 1 |
| Party Integration proxy | 6,717 | 0.608 | 0.161 | 0.153 | 0.981 |
| Local government index | 6,575 | 0.616 | 0.366 | 0 | 0.996 |
| Fiscal Autonomy | 3,409 | 1.004 | 1.440 | 0 | 5.482 |
| GDP per capita (logged) | 6,338 | 7.786 | 1.622 | 3.127 | 11.95 |
| Trade (% of GDP) | 5,902 | 74.99 | 46.89 | 0.021 | 437.3 |
| Government Consumption | 5,780 | 15.80 | 6.242 | 0 | 76.22 |
| Population size (in million) | 6,771 | 38.13 | 131.8 | 0.164 | 1408 |
| Mineral Rent | 6,324 | 0.795 | 2.324 | 0 | 25.16 |
| Oil Rent | 6,198 | 4.079 | 10.11 | 0 | 87.37 |
| *Subnational corruption variables* | | | | | |
| Subnational corruption | 1,232 | -0.055 | 0.739 | -5.661 | 2.990 |
| Municipal directly elected executive | 1,298 | 0.463 | 0.498 | 0 | 1 |
| Municipal plurality | 1,298 | 0.253 | 0.435 | 0 | 1 |
| Regional GDP per capita (logged) | 1,232 | 8.694 | 1.231 | 5.347 | 11.865 |
| Regional population size (logged) | 1,232 | 9.351 | 1.651 | 4.513 | 14.656 |
| Regional offices relative power | 1,194 | 1.006 | 1.276 | -2.493 | 2.953 |
| Subnational elections free and fair | 1,194 | 1.281 | 1.318 | -2.852 | 3.297 |

Table A2: Variables used in regression and sources

| VARIABLES | Source |
|---|---|
| Corruption (ICRG) | International Country Risk Guide |
| Control for corruption (CforC) | World Governance Indicators |
| Corruption perception index (CPI) | Transparency International |
| Political corruption index (PCI) | V-Dem Database |
| Public sector corruption index (PSCI) | V-Dem Database |
| Regime corruption index (RCI) | V-Dem Database |
| Democratic decentralization and Party Integration (DDPI) | Hankla et al. (2019) |
| Democratic decentralization and Party Non-Integration (DDPN) | Hankla et al. (2019) |
| Party institutionalization index | V-Dem Database |
| Party Integration proxy | V-Dem Database |
| Local government index | V-Dem Database |
| Fiscal Autonomy | Regional Authority Index Dataset |
| GDP per capita (logged) | World Bank |
| Trade (% of GDP) | World Bank |
| Government Consumption | World Bank |
| Population size (in million) | World Bank |
| Mineral Rent | World Bank |
| Oil Rent | World Bank |
| *Subnational corruption variables* | |
| Subnational corruption | Borksy and Kalkschmied (2018) |
| Municipal directly elected executive | Hankla et al. (2019) |
| Municipal plurality | Hankla et al. (2019) |
| Regional GDP per capita (logged) | Borsky and Kalkschmied (2018) |
| Regional population size (logged) | Borsky and Kalkschmied (2018) |
| Regional offices relative power | V-Dem Database |
| Subnational elections free and fair | V-Dem Database |

Table A3: Quantile regression results

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Panel A; ICRG | Q 0.25 | Q 0.5 | Q 0.75 | Q 0.90 |
| DDPN | -0.007 | -0.077 | -0.272*** | -0.278*** |
| | (0.062) | (0.048) | (0.054) | (0.082) |
| Obs. | 1999 | 1999 | 1999 | 1999 |
| Pseudo R2 | 0.458 | 0.422 | 0.361 | 0.272 |
| Panel B: CforC | | | | |
| DDPN | 0.003 | -0.077** | -0.259*** | -0.200*** |
| | (0.033) | (0.035) | (0.039) | (0.038) |
| Obs. | 1375 | 1375 | 1375 | 1375 |
| Pseudo R2 | 0.626 | 0.605 | 0.539 | 0.499 |
| Panel C: PCI | | | | |
| DDPN | 0.008 | -0.036*** | -0.053*** | -0.077*** |
| | (0.014) | (0.008) | (0.008) | (0.010) |
| Obs. | 2423 | 2423 | 2423 | 2423 |
| Psuedo R2 | 0.421 | 0.571 | 0.582 | 0.526 |
| Panel D: PSCI | | | | |
| DDPN | -0.006 | -0.038*** | -0.040*** | 0.002 |
| | (0.010) | (0.009) | (0.012) | (0.011) |
| Obs. | 2423 | 2423 | 2423 | 2423 |
| Pseudo R2 | 0.411 | 0.526 | 0.533 | 0.493 |
| Panel E: RCI | | | | |
| DDPN | 0.003 | -0.044*** | -0.062*** | -0.068*** |
| | (0.015) | (0.009) | (0.010) | (0.010) |
| Obs. | 2423 | 2423 | 2423 | 2423 |
| Pseudo R2 | 0.366 | 0.530 | 0.551 | 0.500 |

Notes: The asterisk ***, **, and * are 1%, 5%, and 10% of significance levels, respectively. The standard errors are heteroskedasticity-robust standard errors. Control variables are lagged values of fiscal autonomy, gdp per capita, government consumption, trade openness, oil rent, mineral rent, population size, decade dummies, and world dummies. Results of control variables are not reported. Reference category is 'Democratic decentralization and party integration (DDPI)'.

Table A4: Subnational corruption regression results

| | (1)<br>Corruption |
|---|---|
| DDPN | -1.191*** |
| | (0.303) |
| Municipal Directly Elected Executive | -0.465 |
| | (0.340) |
| Municipal Plurality | -0.742** |
| | (0.332) |
| Regional GDP per capita (logged) | -0.032 |
| | (0.044) |
| Regional Population size (logged) | 0.145*** |
| | (0.042) |
| Regional area (logged) | -0.036* |
| | (0.021) |
| Regional offices relative power | -0.354** |
| | (0.178) |
| Subnational elections free and fair | 0.314* |
| | (0.169) |
| Country dummies | Yes |
| Constant | -0.640 |
| | (0.665) |
| Obs. | 1062 |
| R-squared | 0.532 |
| F-test | 80.729 |

Robust Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5: Panel estimation results with party institutionalization index

| | (1) ICRG | (2) CforC | (3) PCI | (4) PSCI | (5) RCI |
|---|---|---|---|---|---|
| Party institutionalization index (Lagged) | -1.425*** | -0.878*** | -0.404*** | -0.346*** | -0.416*** |
| | (0.127) | (0.103) | (0.026) | (0.026) | (0.027) |
| Local government index (Lagged) | -0.746*** | -0.312*** | -0.103*** | -0.189*** | -0.136*** |
| | (0.093) | (0.092) | (0.021) | (0.021) | (0.023) |
| Fiscal Autonomy (Lagged) | -0.024 | 0.037*** | 0.014*** | 0.015*** | 0.018*** |
| | (0.018) | (0.011) | (0.003) | (0.002) | (0.003) |
| GDP per capita (Lagged) | -0.483*** | -0.626*** | -0.136*** | -0.139*** | -0.131*** |
| | (0.027) | (0.019) | (0.004) | (0.004) | (0.005) |
| Government Consumption (Lagged) | -0.038*** | -0.034*** | -0.012*** | -0.005*** | -0.012*** |
| | (0.005) | (0.003) | (0.001) | (0.001) | (0.001) |
| Trade (% of GDP) (Lagged) | -0.002*** | -0.002*** | -0.001*** | -0.001*** | -0.001*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Oil Rent (Lagged) | 0.011* | 0.038*** | 0.011*** | 0.009*** | 0.011*** |
| | (0.006) | (0.004) | (0.001) | (0.001) | (0.001) |
| Mineral Rent (Lagged) | 0.009 | -0.014** | -0.006*** | -0.004*** | -0.004*** |
| | (0.009) | (0.007) | (0.001) | (0.001) | (0.002) |
| Population size (Lagged) | 0.001** | 0.002*** | -0.002*** | -0.001*** | -0.003*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| World region dummies | Yes | Yes | Yes | Yes | Yes |
| Decade dummies | Yes | Yes | Yes | Yes | Yes |
| Constant | 8.045*** | 6.056*** | 1.890*** | 1.802*** | 1.894*** |
| | (0.203) | (0.123) | (0.028) | (0.028) | (0.031) |
| Obs. | 2273 | 1630 | 2952 | 2952 | 2952 |
| R-squared | 0.635 | 0.820 | 0.765 | 0.728 | 0.730 |
| F-test | 230.578 | 459.570 | 530.661 | 435.318 | 440.724 |

