Environmental pollution and fiscal decentralization. On the role of institutions.

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Abstract

Previous research in the field of Environmental Federalism has not reached an agreement on whether fiscal decentralization leads to an increase in environmental pollution, i.e. a race to the bottom, or decrease in it, i.e. a a race to the top. Farzanegan and Mennel (2012) point out that this discrepancy may be due to institutions. Employing the OLS estimator, they find that fiscal decentralization leads to a race to the bottom which is mitigated by the quality of institutions in both transboundary and local pollutants. In this paper, the GMM estimator is employed to account for endogeneity issues arising from fiscal decentralization and the quality of institutions. Contrarily to what it was previously found, it is shown in this empirical investigation that (1) the effect that fiscal decentralization exerts on pollution depends on the quality of institutions; and (2) fiscal decentralization leads to decreased environmental degradation when countries display high-quality institutions, and thus we find a race-to-the-top, whereas for low-quality institutions the opposite is true. These results hold for transboundary pollutants, but not for local pollutants.

Keywords: Environmental pollution, fiscal decentralization, institutions, race to the top, race to the bottom, GMM estimator.

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1 Introduction

Global warming and climate change have brought environmental federalism[1] to the agenda of policy makers, the academia, and research institutes. Hence, environmental economists have tried to shed light on the relationship between fiscal decentralization and environmental pollution. Although there has already been conducted extensive research in the field, the results seem inconclusive, either depicting a race to the bottom in which regions lower their environmental standards so as to attract international businesses, and thereby increasing pollution; or a race to the top where regions set higher environmental standards in order to create environmentally-friendly environments with the aim of expelling polluting activities to neighborhood regions, and thus decreasing pollution in the area. These contradicting results may be explained by institutions, which have been generally neglected in previous studies (Farzanegan and Mennel, 2012). Therefore, I think it is particularly interesting to elucidate the role that the quality of institutions plays on the effects that fiscal decentralization exerts on environmental pollution.

Over the last decades, we have seen a growing number of central governments that have given up responsibilities in terms of environmental policies to subnational governments. For example, in the United States, during the Reagan mandate in the eighties, the Federal State (national government) transferred environmental competences to state governments (Lester, 1986; Crotty 1987; Davis and Lester, 1987; Potoski, 2001). Furthermore, it seems that the European Union is trying to centralize environmental policies under the decisions taken by the European Comission with the aim of protecting the environment and prevent inter-jurisdictional competition among its member states. Nevertheless, although the direction of the policies are set centrally and member states are supposed to follow its guidelines, it has been reported that member states have failed to comply with them (Jordan, 1999; Knill and Lenschow, 2005; Mastenbroek, 2006). Indeed, member states have provided more power and decision making capabilities in terms of environmental policies to subnational parliaments. Regions within EU member states have room for setting their own environmental policies, and thus get involved in inter-jurisdictional competition. For instance, in southern Catalonia, some cities lowered its environmental standards with the aim of attracting highly-polluting companies, and accepted a compensation from them to allow them to pollute and base their chemical plants in their jurisdiction. The latter turned out to attract several chemical companies that were considering to base their factories somewhere else in the region, and finally

[1] Environmental federalism is a subfield of economics intersecting public and environmental economics, and whose aim is to elucidate how law-giving power over environmental resources is distributed between national and subnational governments.

created a cluster.

As I stated above, previous research is inconclusive. On the one hand, there is a strand of theoretical literature that states that fiscal decentralization leads to a race to the bottom in which countries lower environmental regulations to attract international businesses, thereby increasing pollution (Duerksen, 1983). On the other hand, it has been reported in several empirical investigations that fiscal decentralization could instead lead to a race to the top or not-in-my-backyard phenomenon, where governments raise environmental regulations above the optimal level so as to discourage polluting firms from locating its production in their jurisdictions, and thus decreasing pollution levels (Potoski, 2001). See the literature review in Section 2 for a detailed discussion of the results obtained in previous research.

There are two points regarding environmental federalism worth mentioning. First, despite the evidence presented above, with results going in both directions, a quick look at the data employed in this paper, and specifically in Figure 1 and 2 in Appendix A, reveals that there is no strong positive or negative relationship between pollution levels and fiscal decentralization. Thus there is room to think that another factor is driving the direction of the effects. Second, the direct effect that institutions exert on pollution levels has previously been studied in several papers, and it seems clear that a higher quality of institutions leads to lower levels of pollutants. For example, Panayotou (1997) finds, for the case of SO2 levels, that pollution is lower when institutions display a higher quality; Barrett and Graddy (2000) report that countries presenting a better environmental quality are associated to both higher civil and political freedoms; Farzin and Bond (2006), and Li and Reuveny (2006) state that the level of different pollutants is lower in democratic countries; Damania et al (2003) and Welsch (2004) report in their seminal contributions that more corrupt countries are more willing to ease environmental regulations, thus leading to an increase in environmental degradation.

The last two points lead me to think that the quality of institutions might determine the direction of the effect that fiscal decentralization exerts on environmental pollution and therefore solves the puzzle, connecting both theoretical and empirical approaches, and respective results. Following Farzanegan and Mennel (2012), I hypothesize that (1) fiscal decentralization leads to a race-to-the-bottom and thus increases environmental pollution, and (2) the negative effect of the former on the latter is diminished when countries display high-quality institutions.

Nevertheless, in this paper it is shown that (1) the effect of fiscal decentralization on pollution may depend on the quality of institutions; and (2) fiscal decentralization leads to decreased environmental degradation when countries display high-quality institutions, and thus we find a race-to-the-top, whereas for low-quality institutions the opposite is true. These results hold for transboundary pollutants, but not for

local pollutants. The reason why the results obtained in this paper are different from Farzanegan and Mennel (2012) are twofold. First, endogeneity issues are not accounted for in the aforementioned paper. Second, the data employed are different: whereas only OECD countries are accounted for in this study, they use 80 countries from all over the world. A thorough discussion about it can be found in Section 3.

This empirical research paper is organized as follows. The literature review on Fiscal Federalism and Environmental Federalism will be presented in Section 2. Section 3 presents the model specification. Section 4 is devoted to explaining the data and variables employed in the empirical investigation. The data construction will be presented as well in this section. The estimation results employing the Ordinary Least Squares (OLS) estimator and the Generalized Methods of Moments (GMM) estimator are stated in Section 5. The latter will be followed by the presentation of some robustness checks in Section 6. Finally, the conclusions obtained are reported in Section 7, and the references used to carry out this paper are stated in Section 8. The appendix can be consulted in Section 8.

2 Literature Review

2.1 Fiscal Federalism

Fiscal federalism is a subfield of Public Economics aiming at developing theories on how to vertically organize government expenditure and taxation so as to illustrate which competences (expenditure side) and fiscal instruments (revenue side) should be provided by a centralized government, and which ones should be decentralized (Oates, 1999). Therefore, the most popular, well-established theories on fiscal federalism provide normative, conceptual guidelines on the role that different government levels should adopt, and the more suitable fiscal tools that should be employed so as to better carry out this role (Musgrave, 1959; Oates, 1972).

Since mid-twentieth century, a series of theories on fiscal federalism have emerged and enriched the debate on fiscal decentralization. This extensive literature on the field has typically analyzed the expenditure side, i.e. which level of government should provide the public good, and the revenue side, i.e. which level of government should finance the public good. The classic theories on fiscal federalism, and upon subsequent research on the field lies, were first formalized by Tiebout (1956), Musgrave (1959) and Oates (1972), and provide core principles on optimal decentralization theory.

First, Tiebout (1956) depicts a model in which consumer-voters are mobile and thus will move to the jurisdiction that best ensures that their preferences are fulfilled. This full mobility that consumers display reveal their preferences for public goods.

Therefore, the heterogeneous preferences of citizens are satisfied when sorting into jurisdictions in which local uniform taxes are set and preferences are homogeneous.

The inter-jurisdictional competition leads then to improved public good provision and adjusted tax rates. Following Tiebout's theory, Ferreira et al (2005) states that local governments compete to attract the aforementioned mobile taxpayers by creating appealing jurisdictional environments, both in terms of taxation and public good provision, i.e. by setting sensible, adjusted taxes that allow for correctly financing and providing high-quality public goods and services; and by easing regulations so as to reducing costs and the tax burden borne by firms, and hence attract these companies and thereby citizens from other jurisdictions.

Assuming full mobility of taxpayers could imply therefore that the benefits of decentralization do not apply to developing countries, since they are generally closed economies and in which mobility is very low. However, Gadenne and Singhal (2013) point out that fiscal decentralization lead to clear potential benefits, even if dwellers are not mobile, provided that taxpayers display heterogeneous preferences and there has been prior sorting into smaller jurisdictions with homogeneous preferences, and where asymmetric information exist in favor of local legislators.

Second, Musgrave (1959) develops a fiscal framework within fiscal federalism in which government's responsibilities were divided into three categories: macroeconomic stabilization, income redistribution and resource allocation. The latter one is of great interest here. Musgrave's framework assumes that the central government provides a uniform level of public good to everybody and puts forward two very important results: (1) fiscal decentralization leads to efficiency gains in public good provision, and (2) the introduction of local, or *impure*, public goods in the model demonstrates that the homogeneous provision of such goods leads to efficiency losses, i.e. when preferences across regions or jurisdictions differ, then decentralized provision of such goods must take place (Vo, 2010).

Third, Oates (1972) abstracts from taxpayer's mobility and asserts that publics goods that are either non-excludable or non-rivalrous, i.e. *impure* public goods, should be provided in a decentralized way since households display heterogeneous preferences. He states in his seminal contribution that given that the local and central government's cost of providing the public good do not differ, and its consumption is defined over geographical subsets of the entire population, there will be efficiency gains from decentralizing the public good provision, and thus leading to Pareto improvements. Therefore, unless economic agents display homogeneous preferences, the provision of public goods by a centralized government will yield inefficient outcomes.

