LUND UNIVERSITY
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The Relationship between Fiscal Federalism and CO_2 emissions in China

Abstract: The decentralization of fiscal responsibilities in China has strengthened economic development and enhanced local public management. However, due to fiscal competition, local governments that are fiscally constrained tend to neglect environmental standards in favour of economic growth. This study researches how outcomes of fiscal federalism in China, measured by budgetary ratios of gross regional products, relate to environmental diversities between provinces, measured by CO_2 emission intensity. A panel dataset including 30 Chinese provinces between 2003 and 2015 is empirically tested with fixed-effect method. Test results reveal that provinces with high ratio of revenues have higher CO_2 intensity the same year but lower CO_2 intensity the second year. Results also show that provinces with high expenditure ratios have lower CO_2 intensity. However, provinces with high deficit ratio exhibit lower CO_2 intensity. The overall results indicate that the relationship between the budgetary sizes of provinces and decentralized management of environmental protection is contradictory. This may relate to the exclusion of central-to-local transfers and off-budgetary sources, which vary between provinces and potentially affect the relationship. The study determines that the relationship between provincial fiscal diversities and CO_2 intensity diverges in China depending on which of revenues, expenditures or deficits that is used as a fiscal proxy.

Keywords: *Decentralization, Inter-jurisdictional competition, Fiscal disparities, Environmental protection, CO_2 intensity*

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October 2017

Acknowledgements

I would like to thank my supervisor Sonja Opper for giving me insightful advices and critical guidance through the process of writing. In addition, I would like to thank John and Carolyn Jurns for helping me to improve the language and writing. I especially express my gratitude to Michiel Oskam for driving through half of Sweden in order to guide me through the last stage of the thesis process and to Filip Preston for always helping out no matter what it is.

Most of all, I would like to thank my wife Xiaoyi and all in the family for giving strength and trust when I needed it the most.

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1. Introduction

The economic miracle of China is today a matter of fact. The last four decades of persistent high economic growth is the result of moving from a planned economy towards a socialist-market economy. The decentralization of fiscal governance has been a major market reform that has contributed substantially to China´s economic growth (Montinola, Qian & Weingast, 1996, Lin & Liu, 2000; Ding, McQuoid & Karayalcin, 2015). However, economic development has also given rise to environmental degradation. Rapid industrialization is related to higher energy demand. This, in turn increases CO_2 emissions that affect global warming and therefore human wellbeing. China is currently the world´s largest CO_2 emitting country (Liu, 2015; EIA, 2016), and has drawn attention from the international community to see if it can fulfil the commitment of stabilizing CO_2 emission levels. It is widely acknowledged that an initial stage of economic development is associated with increasing CO_2 emissions[1]. However, it is less clear to what extent a decentralized fiscal system with subnational governments in charge of the local economy affects CO_2 performance.

Fiscal federalism can be viewed as the way decision-making power is divided between of national government (NG) and subnational government (SNG) and how these levels of government interact with each other (Rosen & Gayer, 2014). This study assumes the former aspect to be exogenously given but the latter to be endogenous such that inter-jurisdictional competition affects environmental performance. Economic theory and previous studies highlight both advantages and disadvantages regarding fiscal and environmental federalism. As for advantages, local government has information advantages regarding local preferences, which favours decentralized authority (Hayek, 1945). Moreover, in order to attract capital and labor, local governments tend to compete against each other by sensible taxation and improve the management of public services (Tiebout, 1956). The inter-jurisdictional competition in China serves a critical role in limiting the discretionary authority of central and local governments. This is instituted by the central government granting authority to lower governments while enforcing the system by the central protection of free capital mobility between jurisdictions (Montinola, Qian & Weingast, 1996). Therefore, decentralized competition further enhances the efficiency in providing public goods because of the incentives to act according to local needs (Tiebout, 1956; Oates, 1972; Eichenberger, 1994). This includes efforts to protect the environment (Millimet, 2014). The advantages of fiscal federalism is also supported by Musgrave (1959) who states that public efficiency improves

[1] This is in line with the theory of Environmental Kuznets Curve (EKC) established by Simon Kuznets. For further study, see Kuznets (1955) and Stern (2003).

when central government controls redistribution of income and local governments decide how to allocate public resources.

A main critique for the above stated advantages is the biased incentive structure among local officials. In China, especially in poor regions, upward promotion of local officials within the political hierarchy depends on maximizing economic growth as a signal of achievements (Zhang et al, 2015). This promotion system is prioritized at the expense of environmental degradation (Jia, 2012). Furthermore, inter-jurisdictional competition forces poor local governments to ease environmental standards and lower tax levels in order to attract investments and labour. This causes a race to the bottom where competition for economic development between jurisdictions leads to underfinanced public services that are lower than the social optimum (Oates, 1999). Local governments thus become financially constrained to invest in environmental protection. The race to the bottom may be especially prominent among poor regions due to lower levels of human capital and public infrastructure. The role of decentralization becomes contradictory because environmental regulations are eased in favour of maximizing economic growth.

There are major fiscal disparities between provinces in China. Poor provinces tend to rely more on central transfers to finance local public services than rich provinces (Shen, Jin & Zou, 2012; Naughton, 2007). Since economic development is highly diverse between regions, major differences in CO_2 emissions also exist between provinces (Liu, 2016; Zheng et al, 2014).

1.1 Research question

Even though early economic theory states decentralization to be more socially optimal, disadvantages still remains in the form of biased incentive structures and environmental externalities. In fact, a number of studies in the U.S. (Banzhaf & Chuff, 2012) and globally (Farzanegan & Mennel, 2005; Sigman, 2006) suggest decentralized environmental governance is less cost-efficient when it comes to pollution abatements. Nevertheless, studies that focus on China suggest there are positive effects between fiscal federalism and the spending in pollution abatements (He, 2015; Kang, 2016). Thus, previous studies indicate mixed results regarding how environmental efforts resulting from fiscal decentralization affect environmental performance, not to mention that none of these studies examined the particular relationship between fiscal federalism and CO_2 emissions. Therefore, this study researches how fiscal decentralization affects the intensity of CO_2 emissions on provincial levels in China by asking the following question: How do the size of budgetary revenues,

expenditures and deficits affect CO_2 emissions among provinces in China? This study considers CO_2 emission levels to be influenced by the size of decentralized fiscal management, reflected by budgetary revenues, expenditures and deficits. The thesis simply presumes that inter-provincial fiscal competition determines the size of provincial budgets.

The study aims to find out whether decentralized fiscal responsibilities strengthen China's attempt to fulfil its commitments of stabilizing CO_2 emissions. From the perspective of fiscal federalism, the study seeks to answer whether decentralized authority should be viewed as an "environmental helping hand" or rather as a hindrance. From the perspective of CO_2 emissions, the results of this study may shed new light on how the built-up institutional framework of Chinese fiscal federalism can determine outcomes of environmental performance.

1.2 Data and Methods

The empirical analysis in this study relies on panel data of 30 provinces in China from 2003 to 2015. The use of panel data has several favourable aspects. The advantages include better correction for heterogeneity between observations, more variability that improves efficiency of estimations and greater opportunities to analyse dynamic effects (Kennedy, 2008). Provincial budgetary revenues and expenditures represent proxies of fiscal decentralization and were retrieved from a variety of China Statistical Yearbooks. The study calculates CO_2 emissions by using energy consumption levels multiplied by updated emission factors established by Liu et al (2015). The utilized emission factors reveal more accurate measurements based on sample results from China's energy consumption than do the Intergovernmental Panel on Climate Change (IPCC) standard measures (Shan et al, 2016). Data for energy consumption are retrieved from China Energy Statistical Yearbooks.

1.3 Limitations

There are a number of limitations concerning the data used. Most importantly, the reliability of Chinese official macro-level data remains a disputed subject, especially data concerning economic activity (see Holtz, 2003; Sinclair, 2012). Even though data might be underreported, there is still no reason to believe that incentives vary between local statistical bureaus. Thus, differences in cross-section and time series should still remain robust. A second limitation is related to the exclusion of four provinces due to lack of observations. A third limitation is that the data are restricted to the years of 2003-2015. The reason for this restriction is not only due to lack of data, but also because energy statistics are suspected to be

biased between 1996-2002 due to underreported coal consumption[2]. Finally, the study is limited in that it accounts for aggregate budgetary expenditures without dividing into environmental and non-environmental expenditure sources. The reason to this is also due to lack of data.

1.4 Disposition

The remainder of this paper is organized as follows: Chapter 2 outlays a theoretical background that describes the major economic arguments for fiscal federalism. The chapter also examines necessary institutional conditions, local incentive structures, and the environmental outcome of inter-jurisdictional competition. Chapter 3 explains the Chinese evolution of fiscal federalism and interprovincial competition, the risk of racing to the bottom and how this ties to the environmental performance, measured by CO_2 emissions. Chapter 4 presents the empirical methods, regression results, robustness checks and discussion of results. Chapter 5 finally concludes.

2. Theoretical framework of federalism

Before starting to examine how outcomes of decentralized fiscal responsibilities affect CO_2 emissions in China, this chapter will first highlight the basic economic arguments behind fiscal federalism. In line with Siebert (2008), this study assumes public goods account for efforts to protect the environment and therefore affect CO_2 emissions.

2.1 Theory of fiscal federalism

Fiscal federalism is defined as the scope of decision-making fiscal authority allocated between NG and SNGs and the interaction between government levels (Rosen & Gayer, 2014). The economic theory of fiscal federalism addresses the effects of decentralized fiscal management from both efficiency and equity points of view. Within the theory, it is generally stated that the central government should stabilize the macroeconomic variables that have national impacts, such as inflation, interest rates and income distribution, while the local governments are in charge of public goods that benefits the local economy (Ibid; Musgrave, 1959; Ferreira et al, 2005). The primary goal of decentralization is to improve social welfare, which includes protection of the local environment.