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A6: Panel estimation results with party integration proxy index

| | (1) ICRG | (2) CforC | (3) PCI | (4) PSCI | (5) RCI |
|---|---|---|---|---|---|
| Party Integration proxy (Lagged) | -3.496*** | -2.391*** | -0.758*** | -0.639*** | -0.763*** |
| | (0.228) | (0.205) | (0.046) | (0.045) | (0.048) |
| Local government index (Lagged) | -0.816*** | -0.390*** | -0.093*** | -0.178*** | -0.127*** |
| | (0.091) | (0.091) | (0.019) | (0.019) | (0.021) |
| Fiscal Autonomy (Lagged) | 0.005 | 0.056*** | 0.019*** | 0.019*** | 0.023*** |
| | (0.018) | (0.011) | (0.003) | (0.002) | (0.003) |
| GDP per capita (Lagged) | -0.424*** | -0.572*** | -0.133*** | -0.136*** | -0.128*** |
| | (0.027) | (0.021) | (0.004) | (0.004) | (0.005) |
| Government Consumption (Lagged) | -0.036*** | -0.033*** | -0.011*** | -0.005*** | -0.012*** |
| | (0.004) | (0.003) | (0.001) | (0.001) | (0.001) |
| Trade (% of GDP) (Lagged) | -0.002*** | -0.003*** | -0.001*** | -0.001*** | -0.001*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Oil Rent (Lagged) | 0.009 | 0.034*** | 0.011*** | 0.009*** | 0.010*** |
| | (0.006) | (0.004) | (0.001) | (0.001) | (0.001) |
| Mineral Rent (Lagged) | 0.009 | -0.010 | -0.007*** | -0.004*** | -0.005*** |
| | (0.009) | (0.007) | (0.001) | (0.001) | (0.001) |
| Population size (Lagged) | 0.001** | 0.002*** | -0.001*** | -0.003*** | -0.002*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Decade dummies | Yes | Yes | Yes | Yes | Yes |
| World Region dummies | Yes | Yes | Yes | Yes | Yes |
| Constant | 8.958*** | 6.654*** | 2.079*** | 1.970*** | 2.081*** |
| | (0.197) | (0.121) | (0.027) | (0.028) | (0.031) |
| Obs. | 2293 | 1639 | 3027 | 3027 | 3027 |
| R-squared | 0.651 | 0.830 | 0.767 | 0.727 | 0.731 |
| F-Test | 250.014 | 496.406 | 548.767 | 444.989 | 453.456 |

Robust Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A7: Further lagged independent variables

| Panel A: 3-Year lagged variables | (1) ICRG | (2) CforC | (3) PCI | (4) PSCI | (5) RCI |
|---|---|---|---|---|---|
| L3.DDPN | -0.432*** | -0.028 | -0.021** | -0.020* | -0.032*** |
| | (0.149) | (0.054) | (0.008) | (0.010) | (0.010) |
| L3.DDPI | -0.277** | -0.030 | -0.027*** | -0.051*** | -0.038*** |
| | (0.131) | (0.045) | (0.009) | (0.010) | (0.012) |
| Obs. | 2343 | 1680 | 2978 | 2978 | 2978 |
| Panel B: 5-Year lagged variables | | | | | |
| L5.DDPN | -0.371*** | -0.078** | -0.005 | -0.010 | -0.005 |
| | (0.108) | (0.034) | (0.007) | (0.008) | (0.008) |
| L5.DDPI | -0.171 | -0.035 | -0.016* | -0.034*** | -0.019* |
| | (0.125) | (0.035) | (0.009) | (0.012) | (0.011) |
| Constant | -0.285 | -0.485*** | 0.534*** | 0.463*** | 0.562*** |
| | (0.662) | (0.043) | (0.014) | (0.022) | (0.021) |
| Obs. | 2308 | 1666 | 2819 | 2819 | 2819 |

Notes: The asterisk ***, **, and * are 1%, 5%, and 10% of significance levels, respectively. The standard errors are Driscoll-Kraay standard errors that are heteroskedasticity, autocorrelation, and cross-sectional dependence (HAC) robust standard errors. Control variables are fiscal autonomy, gdp per capita, government consumption, trade openness, oil rent, mineral rent, population size, country and year fixed effects. Results of control variables are not reported.

