Oil booms and subnational public investment: a case-study for Colombia[♣]

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Abstract

Theoretical and empirical studies on oil price shocks have mainly focused on measuring its relationship with macroeconomic performance in developing countries. However, the literature has not explored causal effects of oil price variations on subnational public investment. Using a difference-in-differences strategy, this paper contributes to the literature in identifying these effects for both, departments and municipalities in Colombia. Our results suggest that the most recent oil boom, brought by the rise in international oil prices, had mostly positive and disproportionate effects of public investment on oil producing departments and municipalities. On one hand, departments prioritized their investments in five sectors: recreation and sports, agriculture, transportation, attention to vulnerable population, and justice. On the other hand, for municipalities, four sectors were the most benefited: institutional strengthening, justice, equipment, and recreation and sports.

Key words: subnational investment, price shocks, oil booms
JEL Classification: H72, G15, Q33

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Choques petroleros e inversión pública subnacional: estudio de caso para Colombia[♣]

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Resumen

Gran parte de los estudios teóricos y empíricos sobre choques petroleros se han enfocado en medir su relación con el desempeño macroeconómico en los países en Desarrollo. Sin embargo, estos estudios no han explorado los efectos causales de las variaciones en los precios del petróleo sobre la inversión pública subnacional. Haciendo uso de diferencia-en-diferencias, este documento contribuye a la literatura en identificar estos efectos tanto para departamentos como para municipios en Colombia. Los resultados sugieren que el más reciente choque petrolero, generado por el aumento en los precios internacionales del patróleo, tuvo en su mayoría efectos positivos y significativos sobre la inversión pública de departamentos y municipios productores. Por un lado, los departamentos priorizaron sus inversiones en cinco sectores: recreación y deporte, agricultura, transporte, atención a población vulnerable y justicia. Por otro lado, para los municipios los sectores más beneficiados fueron: fortalecimiento institucional, justicia, equipamiento y recreación y deporte.

Palabras clave: inversión subnacional, choques de precios, bonanza petrolera
Clasificación JEL: H72, G15, Q33

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1. Introduction

Natural resource booms are an area of economic research that has been broadly studied for several decades, and mainly focused on developing countries since their large share of natural resources on the total output. This implies a high dependence on international price variations and, consequently, their economic performance is likely to be affected through several channels on different sectors of the economy. Some authors have argued that natural resource booms have negative consequences on producing countries, especially on middle-income ones. For Latin America, as well as for other regions, the literature has found a generalized decrease in the Gross Domestic Product (GDP) as a result of positive variations in international commodities' prices (McMahon, 1997; Sachs and Warner, 1999; Seymour, 2000; Usui, 1997)

Natural resources are not a curse itself for developing and underdeveloped countries, since its consequences depend on many different aspects such as institutions, type of government, and economic policies, where policy makers have the highest responsibility on determining how to use the extra resources coming from the booms. For example, Usui (1997), when comparing the cases of Indonesia and Mexico, found opposite macroeconomic performances after a positive variation in commodity prices. A key point when booms occur is to identify and prioritize sectors where institutional efforts maximize the returns of the extra resources and the population's well-being. For example, investment in tradable goods, infrastructure and prioritizing sectors with high social returns such as health, education or attention to vulnerable population, have proven to increase the likelihood of higher returns from of natural resource booms (Usui, 1997; Seymour, 2000).

There has been an increasing interest in studying and analysing natural resource booms since it has also been increasing the number of episodes all over the world. All this, combined with the more connected financial markets, gave rise to a faster spreading of positive and negative spillovers, coming from sudden variations in commodities prices, with even quicker consequences in producing countries. The vast variety of natural resources in Latin America has led to as much as thirty booms between 1962 and 2016 (Marín *et al.*, 2018). For Colombia in particular, there have been two natural resource booms during the last fifty years. First was the result of an increase in the international price of coffee during the seventies, and the

second came from an increase in the international oil price at the beginning of the 21st Century (Adler and Magud, 2013; Fernández and Villar, 2014; Marín *et al.*, 2018). Despite the generalized agreement about the existence of an oil boom in Colombia, there are doubts whether or not these resources were properly allocated.

In some cases, public investment is considered a mechanism by which extra revenues are translated into social outcomes, education for example (Bonilla, 2019). The other outcome recurrently analysed, as having effects from natural resources' price shocks is crime. Asher and Novosad (2018) found that increases in prices of minerals led to increases of crimes committed by politicians. Also, Dube and Vargas (2013) found for Colombia increases in violence coming from falls in coffee prices and from increases in oil prices. For royalties in particular, Martínez (2016) found that increases in these revenues do not explain improvements in public services nor in their accountability. As a result, the expected effect of oil prices on socio-economic indicators is ambiguous since, in the one hand, it generates incentives to increase violence and reduce school attendance and, on the other, it expands the fiscal constraint and public investment.

This paper contributes to the literature going a step forward analysing if there is any evidence of a causal effect on local public investment due to the recent oil boom in Colombia. The focus is to measure if there was any disproportionate increase in public investment in oil producing departments and municipalities as a result of increases in international oil prices, when compared with the non-producing. The empirical approach also considers legal framework changes in royalties in 2012 as a potential source of heterogeneity, since this new regulation allowed all departments and municipalities to participate in royalties, regardless of whether or not they produce natural resources.

We use public investment data at department and municipality level between 2008 and 2017. Quantities and prices of oil are also used, the first as a baseline for 2008, and the international price for the whole period 2008-2017 as the source of the exogenous variation. We use the interaction between these two variables as the empirical strategy to identify the effects on local governments' investment decisions. We apply a difference-in-differences approach under a panel data set, which allow us to account for unobservable local governments' time-invariant characteristics.

Results from the baseline specification suggest a positive effect on total public investment in departments during the oil boom. For the municipalities we did not find any effect on the total investment. By sectors, the effects were mostly positive and differential between the two levels of local governments. For example, departments prioritized sectors with high social returns such as agriculture, attention to vulnerable population, culture, education and, recreation and sports. Negative effects were found on reclusion centres, culture, community development and development promotion. Municipalities on the other hand focused their investments on social and infrastructure related projects.

Interestingly we found that the strongest and mostly positive effects are those after the 2012 royalty's reform. Those results are compelling since the reform aimed to redistribute resources amongst every local government irrespective of their production condition. We explore two arguments to explain our results. A first potential explanation is that non-producing subnational governments did not have the institutional capacity and experience to execute the additional revenues. Second, prior 2012 there were five sectors in which producing local governments were compelled to invest royalties. As the reform withdrawn those specific destinations, there is the possibility that oil producing local entities increased disproportionately investments in other sectors after the reform.

The remainder of this paper is organized as follows: Section 2 presents a brief review of the literature on oil shocks, public investment and the Colombian context. Section 3 describes the methodological approach and a detailed description of the data used. Section 4 shows the results and Section 5 concludes.

2. Literature review and Colombian context

2.1 Literature review

Research on commodities' price shocks has been largely discussed in the literature and analysed from several perspectives. Perhaps, one of the leading branches on this topic is the Dutch Disease and its potential negative consequences.[1] However, this paper moves away

[1] The Dutch Disease is commonly known for its macroeconomic negative effects in countries with significant participation of natural resources on total output. This phenomenon occurs as a consequence of the appreciation of the local currency resulting from the increase in the natural resource exports, which then leads to a lower competitiveness of other sectors in international markets. Thus, natural resource producing countries are highly

from this approach as it focuses on the management of the resources generated during oil booms. Research first focused on to identify the periods of shocks and the natural resources involved, to move then on to quantify the additional economic resources generated (Sachs and Warner, 1999; Adler and Magud, 2013; Céspedes and Velasco, 2013; Férnandez and Villar, 2014). In Colombia, Fernández and Villar (2014) identified, in a cross-country analysis for Latin America, the number and duration of the shocks. Marín *et al.* (2018) went one-step forward and quantified the two more recent booms in Colombia, the first in coffee exports, between 1970 and 1975, and the second in oil exports, between 2008 and 2016.