[2] Potential reasons to this relate to the adaption of a new statistical system in 1998 and the abandon of small-scale unlicensed coalmines that resulted in underreported energy usage (Naughton, 2007; Peters, Weber, Guan & Hubacek, 2008).

The idea of improving social welfare by decentralizing public authority was first proposed by Hayek (1945) who pointed out that SNGs have local information advantages. In other words, the production of local public services better reflects the preferences of the people concerned when decision-making power is locally exercised instead of centrally governed. Tiebout (1956) further extended Hayek's arguments of favouring decentralized authorities by explaining the role of inter-jurisdictional competition. Based on the assumption that mobile capital moves freely between jurisdictions, Tiebout argued that inter-jurisdictional competition inevitably forces SNGs to improve the quality of public goods and apply sensible tax rates. As mobile capital and labor freely move in and out of communities, local governments have the task of optimizing the number of residents in accordance with the local public interests. In contrast to a national authority system, the subnational decision-making authority represents an incentive-based institutional framework that enables SNGs to match local public goods with the preferences of mobile labor, which we call consumer-voters. From an environmental perspective, when consumer-voters demand clean environments, the theory suggests that decentralized fiscal governance outperforms centralized governance in providing for these services.

In sum, by viewing environmental protection as a public good, the basic theory of fiscal federalism states the following: First, initial environmental conditions vary between local jurisdictions. Secondly, nobody is more concerned about the local environment than the local people it affects. Lastly, no other governments have more incentives to take measures against environmental degradation than local governments.

2.2 Government incentive structure and hard budget constraints

The theory stated above assumes that local leaders are incentivized to act according to peoples' preferences without being punished if acting on their own discretion. However, this study assumes that governments do not act benevolently without first being incentivized to serve the people. Also, the study assumes that governments do not manage fiscal assignments responsibly if not being forced to do so. Therefore, this section examines important conditions for SNG incentives not to be biased and for sub-national competition to remain durable.

The political structure among some developing countries, including China, deviates from the West. For instance, government decentralization in western countries has taken place at an earlier stage and their democratic system acts as a mechanism of trust between the people and the government. Since common indicators of democracy are rather weak within the Chinese

Communist Party, political trust has to be found through other sources in order for federalism to be sustained. Montinola et al (1996) state that political trust is embedded within the structure of a decentralized system itself. The allocation of authority into national and subnational levels coupled with their complementary responsibilities creates a mechanism of mutual dependency necessary to maintain a decentralized system. Therefore, instead of depending on trust between government and the people, a decentralized system relies on trust between national and subnational governors.

From a national perspective, the central government supports the role of local governance simply because of their information advantages and inter-jurisdictional competition that fosters economic prosperity. At the same time, local governments rely on the central government for protecting competition and eliminating attempts to set up trade barriers. Thus, one level of government carries interests of another level and strives to preserve rather than reverse the framework of allocated authority. Although major democratic institutions are absent in China, the division of political power through federalism forms an institution itself that is sufficiently credible to act as a foundation for market development (Jin et al, 2005). The interdependency between governments adds a new dimension of durability built into the system.

Apart from that responsibilities assigned between SNGs and NG have to complement each other; another important condition for federalism to be effective is that all levels of government have to operate under hard budget constraints to limit the amount of transfers and loans between jurisdictions (Montinola et al, 1996; World Bank, 2000). The condition of hard budget constraints is vital in order to maintain inter-jurisdictional competition. It signals that SNGs have to bear the costs and the benefits resulting from their fiscal management. For instance, if one SNG makes no effort to tax activities causing environmental damages, it cannot expect transfers of environmental investments from another jurisdiction. In order to protect the incentive structure for inter-jurisdictional fiscal competition, it is required that central government withholds subsidies and bailouts to local financial institutions and that SNGs eliminate fiscal transfers between jurisdictions.

In sum, fiscal federalism is durable for any country independent of democracy if the assigned authorities to NG and SNGs are interdependent. The hard budget constraint is a necessary condition in order to incentivize SNGs to responsibly manage fiscal assignments.

2.3 Inter-jurisdictional competition

Moving towards the environmental outcomes of fiscal federalism, this section identifies the strategies SNGs use to compete for mobile capital and how they impact protection of the environment.

Aligned with Tiebout's established theory about inter-provincial competition, SNGs compete for mobile resources in three ways (Ferreira et al, 2005): First, SNGs compete in providing public goods by creating attractive environments for their residents and firms, and optimize their value of public service with limited fiscal budgets. Because fiscal competition takes local preferences into account, public goods are produced and provided more efficiently. Second, SNGs compete for tax revenues that are necessary to finance public goods. The revenue competition acts as an incentive for sensible taxation of peoples' incomes and business. Third, SNGs compete for national and foreign investments by easing regulations such as environmental standards to reduce production costs for firms. The three competition strategies create a variety of policies by which some SNGs manage to increase their budget revenues through capital inflow while other SNGs fail to compete and experience capital outflow. In other words, inter-jurisdictional competition creates both winners and losers. It removes the ability of the losing SNG to improve its tax base while still requiring it to protect the environment.

A major critique for inter-jurisdictional competition to protect the environment targets the competition process. In this scenario, local governments strive to attract mobile capital such as labour and business investments by setting tax rates under their competitors. When government players respond to changes in tax rates, the competition leads towards a race to the bottom and results in insufficient tax revenues (Oates, 1999). Because of low tax rates on mobile capital, local governments struggle to finance public services, which therefore become underprovided (Zodrow & Mieszkowski, 1984) The constrained budget balance consequently forces SNGs to limit the amount of public investment in environment protection and thus lowers their efforts of reducing CO_2 emissions. This suggests that SNGs that are fiscally constrained because of losing mobile capital tax revenues are more likely to have higher emission levels than SNGs with high tax revenues.

2.4 Environmental federalism

The theory of environmental federalism roots in Tiebout's argument that decentralized public authorities improve the provision of public goods through competition and attention to local preferences. However, positive outcomes of decentralized environmental authority often

backfire because of their weak assumptions. Excluding any assumption causes decentralized management to distort consumer-voter preferences and results in environmental degradation. One example is the environmental effect of federalism modelled by Oates and Schwab (1988). Although the model reveals positive effects, it relies on several controversial assumptions. For instance, the model assumes that all community residents are homogeneous and that no pollution spillover effect exists between communities. Several scholars criticize the assumption of perfect information among consumer-voters regarding public goods (Oates, 1981; Bewley, 1981; Oakland, 1987). For instance, it is likely that information about environmental conditions among residents is imperfect and consumer-voters therefore signal biased preferences to SNGs. This leads SNGs to misjudge the actual state of the environment and in turn affects new environmental targets in future policies.

Focusing on the spillover effects; cost of pollutants, such as CO_2 emissions, do not always coincide with the time and place it was emitted. In such scenarios, polluters subjected to CO_2 emissions do not pay the full cost because of negative externalities. The fact that provincial CO_2 emissions affect global warming suggests that large spillover effects exist between provinces. Therefore, the absence of unified environmental standards limits central government's ability to stop local governments from easing regulations of CO_2 emissions in favour of capital inflow. Not only tax rates but also low environmental standards serve as tools for racing to the bottom. Regions risk turning into pollution havens by ignoring the costs of compensation for spillover effects.

3. The evolution of fiscal federalism in China

China started its economic and fiscal reforms by the opening up in 1978. The central government began to gradually decentralize authority top-down to lower levels of government as local people increasingly were acting according to local advantages. These local market-like activities evolved in a bottom-up effect so strong that it fundamentally changed the direction of central government decision-making. While decentralization in China certainly created advantages in the overall governance system, it still has several environmental drawbacks, as we shall discover.

3.1 Pre 1994

China began to decentralize fiscal governance in 1984 by issuing the "fiscal contracting system" (FCS), which divided national government into categories of central, provincial, municipal, county and township levels (Lou, 2009). The fiscal system transformed from

wholly controlled and discretion-based by the centre into a share-based revenue system in which local government retained part of the revenues previously remitted to the center based on negotiated contracts (Ma, 1995). The FCS aimed to give local governments more secure sources of revenues and to enable flexible decision-making of local public spending (Tsui & Wang, 2004). Lower-level government contracted the upper-level regarding shares of revenues and profits remitted to the center for a period of five years and retained what was left (Montinola et al, 1996; Ma, 1996). As a result, SNGs increased their fiscal autonomy and paved the way for market development to expand (Wei, 1996). The fact that local public spending primarily targeted economic growth rather than environment protection suggests that decentralized public responsibilities initially had low significant impact on local environmental management.

Overall, the FCS disfavoured the local government by being discretion-based with a lack of credible commitments from the central government. Established fiscal contracts were often revised even before the contracts expired. Therefore, local governments tried to find exemptions for not paying tax remittances (Ma, 1995). SNGs expanded their off-budget revenues that were excluded from the contracted remittances (World Bank, 1994), and cut local tax levels in favour of attracting mobile capital, which resulted in decreased central revenue share (Lou, 2009). The share of public spending to GDP decreased and acted as a constraint for the central government to manage macroeconomic control (Wang, 1997). The declined share of public spending also limited the central government's ability to uphold environmental control through public intervention. The FCS resulted in fiscal disparity with unequal levels of shared taxes between provinces (Jin, Qian & Weingast, 2005). The irregular revenue and expenditure contracts between provinces and the evolving off-budgetary funds led to differentiation in local spending that affected regional development and enlarged the economic diversity (Wei, 1996). Central government had to develop new institutions that were able to clarify fiscal responsibilities and to protect autonomous authorities from being altered while still benefiting all groups of interests. It had to restore the inter-provincial fiscal disparities in order for underdeveloped provinces to manage the burden of expenditure responsibilities.

3.2 Post 1994

As a response to the weakened central fiscal position, the central government completely revised the FCS in 1994 into a "tax sharing system" (TSS). The new system aimed to change the government decision-making from being discretion-based to become rule-based and nationally unified without opportunities to negotiate remittances (Wang, 1997). Apart

from reinforced institutional quality, the TSS especially intended to increase total revenues as a share of GDP and central revenues as a share of total revenues (Wong, 2013; Niu, 2013; Hussain & Stern, 2009).