**APPENDIX B: Appendices for Chapter 2**

Figure B1: CO2 Emission per capita

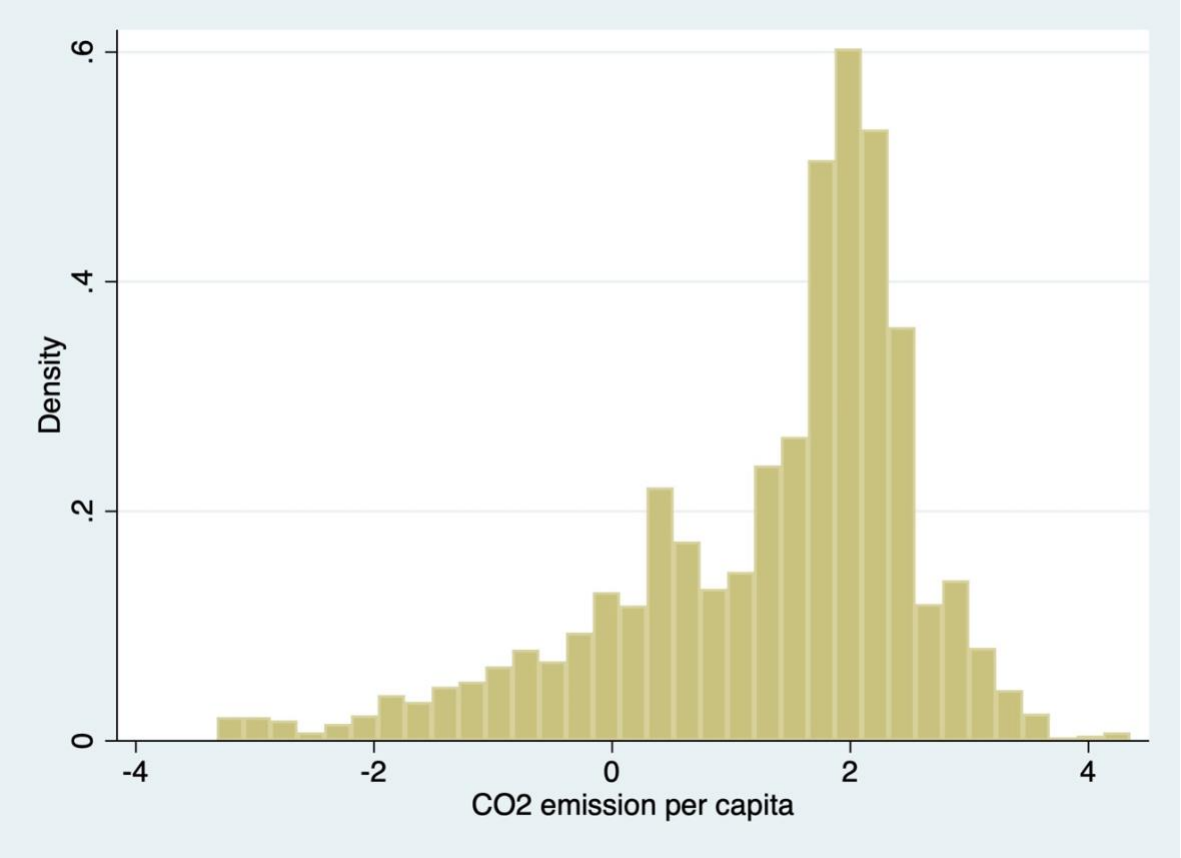


Figure B2: BOD emissions mg/l

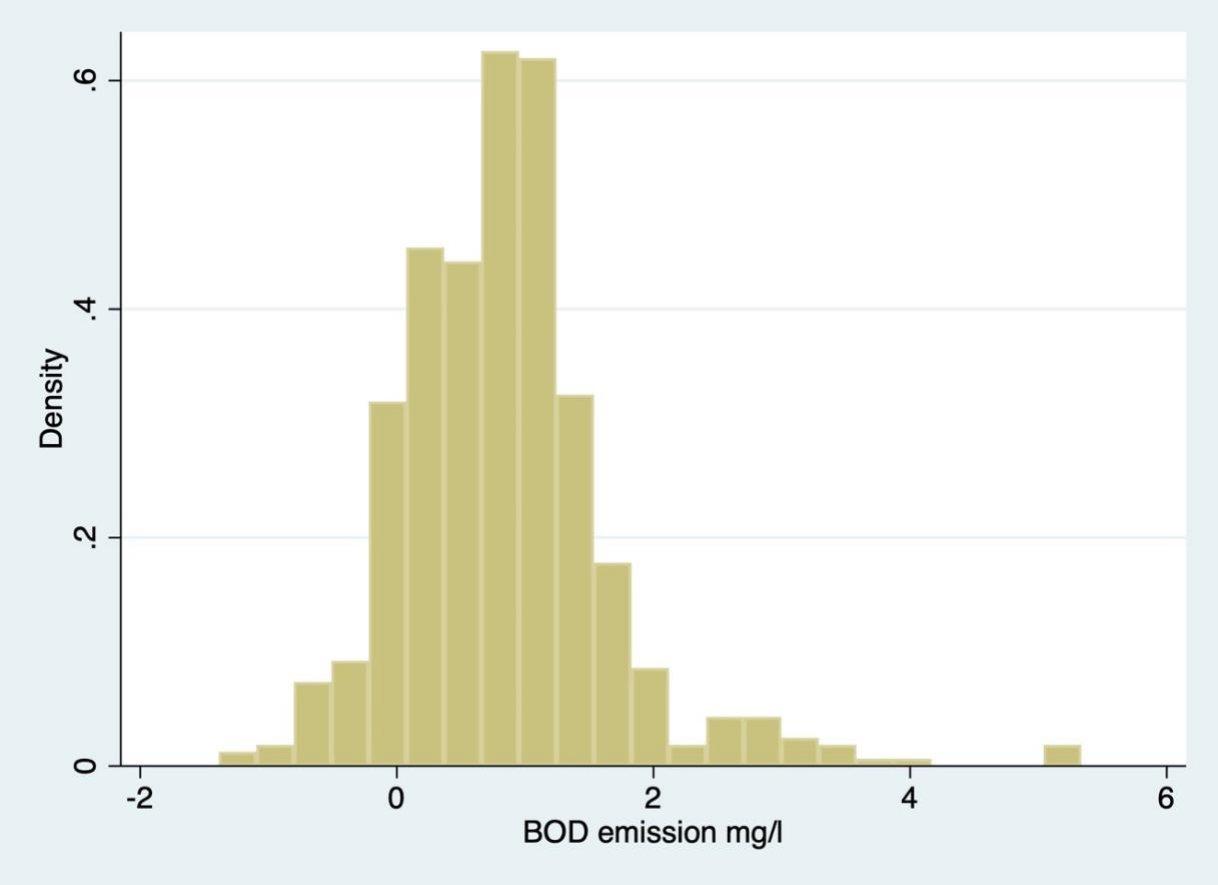
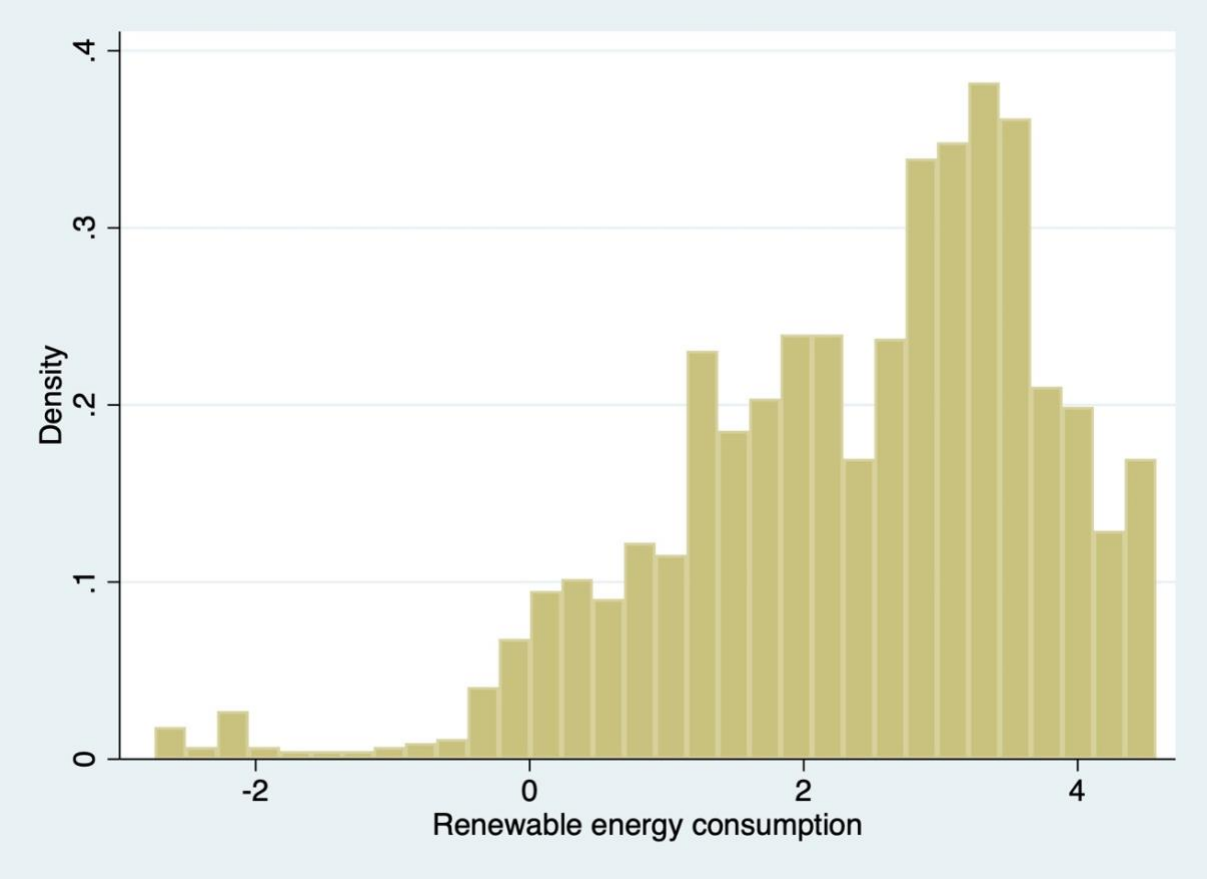


Figure B3: Renewable energy consumption (as a % of Total energy consumption)