He then associates the level at which the public good must be supplied with the level at which citizens benefit from it. That is, in the absence of spillovers, local

governments should provide those public goods the consumption of which exclusively benefits local taxpayers. However, if consumption and provision of a local public good generates spillovers to other jurisdictions, then the state or central government should take on the responsibility of supplying the public good centrally. Therefore, there seems to exist a trade-off between the existence of spillovers and the degree of fiscal decentralization (Oates, 1972).

These theories on fiscal federalism thus put forward several benefits for those countries which choose to decentralize (Hindriks and Myles, 2006; Yushkov, 2015). One of the arguments behind them is that state and local governments will be able to provide better goods and services to its citizens and find superior means to serve them, hence being able to provide different public goods that fulfill the heterogeneous preferences that taxpayers in different jurisdictions display, thereby increasing the so-called allocative efficiency of public goods provision. Furthermore, decentralization also leads to an increased productive efficiency because competition between subnational governments generally leads to providing public goods at a lower cost. However, it has also been reported that in case of economies of scale, a centralized public good provision could indeed be more efficient (Oates, 1999; Thiessen, 2003). Finally, horizontal and vertical fiscal competition are increased under decentralization, which may lead to preventing an ever increased size of the government, and the predatory incentives inherently associated to lawmakers (Brennan and Buchanan, 1980).

Fiscal decentralization may also present some drawbacks. Under excessive decentralization there might be conflicting interests between overpowering subnational governments, i.e. state or local governments, and central governments that have relinquished competencies to the former. This could therefore prevent two of the goals that, according to Musgrave (1959), the government should accomplish: macroeconomic stabilization and income redistribution (Prud'homme, 1995). In particular, under centralization, an inter-regional insurance is set, leading to better risk pooling, and therefore risk sharing. Moreover, Thiessen (2003) also points out that fiscal decentralization, in increasing horizontal competition among subnational governments, may lead to fiscal imbalances, and the default of more disadvantaged districts. It has also been reported that centralizing government activities may result in efficiency gains when there exists information disparities among voters and between jurisdictions due to a decrease in rent extraction (Boffa et al, 2016). Furthermore, it could also be argued that if local politicians are not competent enough, it might be better to centralize public good provision. Therefore, in countries in which the education level is low, and only a few are competent and educated, centralization could indeed be superior. Lastly, Oates (1972) states that optimal decentralization requires local and state governments to completely understand the effects that the decisions

taken in a given region exert on neighboring ones, i.e. internalizing externalities is imperative to achieve optimal decentralization outcomes.

Following the positive impact of fiscal decentralization suggested by both first and second-generation models of fiscal federalism, central governments in developed economies have opted to give up competences such as health, education or housing in favor of local governmental entities during the last decades. That is, a wave of decentralization has taken place with the intention to equip state and local governments with more public decision making capability, enabling them to develop and implement a diverse range of policies. For example, the US federal government has granted an increasing authority to federal states in terms of legal services and welfare among others; the United Kingdom provided Wales and Scotland with their own parliaments in 1998 (Oates, 1999); Germany's federal republic consists of sixteen different federal states, or the so-called *länders*; and similarly Spain presents seventeen autonomous communities and two autonomous cities that enjoy a high degree of competences in legal issues, education, welfare or health. Nevertheless, this is not a particular phenomenon to developed economies, but also to developing economies. Although the latter ones still display less decentralization than the former, especially on the revenue side, developing economies are converging towards the same or very similar decentralized models (Gadenne and Singhal, 2013). For example, China initiated its fiscal decentralization in 1980, allowing provincial governments to bargain with the central one about the amount of taxes and revenues that the former are allowed to collect and forward to the latter respectively (Ma 1995; Zhang and Zou, 2001; HE, 2015). Decentralization in Africa took place with the aim of resolving certain ethnic conflicts in very segregated societies, especially in former French and English colonies where extremely centralized governments that did not take into account local preferences were inherited. In Latin America, the movement towards decentralized governments was initiated as consequence of the political reforms that led the local population to demand greater accountability to its political leaders (Rondinelli et al, 1983; Shah, 2004).

Despite the evidence presented above about the trend toward decentralizing the public sector, there are two examples in Europe going in the opposite direction, which is especially true when it comes to the health sector. Denmark and Norway abolished the local counties in 2000 to reestablish regional governments that could no longer raise taxes, but were directly financed by the central government. The latter keeps track of the regional budgets and sanctions those regions that are not capable of keeping a balanced budget.[2]

[2]See the article *After decades of decentralisation, the state now has a growing role in Nordic health systems* by Richard Saltman, Karsten Vrangbaek, Juhani Lehto and Ulrika Winblad on Blogs LSE - http://blogs.lse.ac.uk/europpblog/2013/03/11/nordic-countries-health-care-

2.2 Fiscal decentralization and environmental pollution

Proponents of centralizing decisions on environmental policies at national levels have argued that letting this responsibility in the hands of subnational governments may lead to suboptimal outcomes for two reasons: (1) divergent environmental standards among regions may create trade distortions, and (2) inter-jurisdictional competition that ends up in a race to the bottom and higher-than-optimal pollution levels (Dalmazzone, 2006). Hence, the key point arguing for centralizing environmental legislative rights lies behind the externalities that may arise when subnational governments take decisions regarding the issue under consideration.

Following the second reason, the efforts made by local governments to attract capital and labor by means of lowering tax rates below their contenders may lead to deficient tax collection, thus depicting a race to the bottom in which local governments initiate a contest where the one that reduces the tax rate the most wins (Oates, 1999). The argument behind this is that an additional reduction in the tax rate will lead to a capital inflow from other jurisdictions. As a result of this race to the bottom, local governments experiencing insufficient tax collection and tight budgets may reduce their investment in environmental protection and thereby their efforts to keep under control pollution levels, thus leading to an increase in pollutants. Another collateral effect of this race to the bottom is thus that, in turn, it may lead to under-provision of public goods and services due to the fact that local governments do not have enough resources (Zodrow and Mieszkowski, 1986; Wilson, 1986; Wildasin, 1989; Kim and Wilson, 1997; Thomas and Thorsten, 2014).

On the other hand, under Oates framework, it seems that a centralized government cannot set an optimal environmental policy that is flexible enough in terms of stringency between jurisdictions because cross-regional variation is costly and the central government lacks perfect information on regional heterogeneous preferences. Hence, this model seems to encourage decentralization. The framework proposed by Oates does not though have a clear prediction on whether pollution increases or decreases with fiscal decentralization, but instead it points out that average pollution levels are dependent on whether the central government can correctly aggregate consumer-voter preferences across regions (Fredriksson et al, 2003).

Following the paper of Oates (1972), Banzhaf and Chupp (2012) state that subnational governments may better take into account the preferences associated to the citizens living in a given district, but may most likely disregard environmental spillovers to other jurisdictions. Furthermore, in their work it is also pointed out that although national, or central, governments are more prone to internalize the aforementioned spillovers, they do not possess enough information about heteroge-

decentralisation-state-crisis/

neous preferences displayed by inhabitants in different regions so as to carry out asymmetric environmental policies that account for them.

In a perfect world, based on free markets, no government intervention, perfect information and the nonexistence of market failures, state and local governments will optimally select the correct and optimal level of pollution, and decentralization will lead to an increase in welfare (Oates and Schwab, 1988, 1996). However, Oates (2002) states that in the existence of market imperfections, inter-jurisdictional competition may lead to either a race to the bottom or not-in-my-backyard phenomenon.

First, a race-to-the-bottom takes place either when regions seek to become more competitive with respect to other ones by lowering environmental standards, or when their economy is to a large extent dependent on polluting industries. Thus the race to the bottom could be seen as an example of the *Prisoner's Dilemma* where a suboptimal equilibrium is achieved given that jurisdictions could be on aggregate better off by at least keeping environmental standards instead of lowering them (Engel 1997; Levinson 2003; Potoski 2001; Woods 2006). Second, the not-in-my-backyard phenomenon appears in regions in which environmental standards are raised so as to repel companies or economic activities that would then pollute in the region (Potoski, 2001). Therefore, in the latter case, the damage is performed in neighboring regions and the one that raises the environmental standards free rides and takes advantage of the production taken place in subsequent polluted jurisdictions. Several studies support the existence of free riding (Gray and Shadbegian, 2004; Sigman, 2005; Lipscomb and Mobarak, 2011), whereas others assert there is no statistical evidence of such behavior within countries (Sigman, 2007; Konisky and Woods, 2010).

Furthermore, the aforementioned market imperfections leading to either a race to the top or bottom also imply the potential existence of environmental spillovers. Environmental spillovers are defined as the effects that decisions taken in a given jurisdiction produce on neighboring ones. They can be of different nature and may create for example trade distortions or an increase in pollution levels in neighboring regions. It may be argued that under a centralized government, negative environmental spillovers could be better contained because the central government might be able to observe the bigger picture and care more about the environment due to the fact that it does not need to get involved in inter-jurisdictional competition to attract companies and citizens. However, in a decentralized country, subnational governments engaging in inter-jurisdictional competition may disregard environmental considerations and display higher pollution levels due to their need to compete and attract resources to their districts, hence generating negative spillover effects in neighboring regions. Therefore, it seems clear that under the existence of high spillover effects, it may be better to centralize the legislative rights over environ-

mental protection, thus creating large homogeneous areas in terms of environmental legislation which let regions compete without using the environment to do so. This could prevent environmental inter-jurisdictional competition and thereby prevent environmental degradation.