Additionally, there are many theoretical and empirical models looking for predictions of the effects of terms-of-trade shocks in small open economies. Results from theoretical analyses are ambiguous and depend on several assumptions. Murphy (1992) developed an optimization model to determine the macroeconomic effects of terms-of-trade shocks in the short and long run. He found that deterioration of terms-of-trade leads to capital accumulation in the long run, and increases current account deficit, while in the short run the effect on investment and current account depends on fundamentals of the economy. On the other hand, Macklem (1993) found that terms-of-trade deterioration decreases national wealth and increases foreign debt in the steady state. A further variation of theoretical models is the differentiation based on the length of the terms-of-trade shocks. At this respect, Servén (1999) found that permanent improvements of terms-of-trade deteriorates the current account, even though it increases capital and investment.

On the empirical side, terms-of-trade shocks have also been of significant interest in macroeconomic studies, with most of them using time series methods. For Saudi Arabia, Dibooglu and Alesina (2004) found that terms-of-trade shocks are related to price levels, real exchange rate and output in the long-term, accounting for about 35% of the output's forecast error variance, but with no effects in the short-term. Also, Mehrara and Mohaghegh (2011), for 12 member countries of The Organization of Petroleum Exporting Countries (OPEC) and eight non-members, suggest that output, monetary shocks and GDP fluctuations are mainly driven by terms-of-trade shocks, while, oil shocks do not seem to have inflationary

vulnerable because of their low production diversification, and hence vulnerable to volatility of the international price of commodities.

consequences. El-Anshasy *et al.* (2005), analysing the relationship between oil prices, GDP growth and public spending in Venezuela, found long-run equilibrium of public revenues and expenditures, in which higher equilibrium revenue levels are related with higher output and oil prices. They also found an indirect impact of oil prices on government revenues, consumption and investments via GDP increases. Serrano (2013), using time series models for Ecuador, found a positive relationship between investment and terms-of-trade. Therefore, it is widely recognized how macroeconomic variables, in oil producing countries, are strongly influenced by international oil price variations.

In terms of public policy, several recommendations have focused on the management of the income windfall generated by natural resource shocks. Usui (1997) compares macroeconomic effects of oil booms in Mexico and Indonesia. In the later, there was a positive effect due to the fiscal and exchange policies implemented coming from increases of investments. McMahon (1997) argues that the risk coming from terms-of-trade shocks is the potential increase in public spending, which is difficult to reverse after the shock.[2] Further studies found decreasing GDP per capita in Latin American countries during boom periods (Sachs and Warner, 1999; Seymour, 2000).[3] From the spending perspective, the literature has also mentioned that an efficient expenditure management is related to transferring part of the resources to the citizens and to taxing income windfalls with the purpose of financing public spending (Devarajan *et al.*, 2010; Ossowki and González, 2012). For the particular case of Colombia, Ocampo and Revéiz (1979) argued that efforts were mainly oriented towards an increase of imports, reducing public investment, but without fiscal measures to reduce exports during the coffee boom. On the other hand, during the oil boom, income windfall was the result of terms-of-trade improvement with no gains for Colombia in terms of fiscal or current account surpluses (Ocampo, 2007). These studies suggest that the consequences led by natural resource booms are conditional to public policies rather than being a curse itself.

One question arising at this stage is about the main determinants of public investments. Despite the large evidence of positive effects of public investment in the economy (Aschauer,

[2] Colombia has shown empirical evidence of irreversible and inflexible public expenditure (Fedesarrollo, 2017).
[3] Seymour (2000) recommends investing windfalls in sectors with higher social returns such as human capital and infrastructure.

1989; Easterly and Rebelo, 1993; Cárdenas *et al.*, 1995; Perdomo, 2002; Suescún, 2007), there are only few empirical studies on the determinants of public investment. In Europe, most of the research aims towards national income, budgetary and fiscal policies (De Hann *et al*., 2013). Mehrotra and Välilä (2006) suggest that an increase of 0,04 percentage points (pp) of public investment (as a share of GDP) is due to a 1% growth of real GDP. For Latin America, Easterly *et al.* (2007) found that the reduction of public investment was not balanced out by private investment, which reduced productive spending and hinders sustainable growth for a rapid reduction of poverty.

For Colombia in particular, IMF (2005) found that lower levels of public investment since the nineties are mainly explained by a decline in public savings and higher current spending, mostly due to increases in wages and pensions. The results also suggest that debt sustainability is one of the main determinants of public investment. In Colombia, debt is related to exchange and interest rates, oil prices and the primary fiscal surplus. Colombian public investment improved during the last part of the twentieth century, while it increased as share of total spending but did not maintain this pattern during the first fifteen years of the twenty-first century.

The relationship between terms-of-trade shocks and public investment is then of significant importance for policy makers. For oil exporting countries, Spatafora and Warner (1995) found that terms-of-trade shocks are related to permanent income, intra and intertemporal relative prices, consumption, investment and savings. Specifically, three channels are likely to affect investment incentives: unions' rent-sharing, OPEC production quotas and wealth increases. They found for 13 out of 18 countries that investment responds positively to terms-of-trade, with elasticities of 0.5731 (of government investments), 0.4085 (of government consumption), and 0.4895 (of private investment).

2.2 Colombian legal framework

In Colombia decentralization has been a key aspect for public investment, specifically in health, education and basic sanitation (Bonet *et al.*, 2014). Political turmoil in the late eighties led to a new Constitution in 1991, where fiscal decentralization stipulated transfers to

subnational governments (departments, districts and municipalities). The main sources of investments for local governments are: own-source revenues; central government transfers (by means of the Participations General System (SGP by its Spanish acronym)); the national government's investment (through the National General Budget (PGN by its Spanish acronym)); and royalties coming from the extraction of natural resources (Bonet and Pérez, 2017).

Regarding the latter, which is one of the main non-conditional resources for local governments, its system was conceived in such a way that only producers, and those implied in the transportation from the origin to the ports or the corresponding place of transformation, would receive royalties from the exploitation of natural resources. Then, in 2012, there was a royalties' reform, which gave rise to the Royalties General System (SGR by its Spanish acronym). Under this new system, all municipalities and departments are eligible to receive royalties irrespective of their condition of producer or non-producer. Additionally, prior 2012 there were four sectors in which oil-producing entities were forced to invest royalties: education, health, PWBS and nutrition, with the highest participation on education and health. After the reform, those inflexibilities were withdrawn in order to enable local governments to prioritize sectors autonomously. One of the underlying goals of the reform was to reinforce a system in order to reduce inequalities amongst departments and municipalities. Local governments' participation in royalties depends now not only on the producing condition but also on their population size and poverty indicators. The way local governments can have access to these resources is by presenting projects, which have to be approved by a multi-sectorial committee.