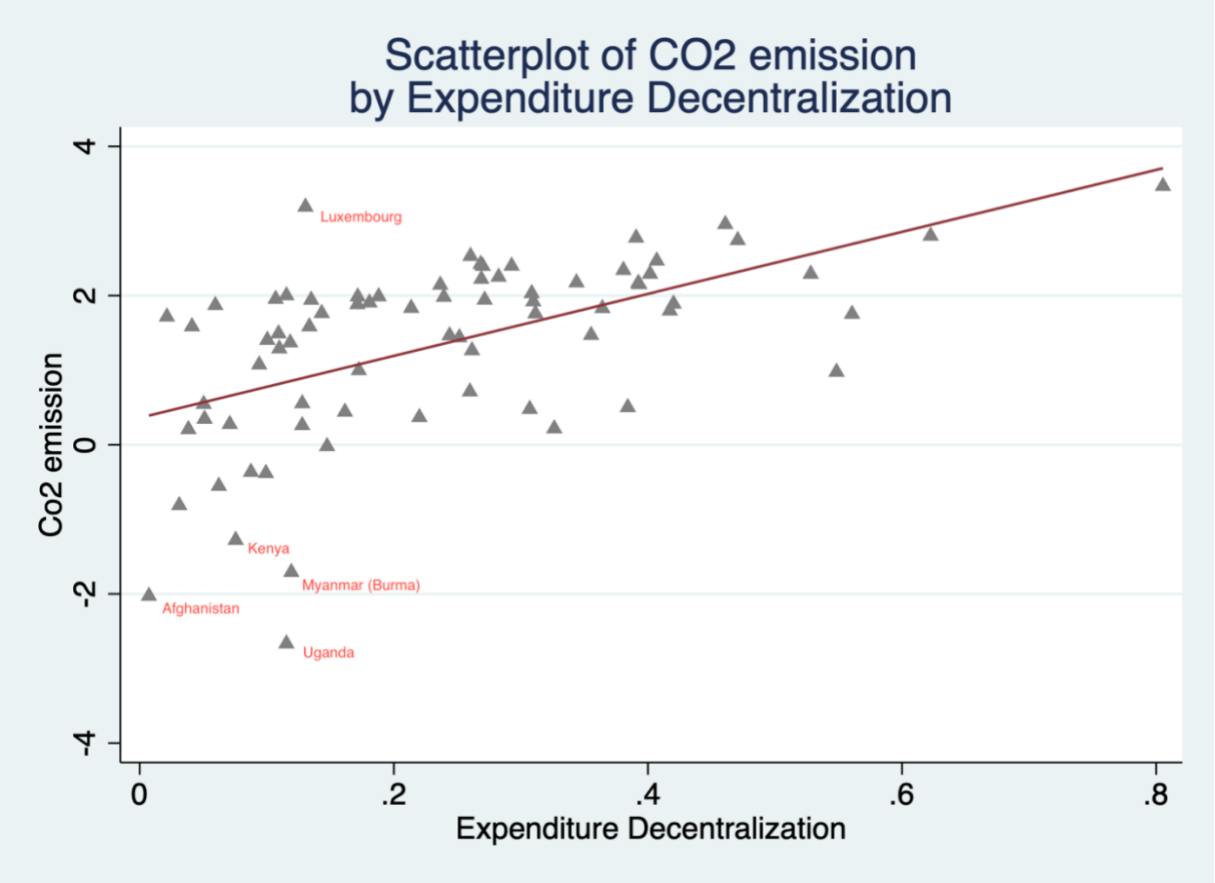



Figure B4: Scatterplot of Co2 emission by Expenditure decentralization
(Outlier countries labelled)

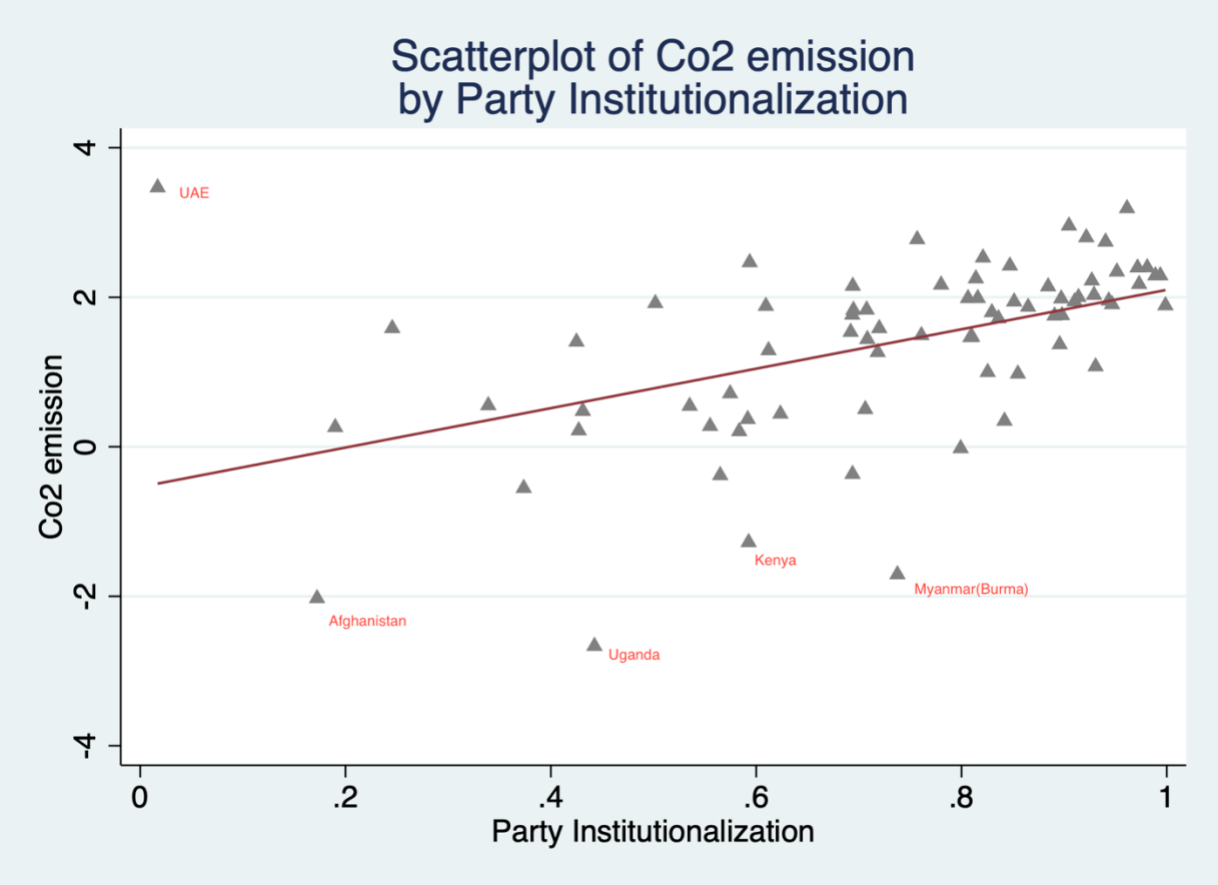
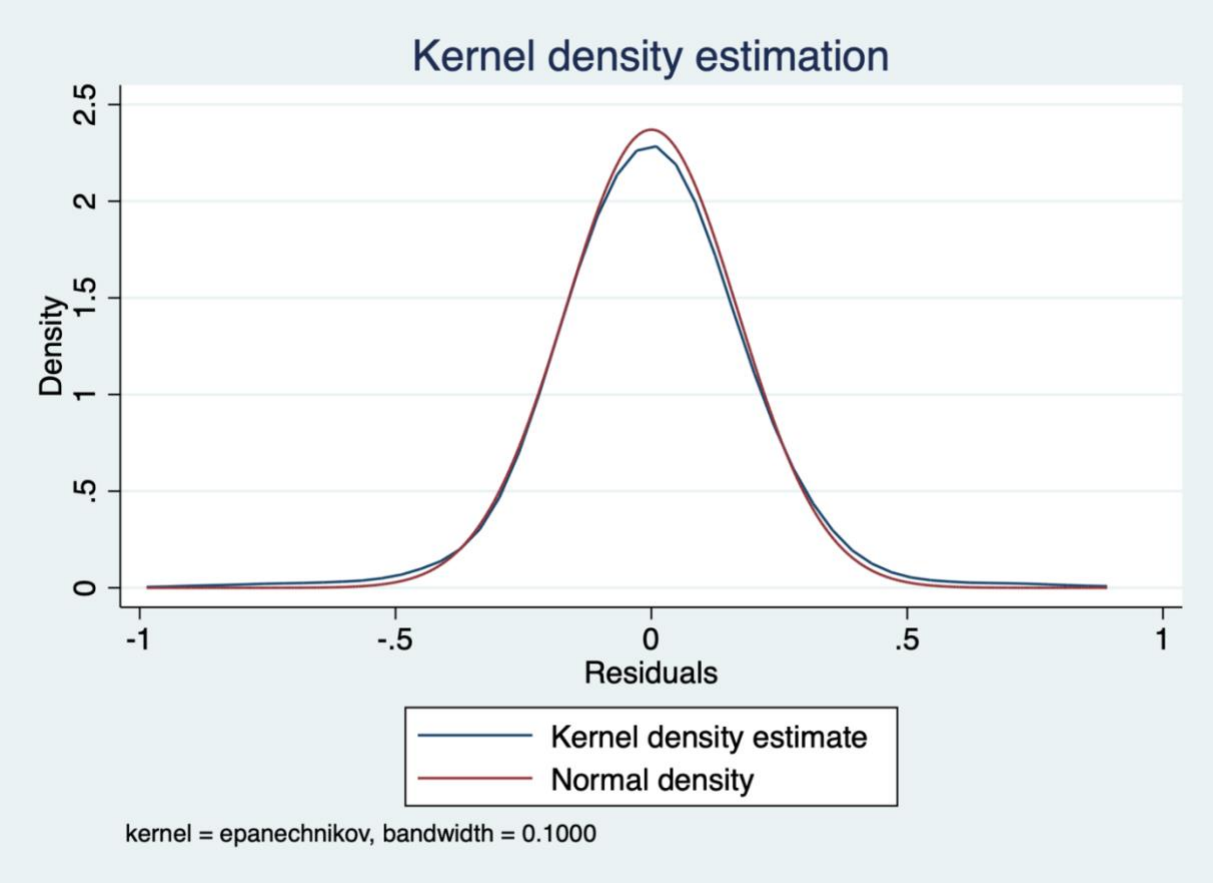



Figure B5: Scatterplot of Co2 emission by Party Institutionalization
(Outlier countries labeled)
(Regression results excluding the outliers from above figures yields similar result as our main estimation results.)