Therefore, the race-to-the-bottom phenomenon happens when individuals do not increase their utility when levels of pollution decrease, whereas the not-in-my-backyard syndrome is inherently associated with jurisdictions in which the disutility from polluting is high enough so that polluting firms are to be expelled from the area by increasing the costs of polluting through increased environmental regulation (Markusen et al, 1995).

The not-in-my-backyard syndrome thus responds to the fact that some jurisdictions aggregately display preferences towards a greener economy with better air, environmental quality and health prospects. Therefore, when failing to relocate economic activity into other jurisdictions and thus free ride, subnational governments are incentivized to place highly polluting industries as close as possible to other jurisdictions, i.e. in the borders, so that the negative effects of pollution are borne by consumers in other regions (Helland and Whitford, 2003; Monogan III et al, 2017).

Although there is extensive research and a vast array of theoretical literature on the topic of environmental federalism pointing out that there might exist a race to the bottom, empirical evidence do indeed find no evidence of such behavior or the opposite. Some results are presented in the following lines.

Potoski (2001) finds no evidence supporting a race to the bottom in the US. He indeed reports that some states go beyond the minimum environmental regulations set by the United States Environmental Protection Agency (USEPA), hence supporting the race-to-the-top hypothesis. List and Gerking (2012) find no change in environmental quality after Reagan's reform in the eighties where he gave responsibilities back to the states, and specifically they assert that a race to the bottom did not happen in this period. Frediksson and Millimet (2002) provide empirical evidence supporting a race to the top among US States. Furthermore, in his study about the US, Millimet (2003) focuses on the years in which Reagan and Bush governed, and (1) supports the evidence presented by List and Gerking (2000), and (2) asserts that environmental decentralization led to a race to the top by mid-1980. Konisky (2007) finds empirical evidence indicating that states engage in strategic regulatory behavior but a strong support is not found for the existence of a race to the bottom. Sigman (2007) finds no evidence supporting the race to the bottom argument, though he states that it seems that decentralization does indeed lead to higher within-country variation in pollution. Kim (2011) is more skeptical about it and states that a conclusion on whether there is a race to the top or bottom cannot be reached without incorporating politico-economic factors to the analysis.

2.3 Institutions and the economy

Over the last decades, academic economists have reported several mechanisms through which institutions affect the economy. In the Introduction in Section 1, a series of papers on the effect that institutions exert on environmental pollution are reported. However, there are several mechanisms through which institutions, and their quality in particular, determine numerous economic outcomes. The aim of this section is thus to provide the reader with a little bit of background on institutions and the relationship between the later and economics.

North (1994) stated in his seminal contribution that neoclassical theory was not the right tool to assess how institutions shape the economy because it is concerned about the operations of markets, but not the development of them. Therefore, the new institutionalism was born to address the issue, and extend the economic science to a point in which institutions are in the center of the study. In this new setting, institutions are defined as "the social and legal norms that underlie economic activity" (Rutherford, 2001; Alston, 2008).

One of the mechanisms through which institutions affect economic growth is property rights. It is believed that the higher the property rights citizens enjoy, the higher the economic growth. The latter seems to be a result of stability and increased trust that lead citizens to invest and start businesses, and so increase economic welfare. Applying a historical perspective, North (2000) reports that restraining the power of the king in Britain, and delegating part of it in the Parliament, led to an increase in property rights protection, efficient market economy and thus economic prosperity. On the contrary, Spain did the opposite, and concentrated too much power in the king, setting a constrained economy in which freedom and property rights were poor, which prevented economic growth. The differentiated models seemed to apply to its respective colonies.

Democratic institutions seem to foster economic welfare and growth through several channels (Acemoglu et al., 2014; Gründler and Krieger, 2016). In particular, Acemoglu et al. (2014) state in their paper that "democracy increases future GDP by encouraging investment, increasing schooling, inducing economic reforms, improving public good provision, and reducing social unrest". However, there are also authors supporting the opposite (Barro, 1994; Pozuelo et al., 2016).

More specifically, the quality of institutions has also been reported to affect public budget composition. Hessami (2014), for example, report in his paper that as corruption increases, public funds are diverted to public expenditure categories characterized by being associated to low-competitive industries.

3 Model specification

The aim of the model that is presented below is to test whether fiscal decentralization leads to an increase in environmental degradation due to an increased inter-jurisdictional competition, i.e. a race to the bottom, and what is the role that institutions play in it. Therefore, the hypothesis I work with is that (1) fiscal decentralization leads to a a race to the bottom and thus increases environmental pollution, and (2) the negative effect of the former on the latter is diminished when countries display high-quality institutions. The hypothesis is tested for both transboundary and local pollutants such as CO2 emissions and SOx emissions respectively.

In a previous paper by Farzanegan and Mennel (2012), a similar model is estimated using the Ordinary Least Squares (OLS) estimator. This empirical strategy leads to biased and inconsistent estimations because endogeneity of fiscal decentralization arises due to reverse causality. Therefore, we only use the OLS estimator as a benchmark, and the preferred estimations in this empirical paper are based on the Generalized Method of Moments estimator (GMM) that panel data allows me to exploit.

The mechanism behind the possibility that fiscal decentralization is endogenous is, as previously stated, reverse causality. For example, carbon dioxide levels have increased about 30% since the commencement of the Industrial Revolution, and the natural levels of the latter pollutant over which it fluctuated for around 400.000 years were clearly surpassed by 1950 (IPCC, 2007). This triggered governments in developed countries to issue laws and spend resources aiming to contend pollution levels and, thus, finally reduce environmental degradation. It can be argued then that environmental pollution produces an increase (or decrease) in fiscal decentralization given that the latter is the natural response for governments when they aim at preserving the environment or, on the contrary, that fiscal decentralization produces the decrease (or increase) in pollution as (sub)national governments could provide better environmental quality. Therefore the direction of the effects is not crystal clear and endogeneity could arise. Furthermore, it has also been stated in the literature regarding the Environmental Kuznets Curve cited in Section 4 that the stage of development, i.e. income, could also be endogenous due to, again, reverse causality.

The panel data at hand allows me to address several shortcomings of cross-sectional data and the OLS estimator in the field under investigation. First, panel data allows for controlling unobserved country and time-specific characteristics, whereas the use of cross-sectional data leads to the so-called omitted variable bias due to the fact that institutional and cultural characteristics are not appropriately accounted for in the latter case. Second, panel data allows for successfully capi-

talizing on the differences that the twenty-six countries accounted for in the study display in their degrees of fiscal decentralization. Finally, it has previously reported that endogeneity of fiscal decentralization and income might most likely arise due to reverse causality. However, the latter can easily be dealt with when employing panel data and the system GMM estimator (HE, 2015).

The model specification is presented below in Equation 1:

$$POLLUTION_{it} = \alpha_i + \beta_1 DEC_{it} + \beta_2 CPI_{it} + \beta_2 DEC * CPI_{it} + X\beta_{it} + \gamma_t + \varepsilon_{it} \quad (1)$$

where POLLUTION is the dependent variable (CO2 and SOx), α_i is the constant or intercept, DEC_{it} refers to either of the fiscal decentralization measures presented above, CPI_{it} is the Corruption Perception Index, the third term $DEC*CPI_{it}$ is the interaction term that will allow for correctly estimating the role of institutions on the matter, X_{it} represents a series of control variables employed in the estimation, γ_t are time dummies that will be employed in some occasions, and ε_{it} is the error term, where $i = 1, 2, ..., n$, $t = 1, 2, ..., T$ and $\varepsilon_1, \varepsilon_2, ..., \varepsilon_n$ are IID $(0,\sigma^2)$.

The GMM approach allows me to exploit the fact that the number of moment conditions is larger than the parameters to be estimated. Typically this would lead to finding no solution for the system of equations determining the different coefficients. However, the GMM estimator handles this problem by weighting the moment conditions, i.e. it gives less weight to those with more variance and more weight to those with less variance. Therefore, this characteristic feature of GMM allows me to use several instruments and obtain powerful estimations. For the purposes of this study, I will generally use all covariates and two to three lags of the dependent variable as instruments in every econometric specification unless stated differently.

This empirical strategy is of course not exempt of potential shortcomings. In panel data, as stated above, there is typically an excess of moment conditions available for instruments because the time variation of the variables results in an abundance of instruments. Therefore, the natural question that arises in this context is: what if the model is overidentified? In order to resolve this problem and make sure my estimations are valid, I test the validity of the overidentifying restrictions by means of the J-Statistic or Hansen Statistic and report it after each estimation performed (Verbeek, 2012). The results of this test are presented in Appendix B for all regressions performed in this paper.

4 Data

The data set comprises annual data for 26 OECD countries, namely Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Israel, Italy, Japan, South Korea, Latvia, Luxembourg, Netherlands, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Turkey, United Kingdom and United States. The sample covers the years from 1995 to 2013.

Data employed in this paper are presented below. A brief explanation of the variables used, definitions, measurement and source of each variable are presented in Table 1. Moreover, descriptive statistics are presented in Table 2.

Finally, in Subsections 4.1, 4.2, 4.3 and 4.4, an explanation of the dependent variable (CO2, and SOx), independent variables measuring the degree of fiscal decentralization (DEC1, DEC2 and DEC3), institutional quality (CPI) and the interaction between the former and the latter, and control variables (GDP, DEN, IDEO, ENERGY and URBAN) is given.

4.1 A measure of environmental pollution

The proxy employed for environmental quality is carbon dioxide (CO2) and sulfur oxide (SOx) emissions. Whereas the former is a transboundary pollutant, the latter is a local pollutant.

CO2 is classified as a transboundary pollutant and the Safe Drinking Water Foundation (SDWF) [3] describes it as "(...) pollution that originates in one country but is able to cause damage in another country's environment, by crossing borders through pathways like water or air", and further adds "one of the problems with transboundary pollution is that can carry pollution away from a heavy emitter and deposit it onto a nation whose emissions are relatively low".