In contrast to the FCS, the TSS distinctively allocated fiscal responsibilities between NG and SNGs, which helped improve the efficiency of government administration. The institutional framework built into the TSS enhanced the credibility of government commitments and made reforms durable enough to empower economic actors to engage in long-term investments (Montinola et al, 1996). The ratio of public sector to GDP and central to local revenues regained power (Dollar & Hofman, 2009; Lam & Wingender, 2015). In fact, total fiscal revenues to GDP increased from 10.5 percent in 1994 to 20.1 percent in 2015 (State Administration of Taxation of PRC, 2015).

However, while the reform kept expenditure responsibilities decentralized, it rapidly recentralized the revenue side (Wong, 2013; Niu, 2013). Consequently, local budget deficits increased and added greater dependency on central transfers (Kamp et al, 2017). The unequal fiscal balance gave central government a stronger bargaining position (Naughton, 2007). Thus, even though the structure of authority within TSS helped improve institutional quality, it reversed the balance of fiscal power to favour the central government and in turn increased the risk of discretion-based governance. While the local share of revenues grew modestly, the local expenditure burden trumped revenues significantly and the gap between the two has increased over time (Asian Development Bank, 2014). Figure 1 below illustrates the growing fiscal gap between NG and SNGs. In fact, until today all provinces are burdened with net budget deficits (China Statistical Yearbook 2016). Such circumstances constrain provincial governments to finance public goods, including the management of environmental protection. Any attempts by the central government to compensate fiscal deficits through transfers remain inefficient due to difficulties in monitoring and securing the use of earmarked transfers.

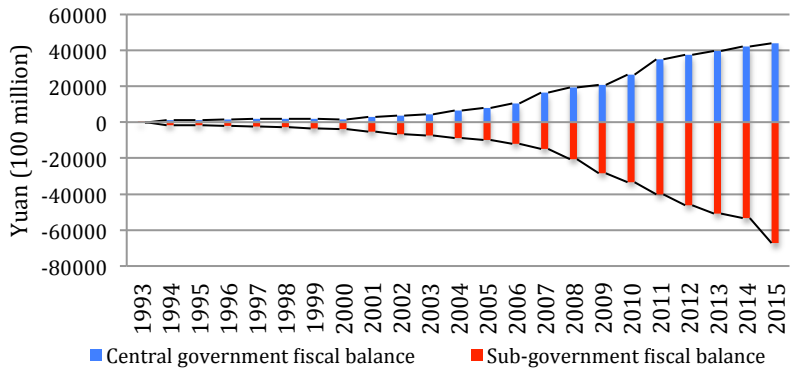

Figure 1 Vertical imbalance of fiscal budgets. Source: China Statistical Yearbook 2016. Compiled by author.

Nevertheless, the fiscal federalism in China indicates that public actors are competitive and still interdependent. However, despite of fostering the overall economic development, decentralization increased the fiscal diversity between provinces and made poor SNGs relatively more dependent on central transfers, which can be used discretionary. These factors suggest that fiscal federalism in China detracts environmental protection relatively more for poor provinces that are fiscally constrained.

3.3 Incentive structure for local environmental effort

The relationship between central and local governments is sensitive to the choice of policy and eagerness for promoting economic development on the local level. This section focuses on the provincial government effort to protect the environment by looking at the expenditure side and assumes that provincial leaders are as much profit-maximisers as central leaders.

A province with low expenditures due to low revenue income is especially reliant on central government transfers to meet national public standards (Shen, Jin & Zou, 2012). On the contrary, the central-to-local transfers signal less pressure for local government to take self-responsible fiscal decisions (Oates, 1999). In other words, there is a risk that transfers are used as bailouts and act as soft budget constraints that loose discipline among local governors to execute central environmental orders. As long as local government primarily has authority over the local economy, central government cannot self-steer local government efforts but only influence them by using the retention rate of local revenues (Jin, Qian & Weingast, 2005). Because we suspect provinces with large fiscal deficits to rely more on central transfers suggest that financially constrained provinces are less incentivised to make efforts in developing the local economy and comply with national environmental standards. In fact, previous studies found provinces with high fiscal imbalance act strategically in setting their environmental stringency and being more energy intensive (Xiong, 2012)

3.4 Economic growth versus environmental protection

In the initial state of development, China decentralized fiscal authority primarily to stimulate economic growth rather than to protect the environment (Fu, 2008; He et al, 2012). Nevertheless, the central government obligates provincial government to implement environmental regulations in order to meet pollution abatement targets (Huang & Xia, 2016). Central government even appoints provincial leaders instead of being elected by the local people, which means that the central political agenda should determine the direction of local management rather than local preferences (Wang, 2012).

However, although central government tries to steer the spending way of local finance through central transfers, they fail in tying together earmarked fiscal resources with environmental responsibilities (Kamp et al, 2017). This raises a question of what cause centrally issued environment standards to be undermined by its self-appointed provincial government? The answer to this question relates to the performance-based promotion system of political leaders. This system rewards government officials to climb up in the political hierarchy depending on economic growth achievements despite its environmental impacts (Jia, 2012). Provincial leaders that achieve higher growth hold an advantage when competing for promotion. In addition, China lacks the law enforcement for punishing local leaders that disregards compliance of environmental standards.

Thus, even though guidelines are issued from top-down level, the environmental protection bureaus (EPBs) still rely on local government finances and become subject to local public interests (Wielens, 2008). The local self-centred strive for economic growth distorts EPBs initial purpose given by the central government to act independently regardless of local political interests. That said, local governments hold some degree of interest to lower pollution levels by subsidizing firms for abatement efforts and can also receive parts of central revenues from emission permits if certain conditions are fulfilled (Chen & Groenewold, 2015).

The question, though, is which of the economic and environmental effect that dominates the other and whether a province has reached a sufficient development stage to shift focus from economic quantity to economic quality. Until now, the signal of economic growth for political promotion has outcompeted environmental concerns. In line with Xiong (2012), this study argues that the signal for economic growth is especially prominent among provinces with high deficits. These provinces are more likely to act strategically by lowering environmental stringency in order to speed up economic growth.

3.5 Inter-provincial competition in China

Inter-jurisdictional competition is thought to develop into an effective instrument for improving public goods and government policies that previously lacked efficiency (Feng et al, 2013). However, fiscal competition in China has both winners and losers. Excessive use of the two main competitive instruments (public expenditure levels and tax reduction on mobile capital) destabilizes the system. It is found that east-coastal regions lower their tax rates in order to attract business investments and to out-compete regions in the central-west, which evolve in a race to the bottom (Yao & Zhang, 2008). Provinces in the central-west have limited sources of fiscal revenues and lower quality of public service. These circumstances

force central-west governments to raise the tax rates, which leads to outflow of business investment and further decrease revenues and constrain the budget balance of poor provinces. In the long run, the continuous shrinking tax base becomes unsustainable for poor governments and widens the fiscal gap to the rich. In response, poor governments increase their fiscal deficits and deregulate environmental standards in order to attract business investments.

In line with Renard and Xiong (2012), this study suggests fiscally constrained governments to act strategically in setting the degree of environmental stringency by the following scenario: Poor provinces with small share of mobile tax base likely encounters greater fiscal imbalances and consequently respond by easing environmental regulations to attract investments. This leads to higher emission levels. In addition, because fiscally constrained provinces struggle to finance basic public services, we suspect these provinces to undermine investments in environmental protection. This acts as a second effect of higher CO_2 emission levels. The fiscal situation, which includes revenues, expenditures and deficits, leads the study to test for each variable separately by the following three hypotheses:

1. *H0: Provinces with lower budget revenues per gross regional product have higher CO_2 emissions per gross regional product.*

2. *H0: Provinces with lower budget expenditures per gross regional product have higher CO_2 emissions per gross regional product.*

3. *H0: Provinces with higher budget deficits per gross regional product have higher CO_2 emissions per gross regional product.*

4. Methodology

4.1 Data

This study uses panel data retrieved from various China Statistical Yearbooks, covering 30 Chinese provinces between 2003-2015. In order to avoid any inconsistencies when modelling, the cross-section and time series data of this study are complete datasets. Therefore the data exclude Hong-Kong, Macao, Taiwan and Tibet as well as the years of observation before 2003 due to limited data access. By limiting the number of provinces and years of observations, the dataset becomes more balanced with complete information for each

variable. This increases efficiency that would otherwise be lost due to excluded observations and, more importantly, lowers the risk of selection bias (Verbeek, 2012).

The quality of the data from various China Statistical Yearbooks, especially GDP growth, remains a topic of debate regarding inaccuracy and manipulation. However, the methods for local agencies to collect data have improved significantly over time by implementing unified international standards (Koch-Weser, 2013). More recent tests of GDP statistics confirm that data are more reliable than critics suggest when considering the complexity of the scope of administration (Holz, 2014). No indicators found suggest any potential biased variables to vary over time or between provinces. Thus, even if biasedness of the overall data potentially exists, this does not change the significance of the relationship, which is of more interest as the study focuses on the direction of relationships rather than their absolute values.

4.2 Variables

Dependent Variable

This study investigates the relationship between the fiscal situation and environmental pollution on provincial level by focusing on CO_2 emissions. The choice of using CO_2 emissions in favour of other commonly used environmental proxies, such as sulphur dioxide, solid waste and wastewater (see He, 2015), relates to several environmental factors. First, not only has the increase of CO_2 emissions in China caused local environmental degradation but it has also significantly contributed to global warming, as China is the largest CO_2 contributor in the world (Chen & Groenewold, 2015). As economic growth remains high, the problem of high CO_2 emissions should be counteracted immediately. Second, China's promise of reducing CO_2 intensity between 2005 and 2020 by 40 percent presumes that provincial governments should improve the management of environmental protection.