3. Methodology and data

3.1 Methodology

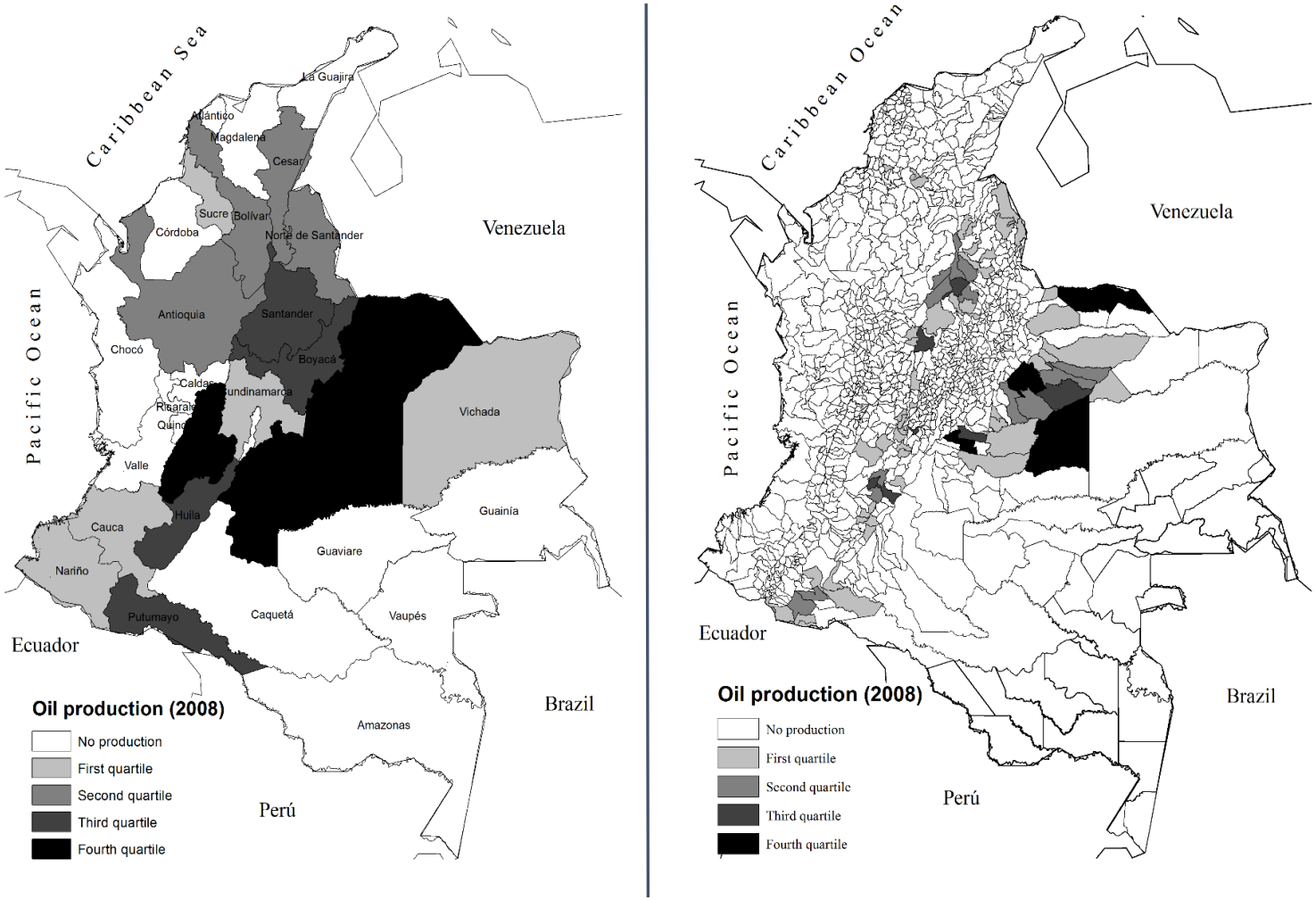
We use a difference-in-differences approach to explore the causal effect of oil booms on local public investment. Oil production in Colombia is carried out in 17 out of the 32 departments, which will be considered as the treatment group. At municipal level, 91 are oil producers. Unobservable time-invariant effects and common year effects across departments are considered by including fixed effects (Angrist and Pischke, 2009). In addition, in order to

control for unobservable variables, potentially related with oil production and public investment at the region level, we include regional linear time trends.

Our dependent variable is the natural logarithm of the investment, in Colombian pesos (COP), by each department and municipality. We estimate the effect on the total investment and over eighteen individual sectors. This in order to determine specific sectors, if any, prioritized by local governments. In terms of the explanatory variables, we use the interaction of department average daily production of barrels in 2008 and the natural logarithm of international oil prices.[4] For the oil price, we use the one year lagged value as Colombian budgeting process restrains to execute additional resources on the contemporary period. Therefore, it is reasonable to argue that an oil price change in *t-1* could affect public investment in *t*. Moreover, the reason for using 2008 oil production, instead of year-to-year variation, is to isolate future production from former public investment decisions and avoid potential endogeneity biases. In other words, public investment decisions in period *t* could affect oil production from *t* onwards. This strategy, combined with the fact that oil reserves are randomly distributed over the territory in function of soil characteristics, gives us the exogenous source of variation dealing with potential endogeneity issues (Dube and Vargas, 2013). The distribution of oil production amongst Colombian municipalities and departments in 2008 is shown in Figure 1. In order to establish the causal effect, we exploit the fact that international oil prices are exogenously determined to Colombian decisions and to regional public investment, as its participation in worldwide oil production is below one percent.

[4] As we collect this information at the municipal level, we consider the oil producing municipalities to compute the average for each department. The price is that of the crude oil (petroleum) simple average of three spot prices; Dater Brent, West Texas Intermediate and the Dubai Fateh.

Figure 1. Oil production distribution in Colombian departments and municipalities



Source: Ministry of Mines and Energy (MME), Hydrocarbons National Agency (ANH by its Spanish acronym) and author's calculations.

Our empirical approach also deals with the change in the legal framework of royalties in 2012. Before this year, royalties from mineral production were only distributed amongst municipalities and departments in which minerals were produced, conveyed and gathered. Additionally, royalties had specific destination investment sectors. From 2012, the SGR was implemented meaning that all municipalities and departments, and not only the producers, would receive royalties. Another change from this reform was that royalties do not have to be allocated to specific sectors, and hence regional policy makers are able to define projects and sectors to invest.[5] To address this concern, we compute the effects with restricted samples, first from 2008 to 2011, and the other from 2012 onwards, as well as considering the full sample with the inclusion of a dummy variable for the period of the reform. Estimates from the first subsample tell us whether those resources allocated by law were executed, and the second let us identify the sectors prioritized by local policy makers. Estimates with the full sample reflect the overall effect of oil prices on public investment sectors.

Following Dube and Vargas (2013), Equation (1) let us determine whether changes in international oil prices disproportionately affected public investment in producing departments and municipalities.

$$\ln\left(Inv_{i,r,t}\right) = \lambda_i + \tau_t + \alpha trend_{i,r} + \gamma \mathrm{Oil}_{\mathrm{i,r,2008}} * \ln(Int.P_{t-1}) + \beta X_{i,r,t} + \mu_{i,t}, \qquad (1)$$

where $Inv_{i,r,t}$ is a vector of public investment outcomes in department/municipality i, region r and year t; λ_i are department/municipality fixed effects; τ_t are year fixed effects; $\alpha trend_{i,r}$ are region specific time trends; $\mathrm{Oil}_{\mathrm{i,2008}}$ is the average oil production in department/municipality i and region r in 2008; $Int.P_{t-1}$ is the international oil price in year $t-1$; and $X_{i,r,t}$ is a matrix of covariates which includes a dummy variable equal to 1 for coal producing departments, a dummy variable equal to 1 from 2012 onwards to consider the legal framework change in royalties, population, central government transfers, and tax revenues in department/municipality i, region r and year t. $X_{i,r,t}$ also includes Colombian intervention interest rate for year t.[6] γ is our estimate of interest, which is not the price elasticity of public

[5] These investments have to be approved by the Collegiate Body of Administration and Decision (OCAD by its Spanish acronym).