SOx is a local pollutant and is a series of compounds of sulfur and oxygen molecules. It is classified as local because it concentrates near soil level and is not generally carried away and deposited in other regions other than the one it is produced in (World Bank, 1998).

The per capita emissions of carbon dioxide, denoted by CO2, and the per capita emissions of sulfur oxide, denoted by SOx, both measured at the country level, are employed here as measures of environmental pollution in the estimations presented in Section 5.

In case a race to the top is found, it is expected that CO2 and SOx emissions decrease as the degree of fiscal decentralization is raised. Therefore a negative sign on the coefficient associated to them would be expected. However, if a race to the

[3] See https://www.safewater.org/fact-sheets-1/2017/1/23/transboundary-pollution

Table 1: Data definitions and sources

Variable	Definition	Measurement	Source
CO2	Carbon dioxide. Transboundary pollutant	Tonnes per capita	OECD
SOx	Sulfur oxide. Local pollutant	Kilograms per capita	OECD
DEC1	Total local government expenditure over total aggregate government expenditure	Percentages	OECD National Accounts Database, own calculation
DEC2	Local government expenditure on environmental issues over aggregate total government expenditure	Percentages	OECD National Accounts Database, own calculation
DEC3	Local government expenditure on environmental issues over aggregate government expenditure on environmenal issues	Percentages	OECD National Accounts Database, own calculation
CPI	Corruption Perception Index	Index: 0 = not corrupt, i.e. high-quality institutions; 10 = very corrupt, i.e. low quality institutions	Transparency International
GDP	GDP per capita	GDP per capita PPP in natural logarithms	OECD, own calculation
DEN	Population density	Population density divided by 10	World Bank, own calculation
IDEO	Ideology of leading party in government	Index: -5 = extreme left-wing government; 5 = extreme right-wing government	Döring and Manow (2011), Parliament and government composition database (ParGov); data for the US is from Benoit and Laver (2006)
ENERGY	Energy use	Kilograms of oil equivalent per capita	IEA Statistics © OECD/IEA 2014
URBAN	Urban Population over total population	Percentages	United Nations, World Urbanization Prospects; IMF.

Table 2: Descriptive Statistics

Variable		**Mean**	**Std. Dev.**	**Min**	**Max**	**Observations**
CO2	overall	8.852	3.961	2.5	24.6	N = 494
	between		3.929	3.253	20.495	n = 26
	within		0.898	5.157	12.957	T-bar = 19
SOx	overall	8.753	2.221	0.647	11.839	N = 494
	between		0.939	6.61	10.902	n = 26
	within		2.02	1.175	11.274	T = 19
DEC1	overall	21.159	9.652	4.713	47.221	N = 433
	between		9.468	9.567	43.904	n = 24
	within		2.366	7.868	31.555	T-bar = 18.042
DEC2	overall	0.979	0.589	11.495	2.675	N = 433
	between		0.589	0.101	2.352	n = 24
	within		0.182	0.18	2.05	T-bar = 18,041
DEC3	overall	62.267	18.182	12.603	113.181	N = 433
	between		16.779	31.493	85.798	n = 24
	within		7.806	34.418	103.933	T-bar = 18.042
CPI	overall	3.378	2.129	0	10	N = 494
	between		1.888	0.516	6.51	n = 26
	within		1.046	1.509	11.345	T-bar = 19
GDP	overall	10.329	0.421	9.005	11.406	N = 494
	between		0.403	9.536	11.244	n = 26
	within		0.145	9.759	10.734	T = 19
DEN	overall	14.583	11.739	1.193	49.909	N = 484
	between		11.998	1.272	47.978	n = 26
	within		0.853	8.763	20.383	T-bar = 18.615
IDEO	overall	0.349	1.841	-5	3.3	N = 494
	between		1.308	-5	2.035	n = 26
	within		1.319	-2.582	4.112	T = 19
ENERGY	overall	40.775	16.233	10.52	94.189	N = 493
	between		16.29	12.835	81.086	n = 26
	within		2.87	29.875	53.878	T = 18.961
URBAN	overall	74.428	11.439	49.764	97.776	N = 484
	between		11.403	50.433	97.313	n = 26
	within		2.044	66.158	82.684	T = 18.961

bottom is to be found, then pollution levels would increase as a response to fiscal decentralization. So a positive sign on the associated coefficient would be expected in this case. Further notice, though, that the direction of the effects will be partially determined by institutions. In both cases, in a race to the top or bottom, it is expected that the quality of institutions mitigate the effects that fiscal decentralization exerts on environmental pollution. For example, if fiscal decentralization leads to a race to the bottom, then I would expect that the increase in pollution will be lower for countries with a higher quality in their associated institutions. I would also expect for institutions to determine the direction of the effects that fiscal decentralization exerts on environmental pollution, i.e. that either finding a race to the top or bottom is a result of institutional quality.

4.2 A measure of fiscal decentralization

In order to construct the different measures of fiscal decentralization employed in this paper, I use data from the OECD National Accounts database. This database gives access to ten expenditure types, namely social protection, health, education, defense, general public services, public order and safety, economic affairs, housing and community amenities, environmental protection, and recreation, culture and religion for different government levels (national, state, local, and social security). Therefore, the fiscal decentralization measures employed in this paper are all regarding the expenditure side.

The reason not to include any decentralization measure regarding the revenue side lies behind the fact that I find it very difficult to measure the effects that the government, and fiscal decentralization in particular, exert on environmental pollution through the collection of taxes. Although taxation on highly-pollutant activities and businesses such as owning a diesel car, fossil fuels or chemical companies among others has typically been one of the means through which governments try to protect the environment, it may be argued that it is very difficult to know (1) what the actual effect of these green taxes is on environmental degradation at the aggregate level, (2) how much taxes are collected regarding the matter under investigation, (3) at what level taxes are collected and who actually dictates or decides them, and (4) what the governments do with these taxes, whether they actually do protect the environment or they are used for other purposes, such as unemployment benefits or education for example. On the contrary, the data about government expenditure on environmental issues is available and I therefore know how much resources are employed to actively face environmental pollution. Furthermore, it may be argued that taxation, i.e. the revenue side, could be more suitable to study more global problems, and expenditures could be preferred when focusing on more local issues,

an argument that reinforces the aforementioned statements. Hence, it seems clear then that if fiscal decentralization affects pollution levels, the effects can be better studied through how the government (locally or centrally) spends part of its budget on environmental protection.

First, DEC1 is constructed by adding up the ten expenditure types at the local government, and then dividing it by total aggregate [4] government expenditure as a whole. Second, a subsequent fiscal decentralization measure employed is DEC2. In that case, I use local government expenditure on environmental protection over total aggregate government expenditure. Finally, I employ DEC3, which is calculated as government expenditure on environmental protection at the local level over total aggregate government expenditure on environmental protection.

The reason behind the use of three measures to proxy fiscal decentralization lies behind the large amount of countries in the dataset employed in this paper. Other papers have focused on a single country, like the US for example, and have carried out empirical investigations on how fiscal decentralization affects environmental pollution. Focusing only on one country allows the researcher to fully understand the environmental protection laws, and at what level decisions regarding the matter under investigation are taken, i.e. local, state or central government. In that case, more proper measures of fiscal decentralization can be adopted. For example, in a country in which decisions regarding environmental protection are taken at the state level, then a measure of fiscal decentralization at that level would be more suitable. Nevertheless, in this empirical paper, twenty-six countries are taken into account. This does not allow me to use a measure for fiscal decentralization that fully and successfully suits every country accounted for here. Therefore, it is assumed in this paper that every country sets its environmental policies at the same government level, i.e. at the local level.

A close look at the OECD National Accounts database reveals that the majority of countries in the OECD spend most of their resources on environmental protection at the local government. In the case of the US, for example, environmental policies are, as stated previously, decided in a decentralized way. On the other hand, environmental protection guidelines in the European Union are largely homogenized and set at the EU level. However, countries that are part of the union decide how to apply these rules, and in particular, some of them let their local governments decide their own policies. Although they have to comply with the EU standards, it has been reported that compliance is indeed a problem and local governments do not fully act accordingly (Jordan, 1999; Knill and Lenschow, 2005; Mastenbroek, 2006). Furthermore, descriptive statistics presented in Table 2 reveal that, on average, sixty

[4] Aggregate government expenditure refers to government expenditure as a whole, i.e. including expenditure made by local, state and national government, and the social security

percent of the total budget regarding environmental protection is spent by local governments in the OECD. Therefore, it seems reasonable to use local government expenditure in order to construct the decentralization measures employed in this paper, and hypothesize that resources spent by local governments in environmental protections go in hand with how free they are to decide and apply environmental policies.

4.3 A measure of institutional quality

As a proxy for institutional quality, the Corruption Perception Index (CPI) from Transparency International is employed. The inclusion of this measure, and its interaction with the fiscal decentralization measures presented above, allows me to study the effects that institutions exert on environmental pollution through fiscal decentralization.

The fact that this index is made through different surveys among international business people, expatriates, local residents and risk analysts, reflexes its subjective nature. The data clarify that the least corrupt countries are the Nordic ones whereas the most corrupt ones are located along the Mediterranean Sea. Furthermore, it may be seen that the CPI presents a high cross-country variation whereas the opposite is true within countries. However, all countries exhibit variation over time.