Until today, there have been no recordings of CO_2 emissions on the provincial level in China's Environmental Statistical Yearbooks. Therefore, this study calculates CO_2 emissions independently by using consumption of main energy sources multiplied by emission factors produced by Shan et al (2016). Energy sources include coal, crude oil and gas. In contrast to the commonly used Intergovernmental Panel on Climate Change (IPCC) standard measures, Shan et al, (2016) argue that the usage of energy improves over time in China and emission factors therefore need to be adjusted accordingly. The data of energy sources are retrieved from China Energy Statistical Yearbooks source. The study normalizes the dependent variable by dividing aggregate provincial CO_2 emissions with the gross regional product (GRP) to compute what from here on is named as CO_2 intensity. The variable can be interpreted as the number of CO_2 kilos per GRP produced. Since GRP is calculated at current prices, we adjust

for inflation by first dividing GRP with provincial indices of GRP at constant prices to calculate real GRP. The base year is 2003 and equals 100.

Independent Variables

The study divides the main explanatory variable, provincial fiscal account, into three variables: budget revenues, budget expenditures and budget deficits. These data are retrieved from China Statistical Yearbooks. The budget revenues consist of all locally collected revenues plus locally shared revenues collected by the central government. Budget expenditures refer to provincial public services, and development planned by provincial governments (China Statistical Yearbook 2015). Appendix 1 presents a more detailed description of the provincial budget components. The budget deficit is calculated as the difference between budget expenditures and revenues. In order to adjust for inflation, both revenues and expenditures are divided by indices of GRP and then multiplied by the base year (=100) in 2003. The study adjusts for provincial variation in size by dividing all three main variables by real GRP.

Control Variables

It is likely that provincial factors beside the fiscal situation also affect CO_2 intensity. Considering the vast size of China's population and economy, there exist major economic, geographical and socio-economic differences between provinces. In order to isolate the fiscal budget effects and for the ceteris paribus condition to hold, the model includes control variables for cross-sectional and time differences that potentially affect CO_2 intensity[3].

GRP per capita and GRP per capita squared

Because China is still at a development stage, economic growth leads to increased demand in energy consumption, which in turn affects environmental quality and causes air pollution (World Bank Group, 2016). Empirical studies have found complementary relationships between GDP, energy consumption and CO_2 emissions on a global level (Saidi & Hammami, 2015), between developing countries (Niu et al, 2011) as well as within China (Li et al, 2011). Furthermore, the study also expects GRP to covariate with the fiscal budget due to the fact that higher GRP increases fiscal revenues and that fiscal expenditures boost GRP through

[3] Apart from covariate with the dependent variable, control variables also need to partly covariate with the fiscal budget variables. If not, the effect of fiscal budget will remain unchanged. However, the co-variation should still be limited in order to avoid multi-correlation within explanatory variables. Further explanation of control variables is presented by Verbeek (2012)

public investments. Previous studies have found that the level of GRP determines whether the relationship between GRP and environmental quality is positive or negative (Grossman & Krueger, 1995). Therefore, we apply the theory of dynamic effects related to the Environmental Kuznets Curve (EKC)[4] for the GRP by including an additional variable for squared GRP per capita.

Ratio of investments in fixed assets to GRP

In line with He (2015) the model includes a confounding variable of physical capital investment as a share of GRP. The investment ratio indicates how much of GRP is saved for investments in further development and how much of GRP goes to final consumption. In the short run, a high ratio of investments will likely increase energy demand but in the long run reduce CO_2 intensity by improving public infrastructure. This study suggests the time series of 13 years are sufficiently long and expects a negative relationship between investment ratio and CO_2 intensity.

Size of passenger and freight traffic per GRP

The number of civil motor vehicles in China increased from 23.8 to 162.8 million between 2003 and 2015 (China Statistical Yearbooks 2016). By using energy sources such as oil, the passenger and large vehicles contributed substantially to the increases of CO_2 emission in China (Wang et al, 2010). Similarly, the length of highways has expanded from 1.8 to 4.6 million kilometres between 2003 and 2015 (Ibid). The variable for passenger traffic-km measures the number of passengers multiplied by the number of kilometres. A second variable for freight-traffic-km measures the number of freight tons multiplied by the number of kilometres. There are two counteractive aspects about the variables. First, higher passenger and freight traffic-km indicates a more efficient transport system, which lowers the CO_2 intensity. However, as long as vehicles use oil as combustion, the same increase also leads to a higher demand for energy. Thus, the net impact depends on which effect dominates the other. Furthermore, we assume that passenger and freight traffic-km covariate with fiscal expenditures by being dependent on public investments in infrastructure. Both variables are normalized as per GRP values.

[4] For more information about the theory of Environmental Kuznets Curve (EKC), see Kuznets (1955) and Stern (2003).

Human capital per capita

Provinces in China with higher human capital reveal signs of improved environmental quality (Jun, Zhong-kui, & Peng-fei, 2011). It requires some degree of knowledge in order to be aware about the long-term consequences of environmental degradation, which is more likely to be obtained among highly educated people. This study expects higher environmental awareness among residents to change consumer behaviour accordingly and to act pressure on decision-making authorities to take stricter measurements. In order to control for human capital, we construct a proxy variable measured as the population share of enrolled students for higher education. The study assumes that higher student enrolment per capita reflects higher provincial human capital on average.

Ratio of secondary industry to GRP

The dominance of secondary industries is more prominent in provinces with middle-income levels. Secondary industry is often related to manufactories and is relatively more energy intensive as opposed to tertiary industries. Therefore, this study expects provinces with high ratio of secondary industry to GRP covariate with high levels of CO_2 intensity.

Model specification

To test the relationship between CO_2 intensity and fiscal situation, the study constructs the following base model:

$$(1) \quad CO_2grp_{it} = \propto_i + \beta_1 BUDGETgrp'_{it} + \beta_2 X'_{it} + \beta_3 YEAR_t + \varepsilon_{it}$$

Model 1 tests for CO_2 emission per GRP by depending on budgetary variables, which are separately tested for revenues, expenditures and deficits. The control variables form a matrix (X'_{it}) including GRP per capita, squared GRP per capita, investment ratio in fixed assets to GRP, passenger and freight traffic per GRP, human capital per capita and ratio of secondary industry to GRP.

Model 1 includes fixed effect variable ($\propto_i$) that account for cross-section specific factors between provinces that are permanent over time. For instance, there exist major geographical differences in terms of climate and temperature between the south and north of China, which affect energy consumption but do not depend on time. The second fixed effect variable ($\beta_4 YEAR_t$) accounts for changes between years that affect all provinces equally, such as fiscal

policies and new environmental regulations. Finally, the error term ε_{it} accounts for the unexplainable variation in CO_2 emissions per GRP.

4.2 Descriptive statistics

This section presents an overview of key statistics characteristics for each included variable in the model. The sample consists of 390 observations divided into 30 provinces on a yearly base between 2003 and 2015.

The descriptive statistics in table 1 summarizes the mean, minimum and maximum values as well as standard deviations for each variable. Observations show large variation between minimum and maximum values for both dependent and independent variables, which is an indication of inter-provincial diversity. When looking at detailed descriptive statistics, variation is overall higher between provinces than within a province over time.

Table 1 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variable					
CO_2 per GRP	390	0,3064	0,2321	0,0258	1,3761
Independent variables					
Revenue per GRP	390	0,0937	0,0313	0,0481	0,2197
Expenditure per GRP	390	0,2005	0,0900	0,0792	0,6269
Deficit per GRP	390	0,1068	0,0839	0,0084	0,5163
Control variables					
GRP per Capita	390	28,4214	19,6537	3,6856	99,1895
Sq GRP per Capita	390	1193052	1695598	13583,89	9838559
Investment per GRP	390	0,6201	0,2129	0,2529	1,3283
Human Capital	390	0,0159	0,0065	0,0039	0,0357
Passenger Traffic per GRP	390	0,0750	0,0410	0,0092	0,1885
Freight Traffic per GRP	390	0,3726	0,4180	0,0419	4,1777
Secondary Industry per GRP	390	0,4688	0,0772	0,1974	0,5905

When computing the averages of CO_2 intensity between 2003-2015, we find that provinces in north China emit more CO_2 per GRP than in the southern provinces. This is illustrated in figure 2 below. One exception is Guizhou, which counts as one of China's poorest provinces and is financially more constrained to reduce environment pollution relative to its neighbours. The right part in figure 2 excludes China's five autonomous regions, which are Xinjiang, Inner Mongolia, Ningxia, Guangxi and Tibet. Even though these provinces are relatively

more self-governed, they receive special financial support from central government (Lai, 2009). Still, the pattern of excluding autonomous regions remains similar to including all 30 provinces.