[6] The intervention interest rate is the rate at which loans to financial institutions, from the central bank, are made and therefore it determines commercial loans rates to individuals and the private sector. In a broader sense, it

investment by sector. This is due to the interaction of oil production and the logarithm of oil prices. Nevertheless, the elasticity can easily be obtained as follows:

$$\varepsilon(\gamma, \mathrm{Oil}_{\mathrm{i,r,2008}})_{op,pi} = \frac{\partial \ln(Inv_{i,r,t})}{\partial \ln(Int.P_t)} = \gamma \mathrm{Oil}_{\mathrm{i,r,2008}}, \quad (2)$$

where $\varepsilon(\gamma, \mathrm{Oil}_{\mathrm{i,r,2008}})_{op,pi}$ accounts for the oil price elasticity of public investment, which is equal to the derivate of the logarithm of public investment with respect to the logarithm of international oil prices. The elasticity is then a function of the estimate and the oil production in each department/municipality. The elasticity of the average oil producing departments is computed as follows:

$$\mathrm{Oil}_{\mathrm{department,r,2008}} = \overline{Oil_{2008}} = 0.341 \quad (3)$$

$$\varepsilon(\gamma)_{op,pi} = 0.341\gamma \quad (4)$$

$$\mathrm{Oil}_{\mathrm{municipality,r,2008}} = \overline{Oil_{2008}} = 0.063 \quad (5)$$

$$\varepsilon(\gamma)_{op,pi} = 0.063\gamma \quad (6)$$

In other words, one percent change in the international oil price causes a $0.35\gamma/0.063\gamma$ percentage change in public investment in departments and municipalities, respectively. To consider a possible lagged effect and compare the magnitude of the oil boom effect on public investment, we also estimate:

$$\ln(Inv_{i,r,t}) = \lambda_i + \tau_t + \alpha trend_{i,r} + \sum_{s=1}^{m} \delta_s \mathrm{Oil}_{\mathrm{i,r,2008}} * \ln(Int.P_{t-s}) + \beta X_{i,r,t} + \mu_{i,t}. \quad (7)$$

In this case, both equations (1) and (7), let us identify the causal relationship between oil price shock and public investment. Furthermore, equations (4 and 6) show oil price elasticities of public investment for the average oil-producing department/municipality. These specifications allow us to differentiate causal effects from period to period in order to assess the length of the oil shock effect and compare year-to-year magnitudes. Every specification clusters standard errors at the department/municipality level in order to control for potential correlation across departments and municipalities.

determines the cost of credits in the national economy, which could finance subnational governments' investment projects.

3.2 Data

Public investment data come from the Treasury and Public Information Consolidator (CHIP by its Spanish acronym) – Unique Territorial Form (FUT by its Spanish acronym). FUT is a financial balance sheet form, which every public entity must submit to CHIP, a system that is part of the National Accounting Office (Contaduría General de la Nación). From this dataset, we get information on local government's public investment by sector from 2008 to 2017, from which we built a panel for the 32 departments and 1100 municipalities.[7]

The data is transformed from current to constant (Dec 2008=100) Colombian Pesos (COP) using the Consumer Price Index (CPI) reported by the National Statistics Agency (DANE by its Spanish acronym). The production of crude oil comes from the National Hydrocarbons Agency (ANH by its Spanish acronym) and the Ministry of Mines and Energy (MME). The international oil price is taken from the International Financial Statistics (IFS) of the International Monetary Fund (IMF).

In order to control for department/municipality individual characteristics, which are related to public investment, we include transfers from the central government to departments/municipalities, own-source revenues, and a set of dummy variables accounting for: (i) the 2012 change in the royalties' legal framework; and (ii) the coal producing departments/municipalities, since local governments receive royalties from both the production of minerals and hydrocarbons. National transfers and own-source revenues are taken from the National Planning Department (DNP by its Spanish acronym). Other regressors include the intervention interest rate (from Banco de la República, the Central Bank of Colombia), and population (from the National Department of Statistics, DANE).[8]

A detailed summary of the whole data set is presented in Tables 1 and 2. The estimation of the oil price elasticity uses the average oil production, in oil producing departments (34.100 barrels/day) and in oil producing municipalities (6.300 barrels/day).

[7] Disaggregation of public investment is made for 18 sectors: education, health, drinking water and basic sanitation, sports and recreation, culture, public services, housing, agriculture, transportation, environment, detention centres, prevention and support of disasters, development promotion, vulnerable groups support, equipment, community development, institutional support and justice. Additionally, we account for the total of public investment at the department and municipality level.

[8] Detailed information about variables, period, aggregation levels and sources are shown in Appendix A, Table A1.

Table 1. Departments' characteristics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variables					
Log total investment	345	12.508	.945	9.273	14.471
Log education investment	345	11.954	1.060	6.511	13.823
Log health investment	344	10.726	.965	8.057	13.079
Log PWBS investment	337	8.780	1.523	2.552	13.120
Log transports investment	340	9.028	1.640	2.778	12.691
Log environment investment	287	6.243	1.804	-.771	10.146
Log penitentiary centres investment	90	4.369	1.299	1.083	8.055
Log disasters investment	313	6.101	1.778	.211	10.442
Log development promotion investment	327	7.075	1.752	2.105	10.906
Log recreation and sports investment	340	7.933	1.411	.666	11.383
Log culture investment	345	7.555	1.051	3.351	10.107
Log public services investment	232	6.629	1.970	-2.462	10.555
Log housing investment	281	6.674	1.905	.078	10.898
Log agriculture investment	322	6.938	1.552	1.559	10.218
Log attention to vulnerable population investment	341	7.516	1.575	2.316	11.762
Log equipment investment	236	6.505	1.870	1.215	10.617
Log community development investment	284	5.861	1.757	.606	10.117
Log institutional strengthening investment	339	8.606	1.441	2.643	11.806
Log justice investment	325	6.925	1.809	.485	10.908
Explanatory variables					
Daily average oil production (hundred thousand barrels).	184	.341	.477	.0002	1.633
Log international oil price	313	4.314	.334	3.757	4.654
Oil production x log oil price	316	.799	1.684	0	7.601
Control variables					
Log population	349	13.401	1.315	10.521	15.716
Log central government transfers	317	12.249	.772	10.323	13.883
Log tax revenue	317	11.205	1.358	7.484	14.152
Intervention interest rate	349	5.177	1.826	3.16	9.81
Royalties legal framework change	349	.642	.480	0	1
Coal producing departments	349	.284	.451	0	1

Table 2. Municipalities' characteristics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variables					
Log total investment	11,840	9.053	1.109	-.676	15.967
Log education investment	11,834	6.628	1.471	-3.918	14.683
Log health investment	11,809	8.166	1.239	-1.569	15.502
Log PWBS investment	11,749	6.352	1.188	-14.175	12.907
Log transports investment	11,761	6.331	1.276	-3.547	13.617
Log environment investment	10,366	4.006	1.668	-6.697	12.057
Log penitentiary centres investment	3,312	2.224	1.702	-5.991	9.023
Log disasters investment	10,888	3.725	1.658	-7.039	11.212
Log development promotion investment	7,841	3.422	1.806	-7.145	14.273
Log recreation and sports investment	11,804	5.033	1.203	-3.377	12.116
Log culture investment	11,824	5.141	1.055	-5.644	12.134
Log public services investment	10,619	4.561	1.646	-6.566	13.247
Log housing investment	9,457	4.421	1.654	-4.792	12.166
Log agriculture investment	11,536	4.508	1.018	-4.460	10.489

Log attention to vulnerable population investment	11,762	5.509	1.207	-5.039	13.330
Log equipment investment	11,254	4.519	1.543	-5.369	13.016
Log community development investment	8,681	2.998	1.564	-6.928	11.528
Log institutional strengthening investment	11,722	5.405	1.250	-3.661	13.006
Log justice investment	11,761	4.967	1.123	-4.511	12.339
Explanatory variables					
Daily average oil production (hundred thousand barrels).	1,130	.063	.117	0	.605
Log international oil price	11,840	4.278	.341	3.757	4.654
Oil production x log oil price (t-1)	11,007	.023	.171	0	2.815
Control variables					
Log population	12,108	9.592	1.119	6.859	15.917
Log central government transfers	10,972	8.904	.928	7.004	14.702
Log tax revenue	10,970	7.065	1.529	1.336	15.600
Intervention interest rate	12,108	5.200	1.850	3.16	9.81
Royalties legal framework change	12,108	.636	.481	0	1
Coal producing departments	12,108	.548	.498	0	1

Figure 2 shows the dynamics of total public investment for oil and non-oil producing departments and municipalities, where a general upward trend is noticeable. The most evident difference between departments and municipalities is the large difference between producing and non-producing departments, in contrast with municipalities where the average investment amounts is similar over time. The reason for these differential patterns between departments and municipalities is the high number of producing departments (17 out of 32) compared with those in municipalities (91 out of 1,101).