Although there are several measures to proxy the quality of institutions, and subjective indicators may present weaknesses, the use of the CPI seems vindicated. Following Hessami (2014), data on corruption-related prosecutions is not a better indicator as it depends on the effectiveness of law enforcement and not always reflects political rent creation and extraction. Moreover, the different surveys employed to construct this index correlate with one another (Lambsdorff, 2005); ideological biases in corruption ratings are reported to be insignificant (Kaufmann et al., 2004); and the CPI is considered to provide year-to-year comparisons given that changes in the sources on the CPI estimates provide small effects, even when sources are not the same in different years (Lambsdorff, 2004).

4.4 Control variables

There is no clear agreement on the determinants of environmental pollution other than income (HE, 2015). However, besides controlling for the logarithm of real GDP per capita in PPP (GDP) as a proxy for income, as stated in the beginning of section 4, and following recent literature on the topic under investigation, I control for population density (DEN), the ideology of the leading party in government (IDEO), energy consumption (ENERGY), and the percentage of urban population (URBAN).

First, the literature regarding environmental economics has come to the conclusion of the existence of the environmental Kuznets curve (EKC hereafter), which states that there exists an inverted-U shape relationship between environmental pollution and per capita income (Selden and Song, 1994; Grossman and Krueger, 1994; Smulders and Bretschger, 2000; Stern and Common, 2001; Kelly, 2003; Lieb, 2004; Dinda, 2004; Chimeli and Braden, 2005; Shen, 2006; Song, Zheng, and Tong, 2008; and Brock and taylor, 2010). Therefore, I include GDP and its square to capture these non-linearities as control variables.

Second, it has also been reported that population density may be one of the reasons behind the increase in environmental pollution. In particular, Cole and Neuamayer (2004), in a paper about the impact of demographic factors on air pollution, and Marc and Ajmad (2016) find that the higher the population density the larger damage to the environment, i.e. the larger the environmental degradation. For this reason, DEN is included in the model specification. Notice, though, that I scale population density when dividing it by ten.

Third, there seems to be a strong correlation between ideology and the attitudes toward environmental preservation and support. Several studies report that whereas individuals supporting left-wing governments are more concerned about the environment and plead for the protection of it, right-leaning dwellers generally display a higher apathy and less support to environmental protection than their counterparts (Forgas and Jolliffe, 1994: Neumayer, 2004; Blankenau et al., 2008; Hamilton et al., 2010; Nawrotzki, 2012). Hence, I think it is reasonable to extrapolate the latter to governments. If individuals who support left-wing parties are more environmentally concerned, then left-wing governments will also display higher preferences for a green, clean, environmentally-friendly economy; and the same logic applies to right-wing governments. Therefore, I include the ideology of the main party in government (IDEO) in the model specification as a control variable.

Fourth, it seems clear that energy consumption affects environmental degradation. It has been reported in the existing literature that energy consumption leads to an increase in pollution (Soytas, Sari and Ewing, 2007; Marc and Ajmad, 2016; Saboori and Sulaiman, 2013; Mobeen Ur and Mushab, 2017; Rehman and Rashid, 2017). I then include energy consumption (ENERGY) as a subsequent control variable in this study.

Finally, over the last decades the developed world, in particular, has experienced a burgeoning urbanization. The increased urbanization produced an increase in goods and services related to transportation, which in turn leads to an increase in fossil fuel consumption, and therefore an increase in environmental degradation (Panayotou, 1997; Deshpande and Mishra, 2007). However, Martínez-Zarzoso (2008) state in her paper that the effects of urbanization on CO2 pollution depend

on the stage of development. In particular, for developed, high-income countries like the ones in the OECD, urbanization leads to a decrease in CO2 emissions.

5 Estimation results

The results for the baseline estimations are reported in Table 3 and 4. In total, twenty-four regressions are presented, of which regressions 1 to 12 in Table 3 employ as a dependent variable a measure of transboundary pollution, such as CO2 emissions. Subsequent regressions presented in Table 4 regard estimations in which a local pollutant, such as SOx, is taken into account as a dependent variable. Furthermore, for each type of pollutant, three different measures for fiscal decentralization are employed (DEC1, DEC2 and DEC3). Which measure is employed in each baseline regression is indicated below the number of the estimation, and each of them is separated by vertical, black lines in Table 3 and 4.

First, estimation results for transboundary pollution, using CO2 emissions as a dependent variable, are presented in Section 5.1. Second, estimation results regarding the effects of fiscal decentralization on local pollution are displayed in Section 5.2.

5.1 Transboundary pollution

The estimation results in Table 3 consistently suggest, across different specifications and measures of fiscal decentralization, that fiscal decentralization leads to a decrease in CO2 emissions if countries display high-quality institutions. However, in those countries presenting institutions whose quality is poor, CO2 emissions increase when subnational governments obtain more decision making capabilities. In particular, the estimation output for regressions (4), (8) and (12), which are estimated using GMM and DEC1, DEC2 and DEC3 respectively, reveal that for those countries displaying institutions whose CPI -the proxy for institutional quality- is higher than 2'4783, 2'816 and 3'26 respectively, an increase in fiscal decentralization leads to an increase in transboundary pollution levels. Therefore, in the case in which the institutional framework is weak, fiscal decentralization will lead to a race to the bottom in which interjurisdictional competition aiming at attracting economic agents will turn out to reduce environmental standards set by subnational governments, and therefore increase transboundary pollution. On the contrary, if the CPI is below the aforementioned figures, an increase in fiscal decentralization produces a race to the top in which environmental standards are raised, and thereby transboundary pollution is reduced.

Table 3: Transboundary pollution (CO2): OLS and GMM estimation results

VARIABLES	(1) DEC1	(2) DEC1	(3) DEC1	(4) DEC1	(5) DEC2	(6) DEC2	(7) DEC2	(8) DEC2	(9) DEC3	(10) DEC3	(11) DEC3	(12) DEC3
DEC	-0.226***	-0.0934***	-1.579***	-2.342***	0.759*	-2.485***	-60.34**	-19.83***	-0.0647***	-0.0970***	-1.708***	-0.596***
	(0.0276)	(0.0225)	(0.142)	(0.738)	(0.447)	(0.456)	(24.73)	(2.359)	(0.0179)	(0.0133)	(0.346)	(0.0655)
CPI	-2.371***	-0.722***	-16.68***	-25.33***	-1.043***	-1.262***	-22.41***	-8.164***	-1.680***	-1.875***	-29.70***	-12.29***
	(0.248)	(0.222)	(1.597)	(8.834)	(0.155)	(0.182)	(8.510)	(0.981)	(0.286)	(0.263)	(6.202)	(1.370)
DEC*CPI	0.0652***	0.0293***	0.641***	0.945***	0.334**	1.106***	23.71**	7.041***	0.0174***	0.0288***	0.500***	0.183***
	(0.00947)	(0.00748)	(0.0657)	(0.320)	(0.139)	(0.137)	(9.385)	(0.816)	(0.00463)	(0.00359)	(0.105)	(0.0199)
GDP		-47.96***		61.71	10.10***	-112.4***		-437.2***		-99.46***		-369.5***
		(11.30)		(76.16)	(0.487)	(12.66)		(45.70)		(12.03)		(37.14)
GDP2		2.313***		-3.504		5.427***		21.06***		4.790***		17.58***
		(0.548)		(3.683)		(0.612)		(2.190)		(0.579)		(1.764)
DEN		0.0710***		-0.152		0.128***		0.486***		0.118***		0.290***
		(0.0113)		(0.0975)		(0.0143)		(0.0498)		(0.0112)		(0.0307)
IDEO		0.172***		1.563***		0.311***		1.016***		0.176***		0.248
		(0.0630)		(0.563)		(0.0595)		(0.227)		(0.0586)		(0.154)
URBAN		-0.0372***		-0.00598		-0.0836***		-0.335***		-0.0665***		-0.180***
		(0.0129)		(0.0835)		(0.0131)		(0.0420)		(0.0120)		(0.0287)
ENERGY		0.172***		0.0580		0.149***		0.0149		0.158***		0.0851***
		(0.0129)		(0.121)		(0.0124)		(0.0318)		(0.0124)		(0.0303)
Constant	16.87***	254.0***	54.83***	-183.5		591.1***	61.76***	2,314***	14.53***	527.3***	110.4***	1,994***
	(0.809)	(58.57)	(3.927)	(385.0)		(66.16)	(20.76)	(243.0)	(1.113)	(63.17)	(20.43)	(199.4)
Observations	421	403	390	390	421	403	406	390	421	403	404	372
R-squared	0.233	0.614			0.198	0.664			0.148	0.656		
GMM	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Local pollution (SOx): OLS and GMM estimation results