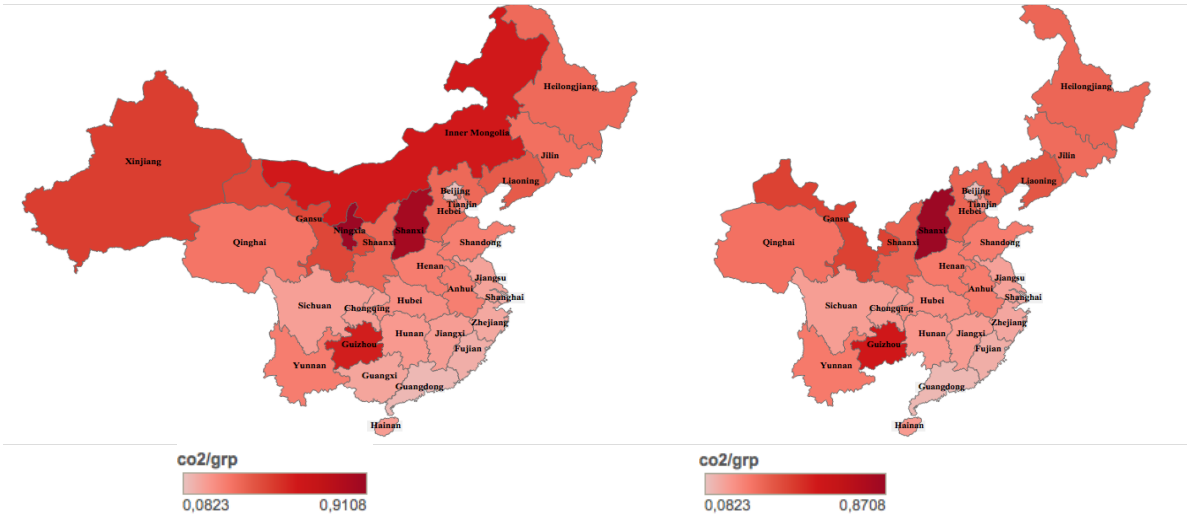

Figure 2 CO_2 per GRP on average 2003-2015

Moving to the revenue side, the north-south diversity is less clear as figure 3 illustrates. The ratio of revenues to GRP is relatively high for both rich and poor provinces such as Beijing and Guizhou. The pattern remains the same when excluding autonomous regions. This indicates that even poor provinces with low GRP per capita set relatively high tax rates in relation to the size of their economy. Thus, it seems that revenues per GRP is not fully determined by the GRP per capita, except for Beijing and Shanghai which represent the highest revenues per GRP.

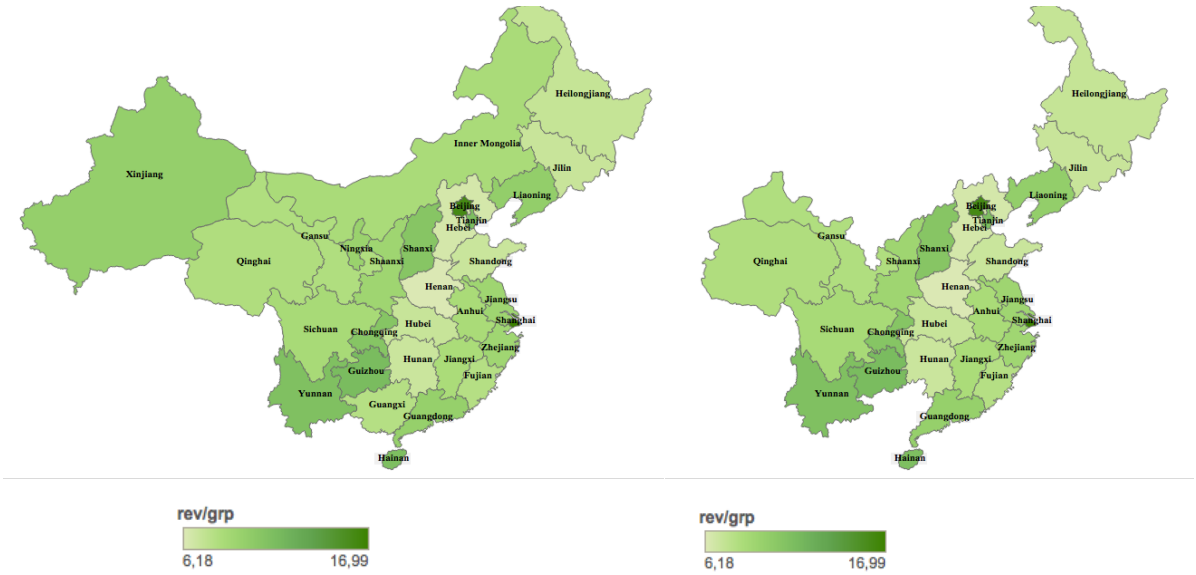

Figure 3 Revenues per GRP on average 2003-2015

Expenditure per GRP is more prominent among poorer provinces in the north and west as figure 4 illustrates. It is worth noting that both Shanghai and Beijing have relatively low

expenditures per GRP. Furthermore, the variation in expenditure intensity between provinces is larger than variation in revenue intensity. Therefore, the high share of expenditures to GRP among the poorer provinces deviates somewhat from their relatively low revenue shares in figure 3. This confirms that poor provinces in the northwest and southwest are more fiscally constrained than others and experience higher ratio deficits.

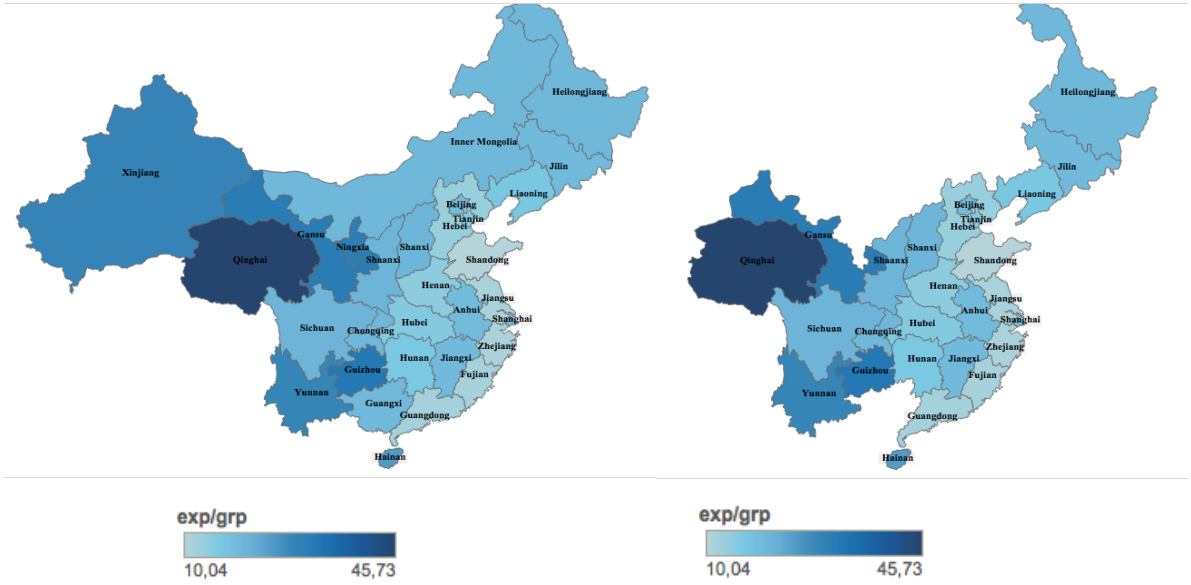

Figure 4 Expenditures per GRP on average 2003-2015

The pattern of deficits illustrated in figure 5 is similar to the provincial diversity of expenditures laid out above. East-coastal regions reveal the smallest deficit ratio and the gap between the most and the least fiscally constrained province is considerably higher for deficits than for revenues and expenditures.

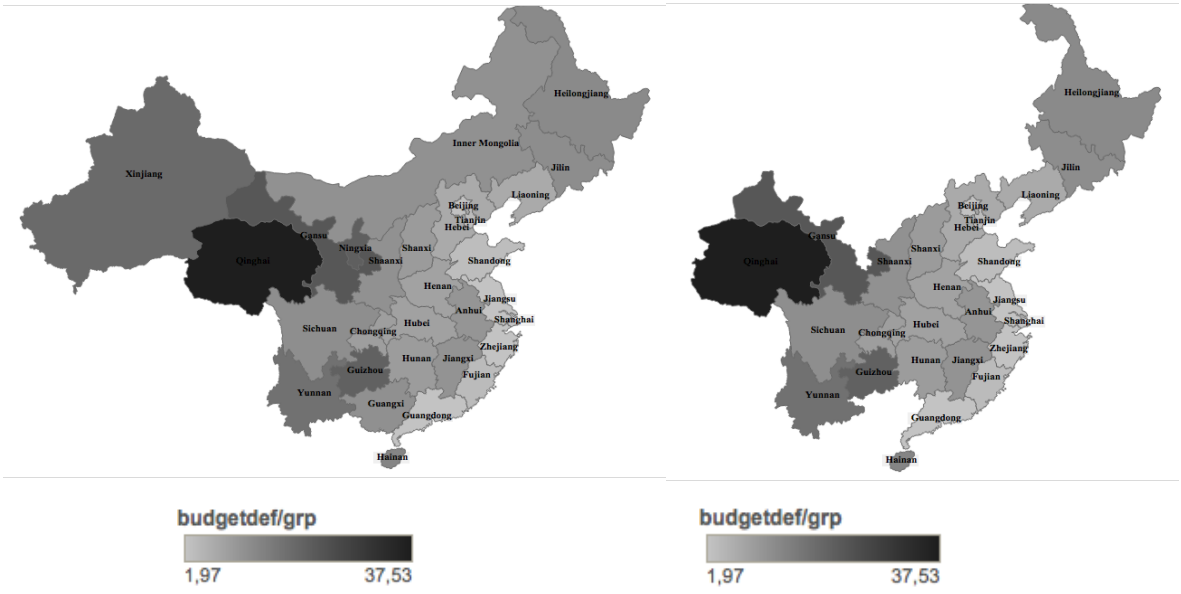

Figure 5 Deficits per GRP on average 2003-2015

Overall, the data illustrated in figure 2-5 confirm the existence of fiscal diversity across south, north, coastal and non-coastal regions. Apart from a few exceptions, high CO_2 intensity and budget expenditure ratios dominate in the north and southwest regions while revenue ratios are more equally spread across all provinces. Furthermore, the gap in public expenditures between provinces is greater than the gap in revenues. Poor provinces rely more on loans, which adds to their budget deficits. Just because a province is poor does not mean that their budget expenditure as a share of GRP is small, but rather that revenues per capita are inadequate to finance public service. The exclusion of autonomous regions in figure 2-5 only decreases the provincial gap for CO_2 intensity because Ningxia has the highest CO_2 intensity on average. Figure 6 illustrates how budget deficits correlate with CO_2 intensity. It compares the difference between including and excluding autonomous regions by exhibiting slightly higher R-squared values for including autonomous regions when fitting a trend line. Thus, we choose to include autonomous regions in the econometric testing.