Figure B6: Kernel density estimation of the residuals.




Kernel density estimates of the residuals follow a normal distribution indicating a pdf of normally distributed observations.

Table B1: Variables used in regression and sources

| Variable | Source |
|---|---|
| (Logged) CO2 emission (Metric ton per capita) | World Bank's World Development Indicators |
| (Logged) BOD emission (mg/l) | United Nations Environment Program (2017) |
| (Logged) Renewable energy consumption (% of total energy consumption) | World Bank's World Development Indicators |
| Revenue Decentralization | IMF - Government Finance Statistics and OECD Fiscal Decentralization database |
| Expenditure Decentralization | IMF - Government Finance Statistics and OECD Fiscal Decentralization database |
| Regional Authority Index | Hooghe et al. (2016) |
| Party Institutionalization | V-Dem Dataset |
| Average Age of Parties | Database of Political Institutions |
| Self-rule | Hooghe et al. (2016) |
| Shared rule | Hooghe et al. (2016) |
| Democratic dec. and party integration | Hankla et al. (2019) |
| Democratic dec. and party non-integration | Hankla et al. (2019) |
| Polity IV | Marshall et al. (2016) - Polity IV Project |
| Proportional Representation (1=Proportional rep. electoral system) | Database of Political Institutions |
| Largest Government Party Orientation (1=Right, 2=Center, 3=Left) | Database of Political Institutions |
| GDP per Capita (logged) | World Bank's World Development Indicators |
| Urbanization rate | World Bank's World Development Indicators |
| Trade Openness | World Bank's World Development Indicators |
| Population (logged) | World Bank's World Development Indicators |
| Civil Society Participation Index | V-Dem Dataset |
| Corruption - ICRG | International Country Risk Guide |
| Government Stability - ICRG | International Country Risk Guide |
| Ethnic Fractionalization Index | Drazanova (2020) |
| Manufacturing sector (% of GDP) | World Bank's World Development Indicators |
| Service sector (% of GDP) | World Bank's World Development Indicators |
| Total natural resource rent (% of GDP) | World Bank's World Development Indicators |
| Oil rent (% of GDP) | World Bank's World Development Indicators |
| Coal rent (% of GDP) | World Bank's World Development Indicators |
| Clean election | V-Dem Dataset |
| Judicial Independence | Global State of Democracy Dataset |
| Local relative power | V-Dem Dataset |

Table B2: VIF tests for multi-collinearity

| Variable | VIF | 1/VIF |
|---|---|---|
| (logged) Co2 per capita | 3.13 | 0.319981 |
| Party Institutionalization | 2.22 | 0.451151 |
| Urbanization | 1.98 | 0.503875 |
| (Logged) Population | 1.88 | 0.531196 |
| Trade Openness | 1.66 | 0.602961 |
| Exp. Dec. | 1.64 | 0.608771 |
| Polity IV | 1.55 | 0.643122 |
| Ethnic Frac. | 1.40 | 0.713522 |
| Proportional system | 1.16 | 0.861337 |
| Party Ideology | 1.15 | 0.872323 |
| Govt. Stability | 1.08 | 0.924170 |
| Mean VIF | 1.71 | |

Table B3: Test results for serial correlation, heteroskedasticity, and cross-sectional dependence

| | Model 1: Revenue Decentralization | | Model 2: Expenditure Decentralization | |
|---|---|---|---|---|
| | Statistics | Probability (Prob.) | Statistics | Probability (Prob.) |
| Serial Correlation | 54.534 | 0.000*** | 55.884 | 0.000*** |
| Heteroskedasticity | 3271.00 | 0.000*** | 2652.59 | 0.000*** |
| Pesaran CD | 10.443 | 0.000*** | 10.443 | 0.000*** |

Notes: ***p<0.01, **p<0.05, and *p<0.1

Table B4: Maddala-Wu and Pesaran CIPS unit root tests

| Variables | Pesaran CIPS (Level) | First Difference | Maddala-Wu (Level) | First Difference |
|---|---|---|---|---|
| (Logged) Co2 emission per capita | 0.689 | -20.58*** | 144.1161 | 1308.4305*** |
| Revenue Dec. | 2.875 | -8.182*** | 440.1497*** | 1109.5941*** |
| Party Institutionalization | 0.774 | -19.642*** | 206.7626*** | 1196.6256*** |
| Polity IV | 7.985 | -2.038** | 300.4876*** | 818.1085*** |
| (Logged) GDP per capita | -3.024*** | -19.050*** | 165.1187 | 1014.0306*** |
| (Logged) Population | -9.095*** | -15.572*** | 305.4942*** | 505.2226*** |
| Urbanization | -3.564*** | -3.580*** | 196.2689*** | 264.6403*** |
| Trade Openness | -5.438*** | -24.213*** | 221.5795*** | 1745.9416*** |
| Government stability | -7.085*** | -22.916*** | 230.5318*** | 966.0825*** |
| Civil Society Participation Index | -3.925*** | -21.749*** | 242.5886*** | 1188.977*** |
| Ethnic Fractionalization Index | 18.582 | -13.380*** | 410.254*** | 1054.5092*** |

H(0): Series is I(1), ***p < 0.01, **p<0.05, and *p<0.1. Chi-square (p-value)

Table B5: Co-integration test results

| Kao test for co-integration | Statistics | p-value |
|---|---|---|
| Modified Dickey-Fuller t | 3.5423 | 0.0002*** |
| Dickey-Fuller t | 1.9935 | 0.0231** |
| Augmented Dickey-Fuller t | 2.6066 | 0.0046*** |
| Unadjusted modified Dickey-Fuller t | 3.0591 | 0.0011*** |
| Unadjusted Dickey-Fuller t | 1.4724 | 0.0705* |
| $H_0$: No co-integration \| $H_{a:}$ All panels are cointegrated | | |
| **Westerlund test for cointegration** | **Statistics** | **p-value** |
| Variance ratio | -5.3252 | 0.000*** |
| $H_0$: No co-integration \| $H_{a:}$ Some panels are cointegrated | | |

***p < 0.01, **p<0.05, and *p<0.1.

Table B6: Instrumental variables regression results

| VARIABLES | (1) CO2 emission per capita (Surface area as IV) | (2) CO2 emission per capita (GFI as IV) |
|---|---|---|
| Expenditure Decentralization | 2.201** | 2.121** |
| | (0.998) | (0.948) |
| Party Institutionalization | 0.725 | 0.710 |
| | (0.511) | (0.488) |
| Interaction (Exp. Dec. and Party Institutionalization) | -2.628** | -2.500** |
| | (1.204) | (1.191) |
| Polity IV | 0.011* | 0.010* |
| | (0.006) | (0.005) |
| Population (logged) | 0.537** | 0.316 |
| | (0.225) | (0.195) |
| GDP per Capita (logged) | 0.392*** | 0.310*** |
| | (0.069) | (0.054) |
| Urbanization rate | 0.016** | 0.018** |
| | (0.007) | (0.007) |
| Trade Openness | 0.001 | -0.001 |
| | (0.001) | (0.001) |
| Largest Government Party Orientation = 1, Right (Base Category) | | |
| Largest Government Party Orientation = 2, Center | -0.016 | -0.043 |
| | (0.039) | (0.031) |
| Largest Government Party Orientation = 3, Left | -0.010 | -0.001 |
| | (0.019) | (0.015) |
| Proportional Representation = 1 | 0.197** | 0.198* |
| | (0.085) | (0.113) |
| Year and Country Dummies | Yes | Yes |
| Constant | -11.948*** | -7.944** |
| | (3.751) | (3.157) |
| Observations | 1,636 | 1,396 |
| Number of countries | 67 | 66 |
| R-Squared | 0.35 | 0.41 |