VARIABLES	(13) DEC1	(14) DEC1	(15) DEC1	(16) DEC1	(17) DEC2	(18) DEC2	(19) DEC2	(20) DEC2	(21) DEC3	(22) DEC3	(23) DEC3	(24) DEC3
DEC	0.0145	-0.0252	0.533**	0.904	-0.621*	-1.053**	-28.50	-11.16*	-0.0258**	-0.0342**	-0.650	-0.294**
	(0.0200)	(0.0226)	(0.272)	(0.870)	(0.317)	(0.490)	(41.35)	(6.180)	(0.0124)	(0.0141)	(0.470)	(0.139)
CPI	0.319*	-0.232	5.831**	9.940	-0.0873	-0.555***	-10.37	-4.749*	-0.283	-0.696**	-10.77	-6.129**
	(0.181)	(0.224)	(2.906)	(9.625)	(0.110)	(0.202)	(15.12)	(2.517)	(0.196)	(0.280)	(7.828)	(2.965)
DEC*CPI	-0.0147**	-0.00399	-0.245**	-0.381	0.114	0.280*	11.40	3.829*	0.00491	0.00678*	0.187	0.0862**
	(0.00706)	(0.00759)	(0.121)	(0.358)	(0.102)	(0.152)	(16.61)	(2.170)	(0.00320)	(0.00382)	(0.136)	(0.0432)
GDP		7.219		-20.38		-9.570		-212.3*		-2.043		-132.7*
		(11.14)		(43.43)		(13.97)		(113.3)		(12.91)		(76.14)
GDP2		-0.381		1.208		0.441		10.17*		0.0752		6.261*
		(0.540)		(2.253)		(0.674)		(5.435)		(0.621)		(3.599)
DEN		-0.0159		0.0787		0.0151		0.229*		0.00444		0.0978*
		(0.0111)		(0.0867)		(0.0152)		(0.126)		(0.0117)		(0.0507)
IDEO		-0.120*		-0.493		-0.0618		0.254		-0.0914		-0.00151
		(0.0634)		(0.387)		(0.0640)		(0.238)		(0.0639)		(0.110)
URBAN		-0.0171		-0.0674		-0.0410***		-0.184**		-0.0314**		-0.0993***
		(0.0130)		(0.0538)		(0.0140)		(0.0838)		(0.0128)		(0.0361)
ENERGY		-0.0266**		0.0403		-0.0309**		-0.113**		-0.0317**		-0.0653**
		(0.0127)		(0.0710)		(0.0132)		(0.0521)		(0.0131)		(0.0276)
Constant	8.260***	-21.02	-5.952	65.25	9.186***	66.42	32.55	1,143*	10.21***	28.33	46.37*	740.3*
	(0.586)	(57.80)	(7.453)	(194.5)	(0.343)	(73.14)	(34.62)	(603.0)	(0.765)	(67.90)	(27.21)	(413.8)
Observations	412	394	390	378	412	394	385	378	410	392	392	352
R-squared	0.017	0.094			0.011	0.087			0.011	0.091		
GMM	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Further notice that the magnitude of the marginal effect of increasing the degree of fiscal decentralization on CO2 emissions depends on the quality of institutions, i.e. the lower the quality of institutions (the higher the CPI), the larger the increase in CO2 emissions as a response to an increase in fiscal decentralization. To illustrate this, let's consider the case of three hypothetical countries where one of them displays a CPI=0, i.e. institutions of the highest quality; the second displays a CPI=5, i.e. institutions of a medium quality; and finally, the third country's associated quality of institutions is very poor, i.e. CPI=10. The marginal effects calculated here are associated to regression (12), and therefore DEC3 is used as a proxy for fiscal decentralization. Hence, a 1% increase in fiscal decentralization leads to an annual (1) decrease of 0,596 tonnes of CO2 per capita when CPI=0, (2) increase of 0,319 tonnes of CO2 per capita when CPI=5, and (3) increase of 1,234 tonnes of CO2 per capita when CPI=10. The two last points clearly depict that the race to the bottom generated by increases in fiscal decentralization, and therefore interjurisdictional competition, intensifies and is exacerbated when institutions are of low quality.

The results from the baseline regressions for transboundary pollutants explained above seem to be sensible, and could be explained by two reasons. First, countries whose institutions are mature, and therefore of high quality, will probably care about environmental protection and be more aware of the spillover effects that environmental pollution creates in neighboring regions, compared to countries displaying low-quality institutions. Hence, these institutions will internalize this negative spillovers and try to protect the environment by raising environmental standards and issuing laws to preserve it. Second, it could also be argued that countries displaying high-quality institutions may also be associated with dwellers that are more concerned about sustainability or the effect that environmental pollution exerts on their health. This may be particularly true in the last years, where the so-called millenials, a generation that has shown to care about it more than previous generations, are changing market habits and representing a larger share in the consumer base.[5] Therefore, subnational governments, in an attempt to attract individuals complying with these characteristics, could raise environmental standards to repel polluting activities into other jurisdictions, and therefore decrease transboundary pollution.

The coefficients associated to the three different measures of fiscal decentralization, and the interaction term with the proxy for the quality of institutions are statistically significant in every specification -generally at the 1%- and consistent across the twelve different specifications, using both the OLS and GMM estimators.

[5] See https://www.ecowatch.com/millennials-climate-change-2482557556.html and https://www.credit-suisse.com/corporate/en/articles/news-and-expertise/millennials-drive-sustainability-201702.html.

Further notice that the introduction of control variables does not change the direction of the effects, i.e. the sign of the coefficients associated to the explanatory variables (DEC and DEC*CPI), but only the magnitude of the effect. That is, the direction of the effects is the same across the different specifications, with only the exception of regression (5), which is estimated with OLS and control variables are not included. This clearly manifests the fact that the results showed in this section for transboundary pollutants are robust and consistent, and they will be reinforced in Section 6 when a series of robustness checks are presented.

Control variables employed in the different specifications presented in Table 3 behave, generally, according to what previous literature in the field has stated (see Section 4). First, across the twelve regressions presented GDP and GDP2 depict the aforementioned inverted-U shape relationship between income and environmental pollution, hence reinforcing the existence of the so-called EKC. Second, the coefficient associated to density (DEN) is statistically significant across regressions (1) to (12) and the sign of the effect is positive, except in regression (4), thus complying with the literature presented above. Third, the variable associated to the ideology of the main party in government (IDEO), in line with the arguments presented before, exerts a positive effect on environmental degradation, i.e. right-wing governments display less support and concern towards environmental protection than their left-wing counterparts and thus lead to higher transboundary pollution levels. Fourth, energy consumption leads to an increase in environmental pollution, also in line with previous empirical investigations, and the coefficient associated to ENERGY is therefore positive, statistically significant in regressions (2), (6), (10) and (12). Finally, the coefficient associated to URBAN is statistically significant in every specification except (4), it is negative and indicates that the higher the urbanization levels, the lower the CO2 emissions, thus complying with Martínez-Zarzoso (2008).

5.2 Local pollution

The estimation results presented in Table 4 regarding the effects of fiscal decentralization on local pollution are clearly not strong and robust enough to assert that there indeed exists a solid, convincing relationship between them.

First, regressions (13) to (16), which are carried out employing DEC1 as a proxy for fiscal decentralization, display opposite signs in the variables of interest with respect to the ones in regressions (17) to (24), when DEC2 and DEC3 are used respectively. Second, it may be appreciated in regressions (15) and (16), using DEC1 and estimating the model by means of the GMM estimator, that whereas the independent variables display statistically significant coefficients at the 5% in the first case, it seems to be no longer true in the second case when control variables

are added to the estimation.

On the other hand, regressions (20) and (24), employing DEC2 and DEC3 respectively as a proxy for fiscal decentralization, and both using the GMM estimator and control variables, display statistically significant covariates at the 10% and 5% respectively, and the signs resemble the ones obtained for transboundary pollutants in Table 3. These two regressions might indicate thus that fiscal decentralization, and institutions through the effect on the latter, exerts the same effects on local pollution as on transboundary pollution. However, I think that the results obtained are statistically weak and solid empirical evidence across specifications is not found to strongly claim it is true.

The reason behind the weak results obtained when evaluating the effect of fiscal decentralization on local pollution may lie behind the fact that spillover effects associated to local pollutants are smaller than the ones associated to transboundary pollutants such as CO2. The spillover effects produced by local pollutants are shorter compared to the ones created by transboundary pollutants because the former form of pollution is deposited in the same place where it is produced, and it is believed not to move to other areas. Therefore, it seems reasonable to think that if environmental spillovers are small, or even non-existent, fiscal decentralization will not lead to either a race to the top or bottom because environmental pollution in this case becomes an internal jurisdictional matter. There is then less room for the free-riding behavior explained in Section 2.2, or interjurisdictional competition in this case.

The neglecting effect that fiscal decentralization exerts on local pollution and the small environmental spillover effects created by local pollutants may indicate that there could be other politico-economic factors that explain why local pollution is produced. In fact, it seems reasonable to think that if spillover effects are not present, and therefore interjurisdictional competition is no longer happening in the context of local pollution, the quality and development of the country should dictate the behavior of its associated institutions towards environmental local pollution. The results presented in Table 4 could point out that institutions alone could indeed play a major role on local pollution. On the one hand, regressions (13) and (15) show through the coefficients associated to CPI that the quality of institutions exerts a positive effect on local pollution, i.e. the lower the quality of institutions, and so the higher the CPI, the higher the local pollution. According to these estimation results, it may be argued that governments in countries in which institutions are of less quality may neglect the environment and therefore they may not be protecting it, thus leading to higher local pollution levels. On the other hand, regressions (18), (20), (22), and (24) predict the opposite: countries displaying low-quality institutions also present lower levels of environmental local pollution. A possible argument for this fact is that low-quality institutions, in being generally associated to for ex-

ample higher corruption among others, repel international companies, investments, and economic activity, thereby leading to a decrease in pollution. Both arguments presented here could be valid hypotheses in this case. However, I think that the model specification employed in this empirical investigation is not a proper one for this purpose due to the inclusion of interaction terms with fiscal decentralization. Furthermore, the first argument could be more suitable for developed economies and the second one for developing ones.

The analysis of the coefficients associated to the control variables included in the estimations also reflects the possibility that the results are not clear or precise. Whereas the signs of the parameters associated to the covariates GDP, GDP2 and DEN comply with what previous literature has reported (see Section 4.4), the ones related to IDEO, ENERGY and URBAN do not. Previous literature in the field has shown that right-wing dwellers (and by extrapolation, right-wing governments), energy consumption and the degree of urbanization may lead to increases in environmental pollution. However, the estimations performed when employing SOx as a dependent variable show that they instead decrease local pollution. Therefore, it seems reasonable to assert that the contradicting parameters found reinforce that the estimations performed and results presented in this section for the case of local pollution are not conclusive.

Therefore, given that the estimation results presented in Table 4 are not constant, conclusive, empirically strong across specifications, and in light of the robustness checks presented in Table 6 in Section 6, I think there is not solid empirical evidence to assert that fiscal decentralization exerts a clear effect on local pollution levels in OECD countries.