Figure 2. Total public investment in oil producing and non-oil producing departments/municipalities

A second characteristic has to do with the two deep falls of public investment, in 2012 and 2016. The first event is consistent with the royalties' reform, and might be related to the uncertainty faced by local governments with the upcoming changes. The second drop seems

to be related with the fall of the international price at the end of 2014 which, given the legal constraints in the new royalties' system in Colombia, may have had a lagged effect on the subnational public investments drop in 2016, effects which are taken into account in the estimations.

A third characteristic has to do with the noticeable cyclicality of public investment, which might be related with the electoral cycle. Consistent with this argument the lower levels of public investment were in 2008, 2012 and 2016, in which local elections took place.[9] Supporting this assumption, Bonilla and Higuera (2017) found larger transfers from the national government to municipalities where mayors belong to the President's political party, suggesting a potential link between transfers and the electoral cycle. This cyclical behaviour has two potential sources. First, the so-called "Ley de Garantías" (Law 996/2005), a regulation intending to avoid clientelistic practices, prohibiting direct public procurement during four months prior to the elections. At local level, governors, mayors, and other members of decentralized entities are not allowed to subscribe any direct contract or to hire or fire workers. The second possible source is that, during the first year of their administration, new elected governments focus their efforts on the design and approval of their investment programs, while in the following years they implement and execute these policies increasing public investment.

Appendix B shows, by sector, the evolution of public investment. Although no unique patterns are evident, we observe some interesting characteristics. On one hand, for 10 out the 18 sectors, public investment in oil producing departments is larger than in non-producing departments for the entire sample, and on the other hand, there seems to be a generalized, and mostly negative variation in 2012. As a result, in most of the cases, there seems to be a convergence pattern where both, producers and non-producers, approach to each other closing the investment gap over time. These facts have important public policy implications since, for particular sectors, as time passes subnational governments, irrespective of their oil-production status, investment gaps are closing. An additional characteristic is that for particular sectors, such as education and health, the public investment pattern over time is steadier. Education, for example, has a consistent increasing trend, making evident the fact

[9] Time fixed effects included in the specifications might help to account for this potential cyclicality.

that education is a basic service and still far from universal coverage.[10] Health, on the other hand has a slight decreasing pattern, which is consistent with the almost universal coverage.

4. Results

In this section, we present regression analyses to assess the effects of oil price variation on public investment in Colombian local governments. We estimate three different specifications. First, we present the results for the baseline model, which explores the oil price on *t-1* elasticity of public investment on *t*. Then, we move on to a two-period specification looking for the potential heterogeneous effects coming from the new royalties' system. Finally, we aim to find lagged effects of oil price shocks on public investment. For all of them, we report results for those sectors where significant effects were found.

4.1 Effects of oil price shocks on local public investment

Table 3 presents the causal relationship between the most recent oil boom in Colombia and public investments of local governments. The estimates are mostly positive, statistically significant and robust to different specifications. The only negative relationship was found for investments in penitentiary centres meaning that, during the oil boom, producing departments reduced investments in this sectors relative to the non-producing. The effect on total public investment is positive, as well as for five other specific sectors (transportation, justice, attention to vulnerable population, recreation and sports, and agriculture). One possible explanation for not finding effects on key sectors, such as health or education, is that they have other sources of financing. For example, these two sectors have as their main source the national transfers (SGP), own-source revenues and national general budget.[11] All these effects are robust to different specifications (Appendix B).

[10] According to Ministry of Education data, in 2017 education net coverage in Colombia was 82.6%. Moreover, differences within the country are very large as there are departments such as Guaviare with an education net coverage of 55%. This indicator is the ratio of enrolled children between five and sixteen years old and the total population of that age group.

[11] Since we only report results for sectors with significant effects, results for the remaining sectors are available upon request.

Table 3. The effect of oil shocks on departments' public investment

Dependent variable	(1) Total	(2) Transportation	(3) Justice	(4) Penitentiary centres	(5) Attention to vulnerable population	(6) Recreation and sports	(7) Agriculture
Oil production x log oil price (t-1)	0.221** (0.0934)	0.953*** (0.249)	0.593** (0.287)	-1.656** (0.660)	0.782*** (0.269)	0.835** (0.357)	0.882*** (0.243)
Controls	X	X	X	X	X	X	X
Department fixed effects	X	X	X	X	X	X	X
Time fixed effects	X	X	X	X	X	X	X
Linear time trend	X	X	X	X	X	X	X
Observations	283	278	269	77	282	280	262
R-squared	0.274	0.231	0.264	0.294	0.294	0.128	0.215
Number of departments	32	32	32	21	32	32	31

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

At municipal level, no effect was found for the total investment (Table 4). Nevertheless, when sectors are taken one at the time four of them stand out: justice, equipment, institutional strengthening, and recreation and sports, which are the sectors to what oil-producing municipal authorities have allocated most of the resources coming from the oil boom.

Table 4. The effect of oil shocks on municipalities' public investment

Dependent variable	(1) Total	(2) Justice	(3) Equipment	(4) Institutional strengthening	(5) Recreation and sports
Oil production x log oil price (t-1)	0.172 (0.143)	0.996* (0.604)	1.970* (1.196)	1.715*** (0.625)	1.037** (0.483)
Controls	X	X	X	X	X
Department fixed effects	X	X	X	X	X
Time fixed effects	X	X	X	X	X
Linear time trend	X	X	X	X	X
Observations	9,771	9,718	9,293	9,677	9,746
R-squared	0.263	0.209	0.061	0.100	0.174
Number of municipalities	1,100	1,100	1,100	1,100	1,100

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

Overall, departments prioritized sectors such as agriculture, attention to vulnerable population, transportation, and recreation and sports, mostly related to what the literature argues of having high social returns. Municipalities on the other hand seems to have focused more on investments related to economic development, as seen in Acemoglu and Robinson

(2013).

With the purpose of offering an alternative interpretation of the results, we compute the corresponding price elasticities of public investment as shown in equations (4) and (6). Since one of the largest sources of revenues in Colombia is the oil production, it is expected that changes in international prices affect macroeconomic fundamentals, and public investment correspondingly. This in turn will affect socioeconomic variables, economic development and well-being (Cárdenas *et al.* 1995; Perdomo, 2002; Suescún, 2007). Table 5 shows oil price elasticities of public investment for those sectors where significant effects were found. For the total investment, a 10% increase in oil prices is related to a 0.75% increase in total public investment in the average oil-producing department. If we consider the department with the largest oil production (Meta), the results suggest that a 10% increase in oil prices will result in a 1.22% increase in total investment.