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B7: Lagged independent variables regression results

| VARIABLES | (1)<br>CO2 emission per capita | (2)<br>CO2 emission per capita | (3)<br>CO2 emission per capita |
|---|---|---|---|
| Expenditure Decentralization (One-Year Lagged) | 1.479** | | |
| | (0.593) | | |
| Party Institutionalization (One-Year Lagged) | 0.940*** | | |
| | (0.167) | | |
| Expenditure Decentralization (Three-Year Lagged) | | 1.452*** | |
| | | (0.459) | |
| Party Institutionalization (Three-Year Lagged) | | 0.884*** | |
| | | (0.214) | |
| Expenditure Decentralization (Five-Year Lagged) | | | 0.636 |
| | | | (0.629) |
| Party Institutionalization (Five-Year Lagged) | | | 0.759*** |
| | | | (0.207) |
| Interaction (Exp. Dec. and Party Institutionalization) | -1.798** | -1.899*** | -1.032 |
| | (0.670) | (0.529) | (0.725) |
| Polity IV | 0.010** | 0.010*** | 0.015*** |
| | (0.004) | (0.003) | (0.003) |
| Population (logged) | 0.342** | 0.432*** | 0.549*** |
| | (0.129) | (0.153) | (0.156) |
| GDP per Capita (logged) | 0.304*** | 0.294*** | 0.271*** |
| | (0.041) | (0.035) | (0.031) |
| Urbanization rate | 0.019*** | 0.017*** | 0.016*** |
| | (0.002) | (0.001) | (0.001) |
| Trade Openness | -0.000 | -0.000 | -0.001 |
| | (0.001) | (0.001) | (0.001) |
| Largest Government Party Orientation = 1, (Base Category) | | | |
| Largest Government Party Orientation = 2, Center | -0.018 | 0.008 | 0.010 |
| | (0.018) | (0.017) | (0.016) |
| Largest Government Party Orientation = 3, Left | 0.007 | 0.004 | -0.000 |
| | (0.014) | (0.014) | (0.016) |
| Proportional Representation = 1 | 0.208** | 0.216** | 0.246** |
| | (0.098) | (0.101) | (0.108) |
| Government Stability | 0.010*** | 0.011*** | 0.012*** |
| | (0.003) | (0.004) | (0.003) |
| Constant | 0.000 | 0.000 | -12.120*** |
| | (0.000) | (0.000) | (2.285) |
| Year and Country Dummies | Yes | Yes | Yes |
| Observations | 1,304 | 1,275 | 1,244 |
| Number of groups | 60 | 59 | 59 |
| R-Squared | 0.5 | 0.49 | 0.49 |

Driscoll-Kraay Robust Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B8: Panel estimation results with economic sectors

| VARIABLES | (1) CO2 emission | (2) BOD emission mg/l | (3) Renewable energy consumption | (4) CO2 emission per capita | (5) BOD emission mg/l | (6) Renewable energy consumption |
|---|---|---|---|---|---|---|
| Expenditure Decentralization | 1.749*** | -21.824 | -0.304 | 1.645*** | -21.622 | 0.008 |
| | (0.615) | (13.647) | (0.771) | (0.570) | (13.162) | (0.708) |
| Party Institutionalization | 0.254* | -1.805 | -0.400 | 0.197 | -1.793 | -0.387 |
| | (0.134) | (4.672) | (0.364) | (0.143) | (4.325) | (0.344) |
| Interaction term (Dec. measure and Party institutionalization) | -1.959*** | 24.532 | -0.716 | -1.956** | 24.308 | -1.027 |
| | (0.725) | (15.166) | (1.179) | (0.665) | (14.627) | (1.138) |
| Polity IV | 0.008** | 0.061*** | -0.028*** | 0.010*** | 0.060*** | -0.026*** |
| | (0.003) | (0.021) | (0.004) | (0.003) | (0.021) | (0.004) |
| Population (logged) | 0.610*** | 4.260*** | -2.024*** | 0.586*** | 4.070*** | -2.050*** |
| | (0.138) | (0.965) | (0.263) | (0.125) | (0.983) | (0.277) |
| GDP per Capita (logged) | 0.356*** | 0.188 | -0.301*** | 0.359*** | 0.200 | -0.323*** |
| | (0.054) | (0.192) | (0.053) | (0.054) | (0.187) | (0.053) |
| Urbanization rate | 0.011** | -0.078*** | 0.001 | 0.011** | -0.074*** | 0.001 |
| | (0.005) | (0.026) | (0.010) | (0.005) | (0.025) | (0.009) |
| Trade Openness | -0.001** | -0.009 | 0.003*** | -0.001** | -0.009 | 0.003*** |
| | (0.001) | (0.007) | (0.001) | (0.001) | (0.008) | (0.001) |
| Largest Government Party Orientation = 1, Right (Base Category) | | | | | | |
| Largest Government Party Orientation = 2, Center | -0.027 | 0.107 | -0.001 | -0.025 | 0.109 | -0.008 |
| | (0.028) | (0.169) | (0.049) | (0.028) | (0.164) | (0.048) |
| Largest Government Party Orientation = 3, Left | -0.006 | 0.278*** | -0.005 | -0.008 | 0.292*** | 0.005 |
| | (0.012) | (0.075) | (0.032) | (0.013) | (0.083) | (0.032) |
| Proportional Representation = 1 | 0.188*** | -0.227 | -0.127 | 0.223*** | -0.201 | -0.141* |
| | (0.064) | (0.206) | (0.096) | (0.055) | (0.211) | (0.078) |
| Service value added (% of GDP) | 0.014** | 0.018 | -0.008 | 0.016** | 0.023 | -0.010 |
| | (0.005) | (0.018) | (0.007) | (0.006) | (0.018) | (0.008) |
| Manufacturing value added (% of GDP) | 0.033*** | 0.021 | -0.014 | 0.034*** | 0.024 | -0.015 |
| | (0.004) | (0.033) | (0.011) | (0.005) | (0.034) | (0.012) |
| Total resource rent, as a % of GDP | 0.012*** | 0.005 | -0.001 | | | |
| | (0.004) | (0.067) | (0.004) | | | |
| Oil rent, as a % of GDP | | | | 0.012* | 0.026 | 0.020*** |
| | | | | (0.006) | (0.059) | (0.006) |
| Coal rent, as a % of GDP | | | | -0.005 | 0.455 | 0.005 |
| | | | | (0.007) | (0.518) | (0.007) |
| Year and Country Dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.000 | 0.000 | 40.139*** | 0.000 | 0.000 | 40.369*** |
| | (0.000) | (0.000) | (4.222) | (0.000) | (0.000) | (4.470) |
| Observations | 1,380 | 264 | 1,123 | 1,380 | 264 | 1,123 |
| Number of groups | 65 | 32 | 64 | 65 | 32 | 64 |
| R-Squared | 0.52 | 0.44 | 0.43 | 0.52 | 0.44 | 0.44 |

Driscoll-Kraay Robust Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B9: Panel estimation results with world region and income region dummies

| VARIABLES | (1) CO2 emission per capita | (2) BOD emission | (3) Renewable energy consumption | (4) CO2 emission per capita | (5) BOD emission | (6) Renewable energy consumption |
|---|---|---|---|---|---|---|
| Expenditure decentralization | 3.723*** | -10.308*** | -2.669** | 3.564*** | -3.344** | -2.864** |
| | (0.506) | (2.265) | (1.036) | (0.651) | (1.654) | (1.234) |
| Party Institutionalization | 0.352** | -1.200** | 0.572 | 1.105*** | 0.459 | -0.321 |
| | (0.147) | (0.541) | (0.367) | (0.174) | (0.353) | (0.430) |
| Interaction (Dec. measure and party institutionalization) | -4.087*** | 10.118*** | 3.836*** | -2.670*** | 3.633** | 3.689*** |
| | (0.554) | (2.273) | (1.152) | (0.722) | (1.749) | (1.367) |
| Polity IV | 0.010*** | -0.008 | -0.022* | -0.009** | 0.037* | 0.028** |
| | (0.004) | (0.020) | (0.011) | (0.005) | (0.022) | (0.012) |
| Population (logged) | 0.039*** | 0.224*** | -0.357*** | 0.057*** | 0.326*** | -0.320*** |
| | (0.012) | (0.045) | (0.027) | (0.013) | (0.049) | (0.032) |
| GDP per Capita (logged) | 0.237*** | -0.294*** | 0.121*** | 0.200*** | -0.612*** | 0.169** |
| | (0.019) | (0.077) | (0.038) | (0.036) | (0.108) | (0.071) |
| Urbanization rate | 0.020*** | 0.021*** | -0.030*** | 0.010*** | 0.014*** | -0.021*** |
| | (0.001) | (0.004) | (0.003) | (0.001) | (0.004) | (0.003) |
| Trade Openness | 0.003*** | 0.004*** | -0.010*** | 0.005*** | 0.013*** | -0.012*** |
| | (0.000) | (0.002) | (0.001) | (0.000) | (0.002) | (0.001) |
| Largest Government Party Orientation = 1, Right (Base Category) | | | | | | |
| Largest Government Party Orientation = 2, Center | 0.095** | 0.213* | 0.046 | -0.010 | 0.352** | 0.155 |
| | (0.040) | (0.121) | (0.095) | (0.048) | (0.137) | (0.104) |
| Largest Government Party Orientation = 3, Left | 0.016 | 0.208*** | 0.092* | -0.077*** | 0.263*** | 0.103* |
| | (0.024) | (0.073) | (0.054) | (0.029) | (0.083) | (0.061) |
| Proportional Representation = 1 | 0.094** | 0.570*** | 0.403*** | -0.148*** | 0.228* | 0.189** |
| | (0.037) | (0.108) | (0.083) | (0.034) | (0.123) | (0.086) |
| World Region dummies | Yes | Yes | Yes | No | No | No |
| Income region dummies | No | No | No | Yes | Yes | Yes |
| Decade dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | -2.785*** | -1.371 | 9.089*** | -3.807*** | -2.137* | 8.845*** |
| | (0.254) | (0.988) | (0.538) | (0.335) | (1.120) | (0.751) |
| Observations | 1,660 | 379 | 1,209 | 1,660 | 379 | 1,209 |
| R-squared | 0.793 | 0.497 | 0.480 | 0.698 | 0.388 | 0.297 |