6 Robustness Checks

In order to reassure and confirm the results obtained in Section 5, a series of robustness checks have been performed and are presented in Tables 5 and 6 below. They are carried out by estimating the model specification presented in Section 3 adding time and country fixed effects, using the differences in the variables from one period to another, and finally adding the lag of the dependent variable and estimating the model by System GMM. Furthermore, notice that, for the sake of brevity, every robustness check performed in this paper is done by using DEC1.

Time fixed effects are employed when estimating regressions (25), (26), (33) and (34). It may be seen that the results obtained in the previous section remain. In the case of transboundary pollution -see regressions (25) and (26)-, fiscal decentralization continues to lead to a race to the top in which transboundary pollution is

decreased when institutions display a higher quality. Furthermore, for the case of local pollution in regressions (33) and (34), the coefficients associated to the independent variables are not statistically significant, showing again the neglecting effects of fiscal decentralization on local pollution levels.

I further employ country fixed effects for the case of transboundary pollution in regressions (27) and (28), and local pollution in regressions (35) and (36). Although the signs associated to DEC1 and DEC1*CPI are the opposite as what has been previously found in regression (27) when no control variables are employed, the signs remain the same when adding them. Thus reinforcing the results previously obtained though the coefficients are not strongly significant. For the case of local pollution in regressions (35) and (36), it is again documented that there seems to be no relationship between fiscal decentralization and environmental pollution.

Another robustness check carried out in this section is presented in equations (27) and (28) for transboundary pollution, and (37) and (38) for local pollution. The model is specified in time differences. In that case, I show again that there exists the same statistically significant relationship in the case of transboundary pollutants and fiscal decentralization, and a non-existent relationship in the case of local pollution.

Finally, I set up a dynamic model in which the lag of the dependent variable is included as an independent variable, and it is estimated by using the System GMM estimator. The results obtained before continue to hold in the case of transboundary pollution in regressions (31) and (32), where the lag of CO2 is statistically significant at the 1%, and the coefficients associated to DEC1 and DEC1*CPI continue to predict an increase in CO2 emissions when countries display low-quality institutions, and a decrease in CO2 emissions when institutions are of high quality. Furthermore, in the case of SOx in regressions (39) and (40), i.e. local pollution, it may be seen that the lag of SOx is the main predictor of current levels of this pollutant, and fiscal decentralization and institutions do not explain local pollution levels.

Hence, the estimations presented in Tables 5 and 6 reinforce and confirm the results obtained in Section 5. On the one hand, increasing the degree of fiscal decentralization among OECD countries seem to lead to an enlargement of transboundary pollution levels when institutions display poor quality, and the opposite is true for high-quality institutions. Therefore, the results and robustness checks indicate that burgeoning trends in the degree of fiscal decentralization have led OECD countries with higher quality institutions into a race to the top because they may better internalize environmental spillovers, and where governments may have lifted environmental regulations to protect the environment and so decrease transboundary pollutants. On the other hand, robustness checks reinforce the weak estimation results presented in section 5.2 regarding local pollution.

Table 5: Robustness Check. Transboundary pollution (CO2 as a dependent variable)

VARIABLES	(25) CO2	(26) CO2	(27) CO2	(28) CO2	(29) CO2	(30) CO2	(31) CO2	(32) CO2
Lag of CO2							0.981***	0.992***
							(0.0149)	(0.0147)
DEC1	-0.227***	-0.0897***	0.128***	-0.0300*	-0.00925*	-0.0134**	-0.0124*	-0.0163**
	(0.0281)	(0.0228)	(0.0317)	(0.0169)	(0.00508)	(0.00584)	(0.00705)	(0.00701)
CPI	-2.377***	-0.593**	0.168	-0.125	-0.0857*	-0.140**	-0.124***	-0.182**
	(0.254)	(0.229)	(0.168)	(0.0944)	(0.0459)	(0.0585)	(0.0467)	(0.0727)
DEC1*CPI	0.0654***	0.0288***	-0.0319***	0.00411	0.00404**	0.00555***	0.00518***	0.00613**
	(0.00967)	(0.00761)	(0.00843)	(0.00441)	(0.00175)	(0.00195)	(0.00193)	(0.00243)
GDP		-43.55***		15.01***		2.191		-0.274
		(11.65)		(5.770)		(3.004)		(3.583)
GDP2		2.133***		-0.827***		-0.110		0.000290
		(0.563)		(0.288)		(0.145)		(0.173)
DEN		0.0682***		0.0108		-0.00158		-0.000274
		(0.0115)		(0.0313)		(0.00296)		(0.00344)
IDEO		0.215***		-0.0183		0.0145		0.00579
		(0.0660)		(0.0177)		(0.0172)		(0.0243)
URBAN		-0.0321**		-0.0620***		0.000301		-0.00115
		(0.0132)		(0.0162)		(0.00341)		(0.00379)
ENERGY		0.169***		0.279***		-0.00141		-6.97e-05
		(0.0132)		(0.00925)		(0.00342)		(0.00470)
Constant	17.39***	227.4***	7.039***	-64.36**	0.687***	-9.938	0.443*	3.448
	(1.154)	(60.61)	(0.560)	(29.27)	(0.207)	(15.61)	(0.226)	(18.62)
Observations	421	403	421	403	397	380	406	375
R-squared	0.247	0.624	0.935	0.984	0.220	0.233		
Time FE	Yes	Yes	No	No	Yes	Yes	No	No
Country FE	No	No	Yes	Yes	No	No	No	No
In differences	No	No	No	No	Yes	Yes	No	No
System GMM	No	No	No	No	No	No	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6: Robustness Check. Local pollution (SOx as a dependent variable)

VARIABLES	(33) SOx	(34) SOx	(35) SOx	(36) SOx	(37) SOx	(38) SOx	(39) SOx	(40) SOx
Lag of SOx							0.177***	0.159***
							(0.0494)	(0.0510)
DEC1	0.0103	-0.0223	0.0526	0.00767	-0.00384	0.000598	0.00965	-0.0252
	(0.0198)	(0.0225)	(0.0708)	(0.0725)	(0.0257)	(0.0303)	(0.0201)	(0.0237)
CPI	0.268	-0.0958	0.319	-0.208	-0.0513	0.0419	0.232	-0.220
	(0.181)	(0.227)	(0.381)	(0.415)	(0.234)	(0.303)	(0.192)	(0.248)
DEC1*CPI	-0.0122*	-0.00387	-0.0129	-0.00248	0.00221	0.00183	-0.0115	1.92e-05
	(0.00705)	(0.00760)	(0.0191)	(0.0192)	(0.00911)	(0.0102)	(0.00771)	(0.00824)
GDP		11.64		-26.31		16.91		17.72
		(11.32)		(24.89)		(15.21)		(11.84)
GDP2		-0.554		1.204		-0.831		-0.894
		(0.547)		(1.240)		(0.735)		(0.572)
DEN		-0.0192*		0.0636		0.00899		-0.00613
		(0.0111)		(0.156)		(0.0149)		(0.0110)
IDEO		-0.0854		-0.151**		0.164*		0.0818
		(0.0652)		(0.0756)		(0.0887)		(0.0842)
URBAN		-0.00939		-0.135*		-0.00729		-0.0256*
		(0.0132)		(0.0701)		(0.0180)		(0.0131)
ENERGY		-0.0310**		0.0900**		0.0211		-0.000914
		(0.0128)		(0.0412)		(0.0175)		(0.0134)
Constant	8.758***	-48.28	9.896***	159.8	0.538	-86.13	6.860***	-76.96
	(0.829)	(58.94)	(1.253)	(126.4)	(1.060)	(79.08)	(0.721)	(61.63)
Observations	412	394	412	394	386	369	394	364
R-squared	0.084	0.147	0.222	0.283	0.039	0.049		
Time FE	Yes	Yes	No	No	Yes	Yes	No	No
Country FE	No	No	Yes	Yes	No	No	No	No
In differences	No	No	No	No	Yes	Yes	No	No
System GMM	No	No	No	No	No	No	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

7 Conclusions

Previous empirical investigations in the field of fiscal decentralization and environmental pollution have arrived at contradictory conclusions, either depicting a race to the top or bottom. Following Farzanegan and Mennel (2012), I try to assess this relationship using panel data econometric techniques, and further account for institutions. Therefore, the aim of this paper is to disentangle the effect that the quality of institutions exerts on local and transboundary pollution through the degree of fiscal decentralization achieved in each country. I do that by introducing an interaction term accounting for both fiscal decentralization and the quality of institutions. In order to accomplish my objective, I have set a series of regressions employing the OLS and GMM estimators.

Farzanegan and Mennel (2012) argue that fiscal decentralization leads to a race to the bottom and thus that it increases environmental pollution, and that the negative effect of the former on the latter is diminished when countries display high-quality institutions. In their paper, the authors employ simple OLS regressions to obtain the aforementioned results. On the contrary, I argue in this paper that the statistical methods employed by these authors are not correct for the purposes they aim for. In the presence of endogenous covariates, the use of the OLS estimator leads to obtaining inconsistent results. Although employing the OLS estimator in this paper too, the main, important estimations performed in this empirical investigation are carried out employing the GMM and System GMM estimator, which allow me to account for endogeneity in the independent variables, i.e. fiscal decentralization and institutions. Therefore, the estimation results presented in this paper are consistent, and represent an improvement with respect to previous investigations.