Table 5. Oil price elasticities of public investment for 2008-2017 sample

	Department (mean)	Municipality (mean)
Daily average oil production in producing departments	0.341	0.063
Sector	Mean elasticity	Mean elasticity
Total	0.075	0
Justice	0.202	0.063
Penitentiary centres	-0.565	0
Vulnerable population	0.267	0
Recreation and sports	0.285	0.065
Agriculture	0.301	0
Transportation	0.325	0
Institutional strengthening	0	0.108
Equipment	0	0.124

Note: As mentioned in the methodology section, we compute elasticity for the average oil-producing department as the elasticity is a function of oil production by department, due to the interaction of the oil price and production. The second column is the elasticity of the average oil producing department, which is computed by multiplying the estimate and the mean oil production, which is 0.341 hundred thousand barrels per day. The third column is the corresponding information for municipalities. To have a reference point, the largest oil-producing department produces 1.63 hundred thousand barrels per day.

The sector in which we found the lowest price elasticity is justice, for both departments (0.202) and municipalities (0.063), while the ones with the largest effects are equipment for

municipalities (0.124), and transportation for departments (0.325).[12] From this baseline perspective, our results suggest that the most recent oil boom, by means of increases in international oil prices, resulted in disproportionate increases of public investment in oil producing departments and municipalities. These results are consistent with previous literature suggesting that natural resources' windfalls should go to sectors with the highest social returns, and those looking for economic development (Spatafora and Warner, 1995; Seymour, 2000).

4.2 Effects before and after royalties' reform

So far, changes implemented by the new royalties' system (SGR) in 2012 have been taken into account by means of a dummy variable in the econometric specification. Nevertheless, since they are source of potential heterogeneous effects, in this subsection we compute the effects into two separate samples, prior the reform (2008-2011), and the after the reform (2012-2017). We present the results for the specification where the effects are significant (Tables 6 and 7).

For departments (Table 6), we found that almost all the effects are driven by the reform, since most of the estimates are only significant for the post-reform period. There is a positive effect for five sectors: agriculture, attention to vulnerable population, recreation and sports, justice, and transportation; and there are three sectors with negative effects: reclusion centres, culture, community development and the promotion of development. It is also interesting to see that, for all sectors positively affected by the oil boom, the royalties reform seems to be decisive, while for sectors where investments were lower for oil-producing departments when compared with non-.producing, the effects are present both, within the pre and post reform periods. The largest elasticities found were in agriculture (0.406) and transportation (0.352) from the positive side, and reclusion centres (-0.666) and community development (-0.653) from the negative side.

[12] CHIP defines equipment investment as resources oriented to extend and ameliorate local government infrastructure and public goods.

Table 6. Departments: effects before and after 2012 reform

Sectors	Oil production x log oil price (t-1)	Elasticity	Observations	R-square	Number of departments
Total					
Pre reform	0.0685	0	93	0.184	32
	(0.0920)				
Post reform	0.246**	0.084	190	0.309	32
	(0.109)				
Agriculture					
Pre reform	0.266	0	87	0.360	31
	(0.511)				
Post reform	1.192***	0.406	175	0.247	31
	(0.350)				
Attention to vulnerable population					
Pre reform	-0.715	0	92	0.135	32
	(1.186)				
Post reform	0.985***	0.336	190	0.401	32
	(0.303)				
Recreation and sports					
Pre reform	-0.282	0	92	0.094	32
	(0.569)				
Post reform	0.904**	0.308	188	0.169	32
	(0.428)				
Justice					
Pre reform	-0.909	0	84	0.083	31
	(1.524)				
Post reform	0.732**	0.250	185	0.330	32
	(0.299)				
Transportation					
Pre reform	0.224	0	91	0.193	32
	(0.559)				
Post reform	1.031***	0.352	187	0.287	32
	(0.294)				
Reclusion centres					
Pre reform	-3.666	0	33	0.272	15
	(2.769)				
Post reform	-1.954**	-0.666	44	0.403	18
	(0.729)				
Culture					
Pre reform	-0.798*	-0.272	93	0.247	32
	(0.466)				
Post reform	0.373**	0.127	190	0.346	32
	(0.151)				
Community development					
Pre reform	-1.914*	-0.653	78	0.153	32
	(1.015)				
Post reform	0.362	0	155	0.183	32
	(0.417)				
Promotion of development					
Pre reform	-1.956**		89	0.074	32
	(0.889)				
Post reform	0.566	0	180	0.076	32
	(0.521)				

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

For municipalities, seven sectors were affected as a consequence of the oil boom: PWBS, recreation and sports, community development, equipment, prevention of disasters,

promotion of development (Table 7). In this case, the evidence is clear and strong in showing the role of the SGR reform in 2012, since all the significant effects are those for the post-reform period and with positive estimates in all cases. The elasticities are lower than those of the departments, which is consistent with the fact that departments receive more royalties than municipalities, and since they are bigger governments with possibly stronger planning teams to present successful projects and invest higher amounts of royalties. The highest elasticities are those for equipment (0.176) and community development (0.155). These results imply that after the reform, in these sectors there were disproportional higher investments in producing than in non-producing municipalities, due to oil price increases even if by means of the reform all municipalities received royalties.

Table 7. Municipalities: effects on public investment before and after 2012 reform

Sectors	Oil production x log oil price	Elasticity	Observations	R-square	Number of municipalities
Total					
Pre reform	-0.116	0	3,183	0.056	1,099
	(0.275)				
Post reform	0.390**	0.025	6,588	0.256	1,100
	(0.162)				
PWBS					
Pre reform	-0.107	0	3,174	0.034	1,098
	(0.732)				
Post reform	1.015**	0.064	6,512	0.097	1,100
	(0.499)				
Recreation and sports					
Pre reform	-0.628	0	3,169	0.063	1,099
	(0.487)				
Post reform	1.548***	0.098	6,577	0.182	1,100
	(0.511)				
Community development					
Pre reform	-1.177	0	2,326	0.009	1,013
	(1.919)				
Post reform	2.453*	0.155	4,852	0.017	1,069
	(1.290)				
Equipment					
Pre reform	0.517	0	3,042	0.020	1,093
	(1.137)				
Post reform	2.790*	0.176	6,251	0.083	1,100
	(1.457)				
Disasters prevention					
Pre reform	0.585	0	2,958	0.114	1,087
	(2.046)				
Post reform	1.438*	0.091	6,025	0.033	1,100
	(0.858)				
Promotion of development					
Pre reform	-1.073	0	2,092	0.012	913
	(2.026)				
Post reform	2.396***	0.151	4,376	0.032	1,032
	(0.875)				

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

These findings are consistent for at least two reasons. First, as a result of the reform royalties are now free to be allocated in any sector, and not only health, education, nutrition and PWBS as they should be before the reform, and then departments and municipalities increased investments, more than proportionally, in other sectors. This is consistent with our results, since no effects were found in the post-reform period for those previous legislation's conditioned sectors, with PWBS as the only exception. Second is that non-oil producing subnational governments did not have the experience and the institutional capacity to operate all these additional resources. These results are of major interest for policy decisions since they show that oil-producing local governments still have considerable incentives to continue producing after the 2012 reform that, together with the oil boom, are related to disproportional increases in public investments when compared with the non-producing departments and municipalities.

4.3 Lagged effects of oil price shocks

In this sub-section we assess the potential lagged effects of the most recent oil boom on local public investments, on the grounds of the usual legal and political constraints faced by local governments. This since new elected governments have a first accommodation and planning stage after taking office before they are able to start implementing investment projects. Then, it is expected that income windfalls have differential effects over time, which has important policy implications.

Based on equation (7) we estimate models, by sector, including four lags of the oil price. This is based on local government's long-term development plans and the electoral cycle taking place every four years.