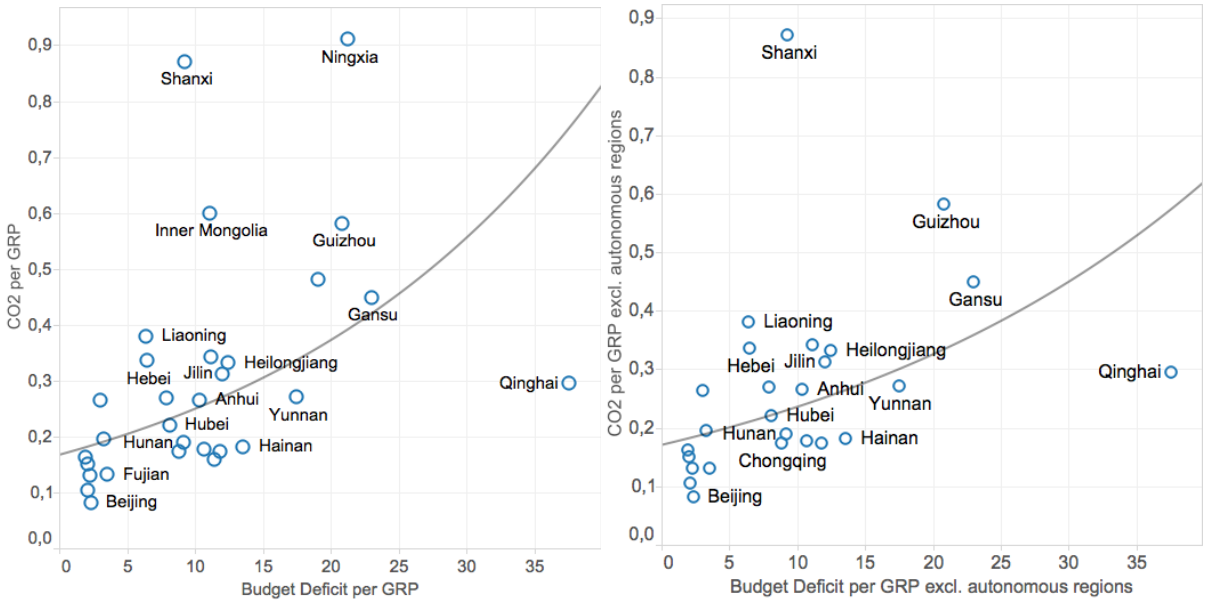

Figure 6 CO_2 per GRP and Budget Deficit per GRP (left) R-Squared value: 0.29.
The right figure excludes autonomous regions: R-Squared value: 0.24.
All data are average values between 2003-2015.

4.3 Econometric testing

Before performing regression analysis on the variables, the study first controls the data through various tests to detect whether the set is biased.

Test for stationarity

For a variable to be stationary, the mean, variance and covariance of the distributed data have to be constant over time (Enders, 2015). If not, regression results risk being spurious. Using

time-series data often implies risk of non-stationarity. The study performs Lewin-Lin-Chu (LLC) unit-root tests for each variable and accounts for trend effect, which are presented in Appendix 2. The test detects non-stationarity for passenger traffic per GRP and share of secondary industry. First-difference variables are constructed for the two non-stationary variables, which then both become stationary. The LLC test results are significant for all remaining variables and the study thus rejects the null-hypothesis of non-stationarity.

Multicollinearity

After transforming non-stationary variables into stationary processes, this thesis test for multicollinearity, which detects problems of unreliable regression estimates by measuring the linear relationship between the independent variables (Verbeek, 2012). Because this study regress fiscal deficits separately from revenues and expenditures, it means that one can ignore the multi-correlation between the concerned variables. However, the test results indicate high multi-correlation between GRP per capita and squared GRP per capita (coefficient=0.95). Therefore, the study chooses to drop out the latter from the model. Correlations between the remaining variables are sufficiently low. Test statistics with correlogram and variance inflation factors are provided in Appendix 3.

Choice of econometric model

After controlling for stationarity and multicollinearity, the study performs a Breusch-Pagan Lagrangian Multiplier (BPLM) test to determine which of the estimators, random effect or pooled OLS that fits best into the data. The test is significant and the study therefore rules out the pooled OLS estimator. However, when performing a Hausman test to determine which of the random or fixed effects that fits best into the data, the test is unable to compute positive P-values. However, comparison of results between random effects and fixed effects reveals similar statistical and economic significance between the dependent and main independent variables. Because this thesis assumes heterogeneity to exist both on the cross-sectional level and over time periods suggests using fixed effects to be the most appropriate estimator. Thus, the study regress the variables by using a fixed effect model, also called *within-estimator*.

4.4 Benchmark Results

The results of the benchmark model are divided into four subgroups of which the first three show separate results for revenues, expenditures and deficits and the fourth subgroup includes both revenues and expenditures.

Table 2 Benchmark Results

	Model 1			
	(1)	(2)	(3)	(4)
Dep. Variable	CO_2grp	CO_2grp	CO_2grp	CO_2grp
Revenue grp	0.492			1.048**
	(0.448)			(0.518)
Expenditure grp		-0.192		-0.377**
		(0.155)		(0.179)
Deficit grp			-0.327*	
			(0.176)	
GRP pc	-0.0030***	-0.0025***	-0.0026***	-0.0032***
	(0.0006)	(0.0005)	(0.0004)	(0.0006)
Invest grp	-0.187***	-0.134***	-0.122**	-0.141***
	(0.0455)	(0.0504)	(0.0487)	(0.0503)
P.Traffic grp	-0.0502	-0.133	-0.126	-0.0648
	(0.509)	(0.507)	(0.505)	(0.506)
F.Traffic grp	-0.0002	0.0006	0.0021	0.0035
	(0.0155)	(0.0155)	(0.0155)	(0.0155)
H.Capital pc	-9.790***	-9.773***	-9.951***	-10.19***
	(2.553)	(2.550)	(2.546)	(2.546)
Sec.Industry grp	0.214	0.181	0.159	0.153
	(0.267)	(0.268)	(0.267)	(0.267)
Constant	0.620***	0.656***	0.652***	0.624***
	(0.0332)	(0.0294)	(0.0275)	(0.0331)
Observations	360	360	360	360
R-squared	0.59	0.60	0.60	0.61

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1
The model uses fixed effects for cross-provincial and time-series specific effects.
All variables are computed as absolute share values except for passenger traffic per GRP and secondary industry share of GRP which are first-difference values.

The results in table 2 reveal several crucial aspects. Data in model 1 is based on absolute ratios and the interpretation of coefficients varies depending on which of the explanatory variables that are significant. The coefficient values equal the changes in number of CO_2 emission kilos per GRP as the independent variable changes by one unit. Starting with revenues, the benchmark test exhibits no significant correlation between revenues and CO_2 emission intensity. The same answer holds for expenditures. Of the three separately tested budgetary variables, only budget deficit per GRP reveals a significant negative correlation with CO_2 intensity. This result contradicts the hypothesis because the study argues co-variation between deficits and CO_2 emissions to be positive but the results state that provinces with higher ratio of fiscal deficits to GRP during 2003-2015 have lower CO_2 intensity. Looking at column 4 in table 2, the test results reveal a positive effect between revenues and CO_2 intensity and a negative effect for expenditures when the two variables are both included.

More precisely, one percentage unit increase in the share of revenues to GRP correlates with 1.048 kilos increase in CO_2 emission per GRP. This result also rejects our first hypothesis. One potential reason that explains the biased result relates to the lagged effect between revenues and emissions. In order to invest in environmental protection, local governments first need to collect sufficient tax revenues to finance such an investment. However, the negative co-variation between expenditures and CO_2 intensity confirms our second hypothesis that provinces with high expenditure levels to GRP spend more on environmental protection, which improves CO_2 intensity.

Moving on the effects of the control variables; GRP per capita is negatively associated with CO_2 intensity for all tests in model 1. This suggests provinces with high GRP to have lower CO_2 intensity. The negative co-variation indicates that CO_2 emissions in China have started to decouple from GDP and might have reached the EKC emission peak where higher GDP leads to lower emission levels. Furthermore, model 1 reveals that both investment ratio and human capital correlates negatively with CO_2 intensity. These go in the same direction as the expectations that we stated in the section for control variables. Finally, the R-squared values state that the model explains around 60 percent of the variation in CO_2 emissions, which we consider to be relatively high.

4.5 Robustness checks

Because the results in the benchmark model reject the first and third hypothesis but confirm the second hypothesis, the study further search to find out whether the benchmark results are reliable by applying several robustness tests.

Dynamic model

First, we construct a dynamic model that accounts for lagged effects of the budgetary independent variables. For instance, the share of revenue to GRP in one year likely affects policy actions and amount of investments the next year. Similarly, if expenditures in environmental technologies are high during one year, we expect that they effect energy consumption in the second year. The relationship for the lagged independent variables interprets as the one percentage unit change in budgetary share of GRP from last year that affects CO_2 intensity for this year. The dynamic model has the following formula.

$$(2) \quad CO_2grp_{it} = \propto_i + \beta_1 BUDGETgrp'_{it} + \beta_2 BUDGETgrp'_{it-1} + \beta_3 X'_{it} + \beta_4 YEAR_t + \varepsilon_{it}$$

Table 3 Results of Dynamic Estimates

	Model 2	
	(5)	(6)
Dep. Variable	CO_2 grp	CO_2 grp
Revenue grp	2.376***	
	(0.740)	
lag Revenue grp	-1.915**	
	(0.794)	
Expenditure grp	-0.366	
	(0.300)	
lag Expenditure grp	-0.0176	
	(0.311)	
Deficit grp		-0.377
		(0.303)
lag Deficit grp		0.0633
		(0.310)
GRP pc	-0.0027***	-0.0026***
	(0.0006)	(0.0005)
Invest grp	-0.125**	-0.125**
	(0.0516)	(0.0508)
P.Traffic grp	-0.0656	-0.111
	(0.507)	(0.511)
F.Traffic grp	0.0035	0.0020
	(0.0154)	(0.0156)
H.Capital pc	-10.12***	-9.919***
	(2.534)	(2.555)
Sec.Industry grp	0.0981	0.144
	(0.276)	(0.278)
Constant	0.648***	0.652***
	(0.0343)	(0.0276)
Observations	360	360
R-squared	0.61	0.60

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1
The model uses fixed effects for cross-provincial and time-series specific effects.
All variables are computed as absolute share of values except for passenger traffic per GRP and secondary industry share of GRP which are first-difference values.