Successfully overcoming the endogeneity issues mentioned above leads me to acquire opposed results to what it has been previously found. First, an increase in the degree of fiscal decentralization leads to an increment in CO2 emissions, i.e. transboundary pollution, when institutions display low quality. That is, subnational governments seem to ease environmental regulations to attract polluting industries and stimulate economic activity, therefore leading to a race to the bottom in which total CO2 emissions increase. On the contrary, when countries display high-quality institutions, increasing fiscal decentralization leads to a decrease in CO2 emissions. In that case, subnational governments may care more about environmental protection and internalize the negative spillovers that environmental pollution generates. Hence, high-quality institutions, given that they could be more aware of the negative consequences that polluting in their regions has on neighboring ones, increase environmental regulation thereby leading to a race to the top in which transboundary pollution is reduced.

Second, across the several specifications and estimations that I conduct throughout this paper, I do not find a statistically significant relationship between fiscal decentralization and SOx emissions, i.e. local pollution. The reason behind this fact could be that given that environmental spillovers associated to local pollutants are small or non-existent, so is interjurisdictional competition. That is, it seems clear that if subnational governments cannot free ride from neighboring regions, and the effects of local pollution are not transferred to other areas, then giving more environmental legislative rights to subnational governments may not prompt them to actually face pollution. Therefore, it could be that other socio-politico-economic reasons may explain how local pollution is created.

In summary, a strong, statistically significant relationship is found between fiscal decentralization and transboundary pollution. A key finding of this empirical investigation is that the direction of this relationship might be determined by institutions and the quality that they display. The main conclusion of this paper is that fiscal decentralization leads to an increase in transboundary pollution by means of loosening environmental regulations when institutions display low quality, and hence a race to the bottom, because low-quality institutions may not internalize the environmental spillovers generated to neighboring regions. On the contrary, fiscal decentralization seems to help to protect the environment, decreasing transboundary pollution when institutions are of high quality, and thus initiating a race to the top, because this high-quality institutions may internalize the aforementioned spillover effects.

The results obtained in this paper seem to be strong and robust. However, it would be naive to neglect that the paper, data and methodology employed present limitations and shortcomings. First, data employed in this empirical investigation only regards OECD countries, which in general display institutions of high quality and very similar characteristics. The latter implies that the results could probably not be extrapolated to countries that present very different characteristics and that are in different stages of development. Second, most of the countries accounted for in this study belong to the European Union (EU), a union of countries that should follow the same guidelines in terms of environmental regulation. The limitation in this case comes from the fact that the EU effect has not been accounted for in the estimations performed by means of a EU dummy variable. As stated along the paper, the problem of compliance has been studied in previous research papers and it actually seems to be a problem in the union. If our estimations mainly capture the EU effect that has not been accounted for, it could be that our results imply that those countries in the EU that display higher institutional quality decrease transboundary pollution when incrementing the degree of fiscal decentralization because these countries indeed comply with EU regulations. Third, although the use of the different decentralization measures has been argued and seems to be well-founded,

they only contain information about the expenditure side. Hence, it would be interesting to know whether the results obtained in this paper hold when employing measures regarding the revenue side. Obtaining the same results employing revenue side fiscal decentralization measures would indeed reinforce and strengthen the results presented here. Finally, the clear lack of results found when assessing the relationship between local pollution and fiscal decentralization could point out that the model specification employed for this purpose could be not correct. Therefore, I think it would be interesting to assess this relationship more thoroughly to better understand it, and suggest ideas in terms of environmental policy.

It is also interesting to address a policy implication that could be derived from this empirical study. Given that the quality of institutions play an important role in the matter under investigation, and that it may determine the outcome on whether fiscal decentralization can help to mitigate CO2 emissions among others, I think it is particularly important to pay attention to the stage of development of countries and its institutions when deciding whether or not decentralizing the public sector. Fiscal decentralization must come hand in hand with the stage of development in countries due to the fact that the quality of institutions and the latter are clearly correlated. More developed economies usually display better quality in their institutions, whereas countries falling behind in terms of development are regularly associated to low-quality institutions. Therefore, developing economies must be careful and patient when assessing whether to increase fiscal decentralization. If they decentralize too quickly, transboundary pollution may increase at a high pace because the low-quality institutions associated to them will initiate a race to the bottom to foster economic activity due to the fact that they are not advanced enough to internalize the negative spillovers that are generated when polluting.

To conclude, some future research should be carried out to confirm the findings presented here, and extrapolate them to other regions in the world displaying different characteristics. First, from the limitations explained above, I think it would be positive to explore the potential outcome that could arise when employing a different proxy for fiscal decentralization, and in particular, one constructed from the so-called revenue side. Second, in order to generalize the findings presented here, it would be particularly interesting to investigate whether the results obtained in this paper hold for other continents like Asia or Africa, where institutions display a lower quality. Furthermore, a richer, complete dataset in which countries from all over the world and more time periods are employed would help to shed light to the relationship between fiscal decentralization and environmental pollution, and the role that institutions play in it, thus providing more robust, consistent and powerful estimations.

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Appendix

Appendix A

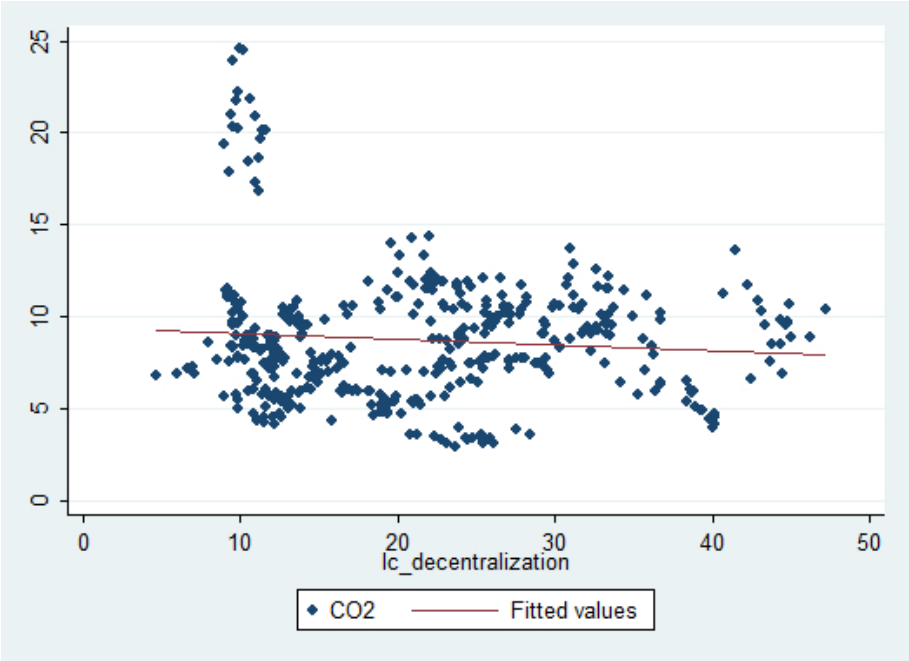

Figure 1: Plotting CO2 emissions against DEC1

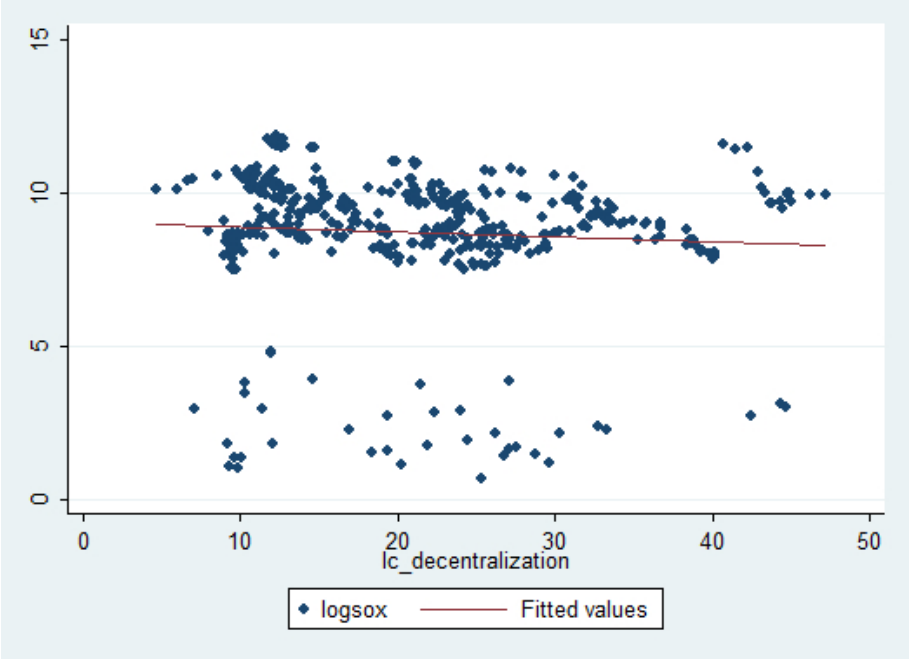

Figure 2: Plotting SOx emissions against DEC1

Appendix B

Table 7: Hansen's J Statistic for overidentifying restrictions

Regression	Hansen's J stat	P-value	Regression	Hansen's J stat	P-value
(3)	1,29e-29		(19)	5,2e-30	
(4)	2,07e-17		(20)	4,7e-14	
(7)	2,1e-30		(23)	2,5e-28	
(8)	5,5e-18		(24)	4,1e-15	
(11)	1,3e-29		(31)	1,5e-29	
(12)	1,960	0,1615	(32)	8,6e-21	
(15)	6,7e-30		(39)	3,5e-30	
(16)	1,7e-17		(40)	7,9e-21	

P-values for the Hansen's J statistic are not reported when the model is perfectly specified. On the other hand, if the number of moment conditions is higher than the moment restrictions, the P-value is offered. The GMM estimation is consistent if we cannot reject the null hypothesis. Clearly, every specification presented in Section 5 and 6 is consistent.