For departments, dynamic specification shows no contemporaneous effect (t-1) on total investments (column 1), and a negative and weak effect on period t-3 (Table 8). On the other hand, when looking at individual sectors (columns 2 to 10) we identified two interesting patterns. First is for agriculture, attention to vulnerable population, environment, and culture, having positive first period effects turning later into negative or zero for most of the remaining lags. The second group of sectors, PWBS, Public services, education, and promotion of development, characterize for having zero contemporaneous effects and some later positive and negative estimates, going on and off without a clear pattern.

Table 8. Dynamic specification on departments' public investment

Dependent variable	(1) Total	(2) Agriculture	(3) Attention to vulnerable population	(4) Environment	(5) Culture	(6) Penitentiary centers	(7) PWBS	(8) Public services	(9) Education	(10) Promotion of development
Oil production x log oil price (t-1)	0.352	1.954**	1.291**	2.252**	0.573*	-2.719**	-0.184	0.980	-0.0670	0.666
	(0.291)	(0.733)	(0.471)	(0.878)	(0.286)	(1.176)	(0.752)	(2.064)	(0.0855)	(1.495)
Oil production x log oil price (t-2)	-0.0608	-1.042**	-1.190*	-1.286	-0.380	0.698	0.891	-2.088	0.157**	-1.545
	(0.186)	(0.409)	(0.671)	(0.805)	(0.284)	(1.731)	(0.566)	(2.590)	(0.0646)	(1.508)
Oil production x log oil price (t-3)	-0.381*	-0.321	-0.526	2.743***	0.318	-1.038	-3.725**	1.679	-0.214	-2.091**
	(0.209)	(0.805)	(1.230)	(0.916)	(0.408)	(1.447)	(1.818)	(1.582)	(0.244)	(0.996)
Oil production x log oil price (t-4)	0.309	0.327	-0.508	0.796	-0.134	-0.527	2.138	-1.511	0.0436	-1.434
	(0.406)	(1.709)	(0.696)	(0.946)	(0.320)	(1.092)	(1.659)	(0.750)	(0.242)	(1.769)
Observations	185	170	185	155	185	44	183	113	185	175
R-squared	0.381	0.257	0.410	0.266	0.329	0.418	0.176	0.207	0.258	0.140
Number of municipalities	32	31	32	32	32	18	32	29	32	32

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

A similar dynamics is also present for municipalities (Table 9). In this case prioritized sectors, those where the contemporaneous effects (t-1) are positive, are equipment, recreation and sports, public services, promotion of development, environment, and institutional strengthening. These effects, as it happens for departments, disappear or become negative for the next period. There is also another group of municipalities for which there is not contemporaneous effects, and with no clear dynamic patterns (transportation, attention to disasters and community development).

Table 9. Dynamic specification on municipalities' public investment

Dependent variable	(1) Total	(2) Equipment	(3) Recreation and sports	(4) Public services	(5) Promotion of development	(6) Environment	(7) Institutional strengthening	(8) Penitentiary centers	(9) Transportation	(10) Disasters attention	(11) Community development
Oil production x log oil price (t-1)	0.813***	2.988***	3.590***	4.006***	5.446***	3.855**	1.886**	-6.096***	1.156	2.289	0.0244
	(0.237)	(1.772)	(1.106)	(1.086)	(1.523)	(1.632)	(0.950)	(1.867)	(1.858)	(1.438)	(1.536)
Oil production x log oil price (t-2)	-0.400	-0.0196	-2.672***	-4.814***	-5.123**	-5.143**	-0.114	6.003***	-0.477	0.767	3.729**
	(0.325)	(2.231)	(0.954)	(1.143)	(2.605)	(2.082)	(0.656)	(1.750)	(2.620)	(1.575)	(1.856)
Oil production x log oil price (t-3)	0.963	2.819	3.056	4.421**	2.196	4.530**	1.564	0.820	8.018**	6.620***	-0.776
	(0.599)	(2.969)	(1.945)	(2.222)	(2.886)	(2.296)	(1.388)	(7.048)	(3.180)	(1.956)	(1.791)
Oil production x log oil price (t-4)	0.114	-1.298	0.484	0.702	0.221	-1.425	-0.867	-8.525***	-1.223	-0.473	-1.455
	(0.342)	(1.171)	(0.977)	(0.651)	(0.724)	(1.086)	(0.733)	(3.258)	(1.332)	(0.825)	(1.576)
Observations	6,588	6,251	6,577	5,944	4,376	5,782	6,547	1,956	6,547	6,025	4,852
R-squared	0.256	0.083	0.183	0.059	0.033	0.063	0.061	0.074	0.236	0.036	0.017
Number of municipalities	1,100	1,100	1,100	1,087	1,032	1,097	1,100	711	1,100	1,100	1,069

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

A general overview of the results let us identified for both, departments and municipalities, the sectors where they have prioritized interests. Nevertheless, as time passed, in average, there is lower interest in these sectors or a potential unsustainability of the projects, which results into relative negative to zero effects. A second possible explanation is that local governments do not use to have long-term investment programs, meaning that they were only planning for the very short term. A third explanation might be related to the deep fall of the international oil prices after 2015, since the largest decrease of total public investment in Colombia occurred in 2016. The average annual oil price went from 95 USD between 2011 and 2014, to 51 USD in 2015.

These findings are consistent with procyclical investment policies, where governments are prone to increase their spending during booms. According to the literature this practice is not the best idea, and is usually related to short-term planning, since international prices of natural resources highly volatile (Devlin, 2005). This leads to strong and unexpected cuts to public investment, causing negative consequences on social and economic development.

5. Conclusions

This paper explores for the first time the causal relationship between the most recent oil boom and subnational investment in Colombian recent history. The main driver of this research is establishing if exogenous international variations, which expand the fiscal constraints, increase individuals' welfare. The potential mechanism that we address in this paper is the public investment. Although the results show mostly positive effects for a group of economic and social sectors, increases in public investments doesn't necessarily imply population's improvements in well-being or the quality of life. Previous literature has shown that economic growth, whatever its source, is highly related to poverty reductions (Obando and Adrian, 2016). For Colombia, Fedesarrollo (2018), exploring the causal relationship between the royalties' reform and welfare indicators, found positive effects.

In this paper we identified key sectors for both, departments and municipalities, for which the effects from the oil boom were positive and significant. Departments, for example, focused on transportation, justice, attention to vulnerable population, recreation and sports, agriculture, environment, and culture, while municipalities targeted equipment, recreation

and sports, public services, promotion of development, environment, justice and institutional strengthening as their main investments. A second result shows that the royalties' reform in 2012 was the main driver of the effect from the oil boom to subnational investments for both, departments and municipalities. This makes sense since, previous to the reform, only oil producers were receiving royalties, while after 2012 all departments and municipalities are allowed to receive royalties based on their population size and poverty indicators, among others. A third result is related to the temporal dynamics of the effects. We found groups of sectors with positive contemporaneous effects, which disappear or turn into negative as time passes. Three hypothesis arises as potential explanations: (1) loss of interest or unsustainability of the projects, (2) short-term planning programs, and (3) the fall in the international oil prices.

These results have important policy implications that should be considered for future natural resources booms. Investments financed with income windfalls should be grounded on long-term basis and be sustainable over time. Ideally, investments should mainly focus on sectors with high social returns and infrastructure development. Even if public investment has proven to have positive consequences on the economy, it is a challenging task for underdeveloped and developing countries to properly allocate income windfall considering their low fiscal surpluses, their high vulnerability to international shocks and their fiscal adjustment through public investment in times of fiscal austerity. As our results suggest, the strong dependence of public investment on oil price variations and its unstable evolution could be the drivers of the undermined impact on social and economic development.