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B10: Panel estimation results with alternative measures of decentralization and party institutionalization

| VARIABLES | (1) CO2 emission per capita | (2) BOD emission | (3) Renewable energy consumption | (4) CO2 emission per capita | (5) BOD emission | (6) Renewable energy consumption |
|---|---|---|---|---|---|---|
| Regional Authority Index | 0.035*** | -0.137 | -0.001 | | | |
| | (0.012) | (0.099) | (0.012) | | | |
| Party Institutionalization | 0.900*** | -1.365 | -0.333* | | | |
| | (0.175) | (1.977) | (0.176) | | | |
| Expenditure Decentralization | | | | 0.674*** | -2.306*** | -1.223*** |
| | | | | (0.129) | (0.751) | (0.214) |
| Average Age of Parties | | | | 0.004*** | -0.011 | -0.004* |
| | | | | (0.001) | (0.011) | (0.002) |
| Interaction (Dec. measure and Party measure) | -0.027** | 0.145 | -0.005 | -0.010*** | -0.015 | 0.011** |
| | (0.010) | (0.105) | (0.016) | (0.002) | (0.015) | (0.004) |
| Polity IV | 0.006** | 0.031 | -0.017** | 0.012*** | 0.046** | -0.011** |
| | (0.003) | (0.030) | (0.007) | (0.003) | (0.019) | (0.005) |
| Population (logged) | 0.667*** | 4.007*** | -1.360*** | 0.415*** | 2.907** | -1.542*** |
| | (0.059) | (0.961) | (0.106) | (0.097) | (1.120) | (0.153) |
| GDP per Capita (logged) | 0.278*** | 0.258** | -0.256*** | 0.331*** | 0.408*** | -0.297*** |
| | (0.031) | (0.115) | (0.077) | (0.043) | (0.143) | (0.064) |
| Urbanization rate | 0.019*** | 0.006 | -0.027*** | 0.017*** | -0.004 | -0.009 |
| | (0.002) | (0.012) | (0.003) | (0.004) | (0.019) | (0.006) |
| Trade Openness | -0.000 | -0.009** | 0.003*** | -0.001** | -0.010*** | 0.004*** |
| | (0.001) | (0.003) | (0.001) | (0.001) | (0.003) | (0.001) |
| Largest Government Party Orientation = 1, Right (Base Category) | | | | | | |
| Largest Government Party Orientation = 2, Center | -0.009 | -0.057 | -0.076** | -0.043** | -0.147 | -0.029 |
| | (0.018) | (0.083) | (0.037) | (0.018) | (0.102) | (0.046) |
| Largest Government Party Orientation = 3, Left | 0.012 | 0.038 | -0.017 | 0.012 | 0.192*** | -0.021 |
| | (0.008) | (0.060) | (0.023) | (0.016) | (0.063) | (0.030) |
| Proportional Representation = 1 | 0.130** | -0.273 | -0.055 | 0.257*** | -0.466* | -0.087 |
| | (0.053) | (0.234) | (0.057) | (0.077) | (0.258) | (0.081) |
| Country and Year Dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 31.719*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (2.031) |
| Observations | 1,828 | 455 | 1,311 | 1,600 | 372 | 1,187 |
| Number of groups | 53 | 35 | 53 | 66 | 34 | 64 |
| R-Squared | 0.61 | 0.40 | 0.42 | 0.42 | 0.50 | 0.41 |

Driscoll-Kraay Robust Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B11: Political decentralization estimation results

| | (1) CO2 emission per capita | (2) BOD emission | (3) Renewable energy consumption | (4) CO2 emission per capita | (5) BOD emission | (6) Renewable energy consumption |
|---|---|---|---|---|---|---|
| Democratic dec. and Party Integration (DDPI) | -0.119*** | -0.549** | 0.500*** | | | |
| | (0.045) | (0.250) | (0.085) | | | |
| Democratic dec. and Party Non-Integration (DDPN) | -0.074 | -0.705*** | 0.074 | | | |
| | (0.049) | (0.247) | (0.084) | | | |
| Democratic dec. and party integration (Base category is DDPN) | | | | -0.046** | 0.086 | 0.374*** |
| | | | | (0.022) | (0.080) | (0.052) |
| Polity IV | -0.007 | 0.040 | -0.027*** | -0.011 | 0.051** | -0.040*** |
| | (0.006) | (0.034) | (0.009) | (0.009) | (0.026) | (0.012) |
| Population (logged) | 0.073*** | 0.104* | -0.145*** | 0.043*** | 0.210*** | -0.194*** |
| | (0.009) | (0.053) | (0.021) | (0.010) | (0.042) | (0.023) |
| GDP per Capita (logged) | 0.259*** | -0.161** | -0.053 | 0.241*** | -0.240*** | -0.062* |
| | (0.019) | (0.079) | (0.033) | (0.019) | (0.060) | (0.034) |
| Urbanization rate | 0.026*** | 0.022*** | -0.031*** | 0.023*** | 0.019*** | -0.028*** |
| | (0.001) | (0.004) | (0.002) | (0.001) | (0.004) | (0.002) |
| Trade Openness | 0.005*** | 0.007*** | -0.007*** | 0.005*** | 0.007*** | -0.009*** |
| | (0.000) | (0.002) | (0.001) | (0.000) | (0.002) | (0.001) |
| Clean election | 0.501*** | -0.570 | -0.681*** | 0.920*** | -0.608 | -0.479*** |
| | (0.114) | (0.767) | (0.155) | (0.114) | (0.471) | (0.175) |
| Judicial Independence | -0.841*** | -0.797* | 3.257*** | -0.671*** | 0.671* | 3.135*** |
| | (0.103) | (0.418) | (0.201) | (0.101) | (0.366) | (0.209) |
| Local Office relative power | 0.050*** | -0.117*** | -0.130*** | 0.062*** | -0.120*** | -0.101*** |
| | (0.009) | (0.029) | (0.020) | (0.008) | (0.029) | (0.022) |
| Largest Government Party Orientation = 1, Right (Base Group) | | | | | | |
| Largest Government Party Orientation = 2, Center | 0.094*** | 0.114 | 0.144** | 0.080*** | 0.014 | 0.121* |
| | (0.029) | (0.118) | (0.073) | (0.029) | (0.096) | (0.073) |
| Larges Government Party Orientation = 3, Left | 0.111*** | 0.149** | 0.016 | 0.099*** | 0.082 | 0.038 |
| | (0.024) | (0.075) | (0.048) | (0.021) | (0.068) | (0.049) |
| World region and decade dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | -3.337*** | -0.280 | 6.500*** | -2.928*** | -3.052*** | 7.105*** |
| | (0.223) | (1.190) | (0.489) | (0.230) | (0.918) | (0.522) |
| Observations | 2132 | 438 | 1509 | 1782 | 385 | 1342 |
| R-Squared | 0.821 | 0.437 | 0.562 | 0.823 | 0.505 | 0.530 |