Results for dynamic effects in table 3 above still state significant positive association between revenues and CO_2 intensity when regressed for the same year. However, lagged revenues covariates negatively with CO_2 intensity, which indicates that our first hypothesis to some extent is true. In other words, provinces with higher ratio of revenues to GRP the last year have lower CO_2 intensity this year. The dynamic model reveals no significant effect for lagged expenditures and deficits. The remaining significant results for control variables in the dynamic model add robustness to the results in the benchmark model.

Models excluding municipalities and autonomous regions

Due to the fact that the benchmark model does not account for cross-provincial trade of energy sources, this study suspects municipalities to import electricity that are produced in other provinces. Therefore, the thesis perform one robustness test where excluding all municipalities (model 3) and another where excluding autonomous regions (model 4). The municipalities include Beijing, Tianjin, Shanghai and Chongqing. The autonomous regions are Inner Mongolia, Ningxia, Xinjiang and Guangxi.

Table 4 Results excluding Municipalities and Autonomous Regions

	Model 3		***Model 4***	
	(7)	(8)	(9)	(10)
Dep. Variable	CO_2grp	CO_2grp	CO_2grp	CO_2grp
Revenue grp	1.315**		0.558	
	(0.632)		(0.509)	
Expenditure grp	-0.368*		-0.254	
	(0.190)		(0.177)	
Deficit grp		-0.317*		-0.233
		(0.188)		(0.174)
GRP pc	-0.0024***	-0.0020***	-0.0023***	-0.0021***
	(0.0007)	(0.0007)	(0.000565)	(0.0004)
Invest grp	-0.126**	-0.0926*	-0.253***	-0.246***
	(0.0577)	(0.0543)	(0.0506)	(0.0495)
P.Traffic grp	-0.287	-0.317	0.199	0.174
	(0.570)	(0.572)	(0.516)	(0.514)
F.Traffic grp	0.169**	0.159**	0.0078	0.0073
	(0.0692)	(0.0692)	(0.0145)	(0.0145)
H.Capital pc	-15.60***	-14.15***	-5.102**	-4.901*
	(3.716)	(3.621)	(2.512)	(2.492)
Sec.Industry grp	0.0893	0.103	0.234	0.241
	(0.307)	(0.308)	(0.269)	(0.269)
Constant	0.606***	0.634***	0.572***	0.584***
	(0.0426)	(0.0392)	(0.0330)	(0.0280)
Observations	312	312	312	312
R-squared	0.61	0.61	0.63	0.63

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1
Model 3 excludes municipalities. Model 4 excludes autonomous regions.
The models use fixed effects for cross-provincial and time-series specific effects.
All variables are computed as absolute share of values except for passenger traffic per GRP and secondary industry share of GRP which are first-difference values.

When excluding autonomous regions, the results exhibit no significant co-variation between budgetary variables and CO_2 intensity. However, results excluding municipalities reveal similar pattern to the results in the benchmark model and therefore confirm rejection of the

first and third hypothesis and confirmation of the second hypothesis. Effects of control variables also remain robust.

Models with subgroups of high- and low GRP and control for urban population

Apart from being dependent on imports of electricity, municipalities also have relatively high GRP per capita. Because results of excluded municipalities are significant lead this study to suspect that regions with high GRP per capita more likely reveals significant results. The study performs regional tests by dividing provinces into groups of low- and high GRP. Most rich provinces situates along the east-coastal areas. The separate tests for rich and poor regions indicate whether relationship is similar independent of development stage. The thesis assumes that all rich provinces have relatively high budgetary revenues as well as more sophisticated production technologies, while poor provinces have lower budgetary revenues but higher share of secondary industries. Appendix 4 outlays the division of rich and poor provinces.

The control for urbanization is defined as the urban ratio of population. This variable is included because the cross-provincial and time series fixed effects do not capture changes in urbanization since it varies both over time and between provinces simultaneously. Provinces with higher ratio of urban population suppose to covariate negatively with CO_2 intensity due to their more advanced production technologies. Note that model 6 only covers years between 2005-2015 and therefore have less observation compared to the benchmark model.

Results in table 5 below exhibit positive co-variation between revenues and CO_2 intensity only for poor provinces and not for rich. This is an important finding because it concentrates the effect among poor provinces. Note also that the coefficient value of revenues for poor provinces in model 5 is higher than in the benchmark model, meaning that changes in revenue share affects poor provinces more than provinces overall. When controlling for share of urban population, the results in model 6 of budgetary variables confirm those in the benchmark model. Even though model 6 indicates that highly urbanized provinces have lower CO_2 intensity, the coefficient values for budgetary variables remains almost the same as in the benchmark model.

Table 5 Results of Separating Rich and Poor Provinces

	Poor provinces	***Rich provinces***	***Urbanization***	
	Model 5		Model 6	
	(11)	(12)	(13)	(14)
Dep. Variable	CO_2grp	CO_2grp	CO_2grp	CO_2grp
Revenue grp	2.082**	0.638	1.266***	
	(0.869)	(0.724)	(0.445)	
Expenditure grp	-0.312	0.0965	-0.376**	
	(0.235)	(0.501)	(0.163)	
Deficit grp				-0.339**
				(0.163)
Urban share			-0.498*	-0.517*
			(0.282)	(0.284)
GRP pc	-0.0052**	-0.0035***	-0.0025***	-0.0018***
	(0.0021)	(0.0005)	(0.0006)	(0.0006)
Invest grp	-0.0434	-0.155***	-0.0655	-0.0319
	(0.0914)	(0.0560)	(0.0495)	(0.0475)
P.Traffic grp	-0.557	-0.00965	-0.158	-0.248
	(0.804)	(0.543)	(0.479)	(0.481)
F.Traffic grp	0.221**	-0.00818	0.00346	0.00157
	(0.0882)	(0.0114)	(0.0167)	(0.0168)
H.Capital pc	-20.50***	-5.497**	-10.96***	-10.68***
	(5.551)	(2.343)	(3.085)	(3.106)
Sec.Industry grp	-0.0458	0.346	-0.0141	0.000894
	(0.413)	(0.316)	(0.220)	(0.222)
Constant	0.578***	0.496***	0.801***	0.846***
	(0.0627)	(0.0409)	(0.0975)	(0.0962)
Observations	180	180	300	300
R-squared	0.59	0.72	0.65	0.64
No. of provinces	15	15	30	30

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1
The models use fixed effects for cross-provincial and time-series specific effects.
All variables are computed as absolute share of values except for passenger traffic per capita and secondary industry share of GRP which are first-difference values.

Model for growth changes

All performed robustness tests so far confirm the results in the benchmark model. That is, the study rejects the first and third hypothesis while confirming the second hypothesis. However, because production technologies improve over time, the thesis suggests that CO_2 intensity also decreases over time. At the same time, the ratio of fiscal budget revenues and expenditures to gross domestic product has regained power since the implementation of TSS. Therefore, the study performs a final robustness test by comparing how the growth rates of CO_2 intensity and budgetary variables covariate with the following model.

$$(7)\quad \Delta \ln (CO_2 grp)_{it} = \propto_i + \beta_1 \Delta \ln (BUDGETgrp')_{it} + \beta_2 \Delta \ln(Xpc')_{it} + \beta_4 YEAR_t + \varepsilon_{it}$$

To simplify the interpretation of values, the growth model uses natural logarithmic values for all variables. Since all values are computed as first-differences, the interpretation is the change of percentage units in growth. The remaining features in the growth model are the same as the benchmark model.

Table 6 Results of Growth Changes

	Model 7			
	(15)	(16)	(17)	(18)
Dep. Variable	Δln(CO2grp)	Δln(CO2grp	Δln(CO2grp	Δln(CO2grp
Revenue grp	0.165*			0.157
	(0.0908)			(0.0983)
Expenditure grp		0.0794		0.0200
		(0.0908)		(0.0979)
Deficit grp			0.00567	
			(0.0307)	
GRP pc	-0.728***	-0.685***	-0.669***	-0.729***
	(0.119)	(0.117)	(0.116)	(0.120)
Invest grp	-0.0362	-0.0273	-0.0101	-0.0398
	(0.0681)	(0.0702)	(0.0678)	(0.0704)
P.Traffic grp	0.0603	0.0605	0.0657	0.0593
	(0.0447)	(0.0452)	(0.0448)	(0.0451)
F.Traffic grp	0.0073	0.0058	0.0075	0.0069
	(0.0261)	(0.0262)	(0.0262)	(0.0262)
H.Capital pc	0.627***	0.617***	0.612***	0.627***
	(0.104)	(0.105)	(0.105)	(0.105)
Sec.Industry grp	0.371**	0.395**	0.367**	0.378**
	(0.176)	(0.179)	(0.177)	(0.179)
Constant	-0.0185	-0.0201	-0.0191	-0.0189
	(0.0184)	(0.0186)	(0.0187)	(0.0185)
Observations	360	360	360	360
R-squared	0.28	0.27	0.27	0.28

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1
The model uses fixed effects for cross-provincial and time-series specific effects.
All variables are computed as first-difference of the natural logarithm values.

Test results of the growth model (7) above reveal significant correlation only for growth changes in budgetary revenues. The positive coefficient signifies that one percentage unit increase in revenue share of GRP associates with 0.17 percentage unit increase in growth of CO_2 intensity. Thus, not only absolute revenue rates but also the changes in revenue growth covariates positively with CO_2 intensity. This result further confirms rejection of the first

hypothesis. The results for growth in expenditures and deficits in model 7 are insignificant and do not add robustness to the significant results found in the benchmark model regarding the second and the third hypothesis.

4.6 Discussion of results

Apart from the dynamic model, significant results for all other models presented above resolutely reject the first hypothesis that provinces with lower budget revenues per GRP have higher CO_2 intensity. In fact, the results indicate a positive relationship and that the effect is more prominent among poor provinces. This states that richer provinces to a less extent depend on their fiscal situation for improving CO_2 intensity. The effect of a large private sector may contribute to the efforts of improving environmental quality. Poor provinces do not necessarily improve their fiscal situation by increasing their budget revenues to GRP because such change can relate to lower GRP growth rather than a major increase in the fiscal tax base. Interestingly, the dynamic model reveals negative correlation between budget revenues and CO_2 emission levels. Thus, the overall result is mixed depending on whether the relationship is dynamic or not and indicates that provinces with higher revenue share will improve their CO_2 intensity in the future but increase the intensity at the present. It is reasonable to assume that for increasing fiscal revenues to have an effect on environmental quality by investing will require a certain period of time. In sum, results in the short run suggest rejecting the first hypothesis but the effects in the long run still support the first hypothesis.

The negative correlation between expenditures and CO2 emissions is robust for several tests and confirms the second hypothesis that provinces with higher expenditure shares of GRP are less CO_2 intensive. However, the negative correlation between deficits and CO_2 emissions not only lead to reject the third hypothesis but also contradicts the theory laid out in chapter 2 and 3 that fiscally constrained provinces invest less in environmental protection and lax environmental standards. As opposed to budget revenues, the budget deficits revealed no significant reverse correlation when including the previous time period. Therefore, this study rules out that provinces with high deficit ratio will contribute to higher CO_2 intensity in the future.

Overall, the interpretations of the budgetary variables in relation to the theory of fiscal federalism vary depending on how one defines fiscally constrained provinces. The theory states that poor provinces with smaller tax base are fiscally more constrained. However, the

data show that some poor provinces still have a moderate fiscal revenue size to their GRP. In fact, the fiscal proxies utilized in this study have several weak properties: First, the budgetary revenues and expenditures exclude off-budgetary taxes and spending. The off-budgetary finances distort the clearness of a province's actual fiscal situation. Second, the budgetary variables leave out central-to-local transfers, which have increased over time and become vital for poor provinces to finance public services and environmental investments. Therefore, the results from this chapter should be interpreted with carefulness due to their limited explanation of causal relationships and risk of being misinterpreted.

5. Conclusion

While the decentralization of fiscal authorities in China has contributed substantially to the economic growth, it has also led to large fiscal disparities between SNGs. Due to the inter-jurisdictional competition for mobile capital, provinces that loose the competition race end up with unsustainable high budget deficits. The argument is that poor provinces becomes financially constrained which lowers their ability to invest in environmental protection and may lead their political leaders to act strategically in setting environmental stringencies that counteract improvements of environmental quality. This study attempted to examine the fiscal and environmental diversities in China by studying the relationship between budgetary size and CO_2 emissions on provincial level. Based on the established theory about decentralized fiscal management and public concerns for environmental protection, the study argues that crucial components of the theory rely on weak assumptions and that the risk of local leaders to act discretionary is especially prominent among poor governments. To measure the fiscal circumstances of SNGs, this study hypothesized that provinces with low shares of revenues and expenditures to GRP or high shares of deficits to GRP have higher CO_2 intensity.

The empirical results show that higher expenditures ratios correlate with lower CO_2 intensity. However, the study also finds that higher ratios of revenues associate with higher CO_2 intensity the same year but lower CO_2 intensity the next year. One robustness test confirms that the effect is concentrated among poor provinces. Most contradictory, the results for ratio of budget deficits reveal negative effect on CO_2 intensity. Thus, the findings both reject and confirm that provinces with relatively low revenues and expenditures or high deficits are more CO_2 intensive than other provinces. The results are also constrained by the unsureness of CO_2 emission spillover effects between provinces.

From a broader perspective, the results of budget revenues confirm to some extent the theory that rich provinces compete for mobile capital by lowering their tax rates while poor provinces react by raising their tax rates, as stated by Yang and Zhang (2008). Provinces still race to the bottom when competing for mobile capital and set their environmental stringency accordingly but the race is reflected through other factors, such as GDP growth, rather than the revenue ratio to GRP. Provincial governments excessively use off-budgetary sources of finance and rely on central-to-local transfers (Wang, 2012). This might explain why the results of deficits contradict the theory about lower environmental stringency among fiscally constrained governments, because transfers and off-budgetary sources biases both the officially stated fiscal situation and deviates from the theory of self-responsible fiscal management under hard budget constraints.

Nevertheless, empirical results of this study still do not rule out the negative relationship between fiscally constrained provinces and higher CO_2 emissions. It is likely that fiscal federalism has strengthened the attempt to reduce CO_2 emissions nationally because the overall share of public expenditures to GDP has increased over time. However, the sub-national effects of fiscal decentralization on CO_2 emissions based on the fiscal and environmental diversities remain to some extent unclear. The fact that fiscal federalism improves local fiscal management but that poor local governments still rely on central transfers means that decentralization in China both incentivizes and at the same time disincentivizes the local governments to manage environmental protection.

Finally, in order to relate the theory of a fiscal race to the bottom with changes in CO_2 intensity, the fiscally constrained provinces cannot be reflected only by the ratio of budget aggregative revenues, expenditures and deficits to GRP. This is one major limitation of this study and suggests further research to control for transfers and off-budgetary revenues and expenditures in order to better isolate the effects of the fiscal sizes. Another aspect worth considering is to examine the effects from shares of environmental investments or pollution fees. The results could further be improved by expanding the time-period of data and elaborating with alternative methods of normalization. The study leaves these suggestions for future research.

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Appendix 1.

a) Components of budget revenues:

Business tax, profit handed in by the local enterprises, city maintenance and construct tax, house property tax, urban land use tax, land appreciation tax, tax on vehicles and boat operation, farm land occupation tax, deed tax, and tobacco leaf tax, stamp tax, 25% of the value added tax, 40% the share part of the corporate income tax, 40% of individual income tax, 3% of stamp tax on securities transactions, resource tax other than the tax on offshore petroleum resources, local non-tax revenue, etc

Source: China Statistical Yearbooks

b) Components of budget expenditures:

Main expenditures for general public services, expenditure for public security, and expenditures for social development which are planed by local governments, etc

Source: China Statistical Yearbooks

Appendix 2.

LLC unit root tests Model 1:

	Levin-Lin-Chu (LLC)			
	Level		First Difference	
Variable	**t-statistic**	**p-value**	**t-statistic**	**p-value**
CO2 per GRP	-3.7483	0.0001	-	-
Revenue per GRP	-2.5594	0.0052	-	-
Expenditure per GRP	-5.6570	0.0000	-	-
Deficit per GRP	-6.5531	0.0000	-	-
GRP per Capita	-4.6674	0.0000	-	-
Sq GRP per Capita	-7.5689	0.0000	-	-
Investment per GRP	-5.9928	0.0000	-	-
Human Capital	0.9637	0.8324	-3.9213	0.0000
Passenger Traffic	-4.0764	0.0000	-	-
Freight Traffic	-11.9006	0.0000	-	-
Secondary Industry	1.0019	0.8418	-5.0633	0.0000

Ho: Panels contain unit roots.
Notes: All tests include panel means and time trends.

Appendix 3.

Variance Inflation Factor (VIF) for Model 1:

Variable	VIF	1/VIF
GRP pc	3.13	0.319269
Revenue per GRP	3.07	0.325417
Expenditure per GRP	2.83	0.353479
Human capital pc	2.47	0.405239
Investment per GRP	2.02	0.494061
Sec. industry per GRP D1.	1.43	0.699690
Freight traffic per GRP	1.16	0.862350
Passenger traffic per GRP D1.	1.05	0.954908
Mean VIF	2.15	

Correlogram Model 1:

	CO2	Revenue	Expend.	Deficits	GRPpc	Invest.	Passanger traffic D1.	Freight traffic	Human capital	Sec.industry D1.
CO2	1.0000									
Revenue	-0.2451	1.0000								
Expenditure	0.1708	0.3426	1.0000							
Deficits	0.2713	-0.0008	0.9392	1.0000						
GRPpc	-0.4526	0.6824	-0.0687	-0.3225	1.0000					
Investment	0.0324	0.1243	0.6065	0.6002	0.0237	1.0000				
Pass. traffic D1.	0.0048	0.0251	-0.0981	-0.1136	0.0887	-0.1647	1.0000			
Freight traffic	0.0663	0.0957	-0.0831	-0.1234	0.0774	-0.1533	0.0909	1.0000		
Human capital	-0.4108	0.4927	-0.2110	-0.4046	0.6820	0.0325	0.0272	0.2613	1.0000	
Sec.industry D1.	0.2295	-0.4145	-0.1856	-0.0460	-0.4613	-0.2785	-0.0180	0.0581	-0.3296	1.0000

Appendix 4.

Subgroups of provinces:

Rich Provinces

Guangdong, Fujian, Zhejiang, Shanghai, Jiangsu, Shandong, Hebei, Tianjian, Beijing, Liaoning, Inner Mongolia, Shaanxi, Hubei, Chongqing, Jilin

Poor Provinces

Heilongjiang, Xinjiang, Gansu, Ningxia, Shanxi, Henan, Anhui, Jiangxi, Hunan, Guangxi, Guizhou, Yunnan, Sichuan, Qinghai, Hainan