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B12: Regional and Local government indices

| | (1) CO2 emission per capita | (2) BOD emission | (3) Renewable energy consumption | (4) CO2 emission per capita | (5) BOD emission | (6) Renewable energy consumption |
|---|---|---|---|---|---|---|
| Regional govt. index | 0.210 | 0.875 | -0.370** | | | |
| | (0.133) | (3.711) | (0.151) | | | |
| Local govt. index | | | | -0.684** | 1.036 | 1.507*** |
| | | | | (0.268) | (3.191) | (0.297) |
| Party Institutionalization | 0.653*** | 2.698 | -0.611** | 1.054*** | 0.707 | -1.479*** |
| | (0.086) | (3.140) | (0.236) | (0.170) | (3.290) | (0.313) |
| Interaction term | -0.348** | -2.062 | 0.332 | -0.684** | 1.036 | 1.507*** |
| | (0.168) | (3.816) | (0.211) | (0.268) | (3.191) | (0.297) |
| Polity IV | 0.009*** | 0.061*** | -0.016** | 0.007** | 0.079*** | -0.013* |
| | (0.003) | (0.022) | (0.006) | (0.003) | (0.024) | (0.007) |
| Population (logged) | 0.661*** | 3.175*** | -1.170*** | 0.623*** | 4.130*** | -1.119*** |
| | (0.073) | (0.847) | (0.129) | (0.082) | (0.923) | (0.145) |
| GDP per Capita (logged) | 0.359*** | 0.388** | -0.197*** | 0.351*** | 0.451*** | -0.191*** |
| | (0.033) | (0.166) | (0.053) | (0.033) | (0.149) | (0.053) |
| Urbanization rate | 0.016*** | -0.003 | -0.021*** | 0.016*** | 0.013 | -0.021*** |
| | (0.002) | (0.017) | (0.002) | (0.002) | (0.016) | (0.002) |
| Trade Openness | 0.002** | -0.008** | 0.004*** | 0.001 | -0.009*** | 0.004*** |
| | (0.001) | (0.004) | (0.001) | (0.001) | (0.003) | (0.001) |
| Largest Government Party Orientation = 1, Right (Base Group) | | | | | | |
| Largest Government Party Orientation = 2, Center | -0.012 | -0.124 | 0.013 | 0.008 | -0.103 | -0.014 |
| | (0.022) | (0.108) | (0.029) | (0.025) | (0.103) | (0.031) |
| Largest Government Party Orientation = 3, Left | -0.008 | 0.091** | -0.016 | -0.007 | 0.064 | -0.022 |
| | (0.011) | (0.037) | (0.027) | (0.012) | (0.045) | (0.028) |
| Proportional Representation =1 | 0.110** | -0.145 | -0.039 | 0.117** | -0.121 | -0.017 |
| | (0.053) | (0.153) | (0.099) | (0.053) | (0.193) | (0.103) |
| Clean election | 0.107 | 0.391 | -0.266* | 0.084 | -0.518 | -0.229 |
| | (0.073) | (0.851) | (0.137) | (0.074) | (0.817) | (0.175) |
| Judicial Independence | -0.219** | -2.195** | 0.359 | -0.275** | -1.906** | 0.265 |
| | (0.104) | (0.886) | (0.247) | (0.109) | (0.881) | (0.217) |
| Constant | -14.808*** | 0.000 | 25.807*** | -14.452*** | 0.000 | 25.661*** |
| | (1.190) | (.) | (1.978) | (1.273) | (.) | (2.302) |
| N | 2018 | 412 | 1470 | 2018 | 412 | 1470 |
| Number of countries | 60 | 33 | 60 | 60 | 33 | 60 |
| R2 | 0.48 | 0.44 | 0.36 | 0.49 | 0.41 | 0.37 |

Driscoll-Kraay Robust Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B13: List of countries

| Country | World Region | Income Region |
|---|---|---|
| Albania | Europe & Central Asia | Upper-middle income |
| Armenia | Europe & Central Asia | Upper-middle income |
| Australia | East Asia & Pacific | High income |
| Austria | Europe & Central Asia | High income |
| Azerbaijan | Europe & Central Asia | Upper-middle income |
| Belarus | Europe & Central Asia | Upper-middle income |
| Belgium | Europe & Central Asia | High income |
| Bosnia | Europe & Central Asia | Upper-middle income |
| Brazil | Latin America & Caribbean | Upper-middle income |
| Bulgaria | Europe & Central Asia | Upper-middle income |
| Canada | North America | High income |
| Chile | Latin America & Caribbean | High income |
| China | East Asia & Pacific | Upper-middle income |
| Colombia | Latin America & Caribbean | Upper-middle income |
| Costa Rica | Latin America & Caribbean | Upper-middle income |
| Croatia | Europe & Central Asia | High income |
| Cyprus | Europe & Central Asia | High income |
| Czech Republic | Europe & Central Asia | High income |
| Denmark | Europe & Central Asia | High income |
| El Salvador | Latin America & Caribbean | Upper-middle income |
| Estonia | Europe & Central Asia | High income |
| Finland | Europe & Central Asia | High income |
| France | Europe & Central Asia | High income |
| Georgia | Europe & Central Asia | Upper-middle income |
| Germany | Europe & Central Asia | High income |
| Greece | Europe & Central Asia | High income |
| Honduras | Latin America & Caribbean | Lower-middle income |
| Hungary | Europe & Central Asia | High income |
| Indonesia | East Asia & Pacific | Lower-middle income |
| Iran | Middle East & North Africa | High income |
| Ireland | Europe & Central Asia | High income |
| Israel | Middle East & North Africa | High income |
| Italy | Europe & Central Asia | High income |
| Japan | East Asia & Pacific | High income |
| Kazakhstan | Europe & Central Asia | Upper-middle income |
| Kenya | Sub-Saharan Africa | Lower-middle income |
| Korea South | East Asia & Pacific | High income |
| Kyrgyzstan | Europe & Central Asia | Lower-middle income |
| Latvia | Europe & Central Asia | High income |
| Lithuania | Europe & Central Asia | High income |
| Luxembourg | Europe & Central Asia | High income |
| Macedonia | Europe & Central Asia | Upper-middle income |
| Mauritius | Sub-Saharan Africa | Upper-middle income |
| Moldova | Europe & Central Asia | Upper-middle income |

Table B13: List of countries (continued)

| | | |
|---|---|---|
| Mongolia | East Asia & Pacific | Upper-middle income |
| Myanmar (Burma) | East Asia & Pacific | Lower-middle income |
| Netherlands | Europe & Central Asia | High income |
| New Zealand | East Asia & Pacific | High income |
| Norway | Europe & Central Asia | High income |
| Paraguay | Latin America & Caribbean | Upper-middle income |
| Peru | Latin America & Caribbean | Upper-middle income |
| Poland | Europe & Central Asia | High income |
| Portugal | Europe & Central Asia | High income |
| Romania | Europe & Central Asia | Upper-middle income |
| Russia | Europe & Central Asia | Upper-middle income |
| Serbia | Europe & Central Asia | Upper-middle income |
| Slovak Republic | Europe & Central Asia | High income |
| Slovenia | Europe & Central Asia | High income |
| South Africa | Sub-Saharan Africa | Upper-middle income |
| Spain | Europe & Central Asia | High income |
| Sweden | Europe & Central Asia | High income |
| Switzerland | Europe & Central Asia | High income |
| Thailand | East Asia & Pacific | Upper-middle income |
| Tunisia | Middle East & North Africa | Lower-middle income |
| Turkey | Europe & Central Asia | Upper-middle income |
| UAE | Middle East & North Africa | High income |
| Uganda | Sub-Saharan Africa | Low income |
| Ukraine | Europe & Central Asia | Lower-middle income |
| United Kingdom | Europe & Central Asia | High income |
| United States | North America | High income |
| Uzbekistan | Europe & Central Asia | Lower-middle income |

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# VITA

Kshitiz Shrestha was born in Chitwan, Nepal. He completed his Bachelor of Science degree in Accounting and Finance from Nicholls State University in Thibodaux, Louisiana in 2013. In 2011, he was awarded as the 'Outstanding International Male Scholar Award.' He joined the University of North Texas in August 2014 and received the degree of Masters of Science in Finance in May 2016. He was awarded 'Outstanding Graduate Student Award' in 2016. During his masters, he served as the president of 'Financial Management Association – Steven C. Cole Chapter' and 'Student Investment Group.'

Kshitiz joined Georgia State University in 2017, when he started the PhD program in Economics. In 2018, he joined International Center for Public Policy (ICEPP) as a Graduate Research Assistant. Since then, he has worked under the supervision of Professor Jorge Martinez-Vazquez. He has been involved in a number of policy reform projects including the state of Georgia, Connecticut, and government of Grenada. His primary research interest areas are Public Economic and Labor Economics, specifically fiscal and political decentralization, climate change, corruption, wealth inequality, and labor migration. Mr. Shrestha's dissertation focuses on the impact of political and fiscal decentralization on corruption and climate change in cross-country setting.

On May 2017, Mr. Shrestha started a job as Senior Research Associate in Fiscal Research Center in Atlanta.