References

Acemoglu, D., & Robinson, J. A. (2013). *Why nations fail: The origins of power, prosperity, and poverty. Crown Books.*

Adler, G., & Magud, N. (2013). Four Decades of Terms-of-Trade Booms: Saving-Investment Patterns and a New Metric of Income Windfall. *IMF*. WP/13/103.

Angrist, J., & Pischke, J. (2009). *Mostly harmless econometrics: an empiricist companion*. Princeton: Princeton University Press.

Aschauer, D. (1989). Is government spending productive? *Journal of Monetary Economics*, 23, 177-200.

Asher, S., & Novosad, P. (2018). Rent-Seeking and Criminal Politicians: Evidence from Moning Booms. *Mimeo.*

Asociación Nacional de Instituciones Financieras – ANIF. (2016). Efectos comerciales del fin del superciclo de commodities. *Anif – Comentario económico del día.* Bogotá.

Bonet, J., Pérez, G., & Ayala, J. (2014). Contexto histórico y evolución del SGP en Colombia. *Documentos de trabajo sobre Economía Regional*, 205, 1-60. Banco de la República – Centro de Estudios Económicos Regionales (CEER).

Bonet, J., & Pérez, G. (2017). Financiamiento y calidad del gasto social en la región Caribe colombiana. *Documentos de Trabajo Sobre Economía Regional y Urbana*, No. 262, 1-36. Banco de la República – Centro de Estudios Económicos Regionales (CEER).

Bonilla-Mejía, L., & Higuera-Mendieta, I. G. (2017). Political alignment in the time of weak parties: Electoral advantages and subnational transfers in Colombia. *Documentos de Trabajo Sobre Economía Regional y Urbana; No. 260*.

Bonilla, L. (2019). Illegal Mining and Human Capital Accumulation: Evidence from the Colombian Gold Rush, *Documentos de Trabajo sobre Economía Regional y Urbana*, no. 280. Banco de la República – Centro de Estudios Económicos y Regionales (CEER).

Cárdenas, M., Escobar, A., & Gutiérrez, C. (1995). La contribución de la infraestructura a la actividad económica en Colombia 1950-1994. *Ensayos sobre política económica,* 28, 139-187.

Céspedes, L.F., & Velasco, A. (2012). Macroeconomic Performance During Commodity Price Booms and Busts. *NBER Working Paper Series,* WP-18569.

De Haan, J., Sturm, J.E., & Sikken, B.J. (1996). Government Capital Formation: Explaining the Decline. *Weltwirtschaftliches Archiv,* 132(1), 55-74.

Devarajan, S., Swaroop, V., & Zou, H. (1996). The composition of public expenditure and economic growth. *Journal of Monetary Economics,* 37(2), 313-344.

Devlin, J. (2005). Managing oil booms and busts in developing countries. *Managing economic volatility and crises: a practitioner's guide.*

Dibooglu, S., & Aleisa, E. (2004). Oil prices, terms of trade shocks, and macroeconomic fluctuations in Saudi Arabia. *Contemporary Economic Policy,* 22(1), 50-62. Western Economic Association International.

Dube, O., & Vargas, J. (2013). "Commodity Price Shocks and Civil Conflict: Evidence from Colombia", *The Review Of Economic Studies*, *80*(4), 1384-1421. doi: 10.1093/restud/rdt009

Easterly, W., & Rebelo, S. (1993). Fiscal Policy and Economic Growth: an Empirical Investigation. *Journal of Monetary Economics,* 32(3), 417-458.

Easterly, W., Irwin, T., & Servén, L. (2007). Public investment and fiscal stability. *World Bank Policy Research Working Paper,* 4158, 1-32.

El-Anshasy, A., Bradley, M.D., & Joutz, F.L. (2005). Evidence on the Role of Oil Prices in Venezuela's Economic Performance.

Fedesarrollo. (2017). *Comisión del gasto y la inversión pública: Informe final.* Bogotá: Fedesarrollo.

Fedesarrollo. (2018). Evaluación de los impactos causados en las regiones productoras de hidrocarburos y minerales con el actual Sistema General de Regalías. Bogotá: Fedesarrollo, 143 p. Informe final. 5 vols.

Fernández, C. & Villar, L. (2014). Bonanzas temporales de recursos: una perspectiva global. *Monetaria.* 178-232.

IMF. (2005). Public Investment and Fiscal Policy – Lessons from the Pilot Country Studies. International Monetary Fund.

Macklem, R.T. (1993). Terms-of-Trade Disturbances and Fiscal Policy in a Small Open Economy. *The Economic Journal,* 103(419), 916-936. Wiley on behalf of the Royal Economic Society.

Marín, L.; Bonet, J.; Pérez, G. (2018). "¿Cuál es la dimensión y en qué se gastó la reciente bonanza en Colombia?", *Documentos De Trabajo Sobre Economía Regional y Urbana*, No. *273*, 1-47. Banco de la República – Centro de Estudios Económicos Regionales (CEER).

Martínez, L.R. (2016). Sources of revenue and government performance: evidence from Colombia. *Available at SSRN: https://ssrn.com/abstract=3273001 or http://dx.doi.org/10.2139/ssrn.3273001*.

Mehrara, M., & Mohaghegh, M. (2011). Macroeconomic Dynamics in the Oil Exporting Countries: A Panel VAR study. *International Journal of Business and Social Science,* 2(21), 288-295. Centre for Promoting Ideas.

McMahon, G. (1997). The Natural Resource Curse: Myth or Reality? *Mimeo.* World Bank Institute.

Mehrotra, A.; Välilä, T. (2006). "Public Investment in Europe: Evolution and Determinants in perspective", *Fiscal Studies*, *27*(4), 443-471.

Murphy, R.G. (1992). The Terms-of-Trade, Investment, and the Current Account. *Journal of International Economic Integration,* 7(1), 58-79. Center for Economic Integration, Sejong University.

Obando, N., & Andrian, L. G. (2016). *Measuring Changes in Poverty in Colombia: The 2000s*. Inter-American Development Bank.

Ocampo, J.A., & Revéiz, E. (1979). Bonanza cafetera y economía concertada. *Revista Desarrollo y Sociedad*, 2.

Ocampo, J.A. (2007). La macroeconomía de la bonanza económica latinoamericana. *Revista de la CEPAL N°93,* Santiago de Chile.

Ossowaki, R., & Gonzáles, A. (2012). Manna from Heaven: The Impact of Nonrenewable Resource Revenues on Other Revenues of Resource Exporters in Latin America and the Caribbean. *IDB Working Paper Series,* 337. Washington, D.C.

Perdomo, A. (2002). Inversión Pública Sectorial y Crecimiento Económico: Una Aproximación desde la Metodología VAR. *Archivos de Economía,* 208. Departamento Nacional de Planeación, República de Colombia.

Sachs, J. D., & Warner, A. M. (1999). The big push, natural resource booms and growth. *Journal of development economics*, *59*(1), 43-76.

Serrano, J.C. (2013). Análisis dinámico de la recaudación tributaria en el Ecuador aplicando modelos VAR. *Revista Fiscalidad*, 123-167. Guayaquil.

Servén, L. (1999). Terms-of-trade shocks and optimal investment: another look at the Laursen-Metzler effect. *Journal of International Money and Finance,* 18, 337-365.

Seymour, L.J.M. (2000). East timor's resource curse? *Far Eastern Economic Review,* 163, 36-36.

Spatafora, N., & Warner, A. (1995). Macroeconomic Effects of Terms-of-Trade Shocks. *Policy Research Working Paper Series,* 1410, 1-37. World Bank.

Suescún, R. (2007). The role of fiscal policy in human development and growth. World Bank.

Usui, N. (1997). Dutch disease and policy adjustments to the oil boom: A comparative study of Indonesia and Mexico. *Resources Policy,* 23(4), 151-162

Appendix Section

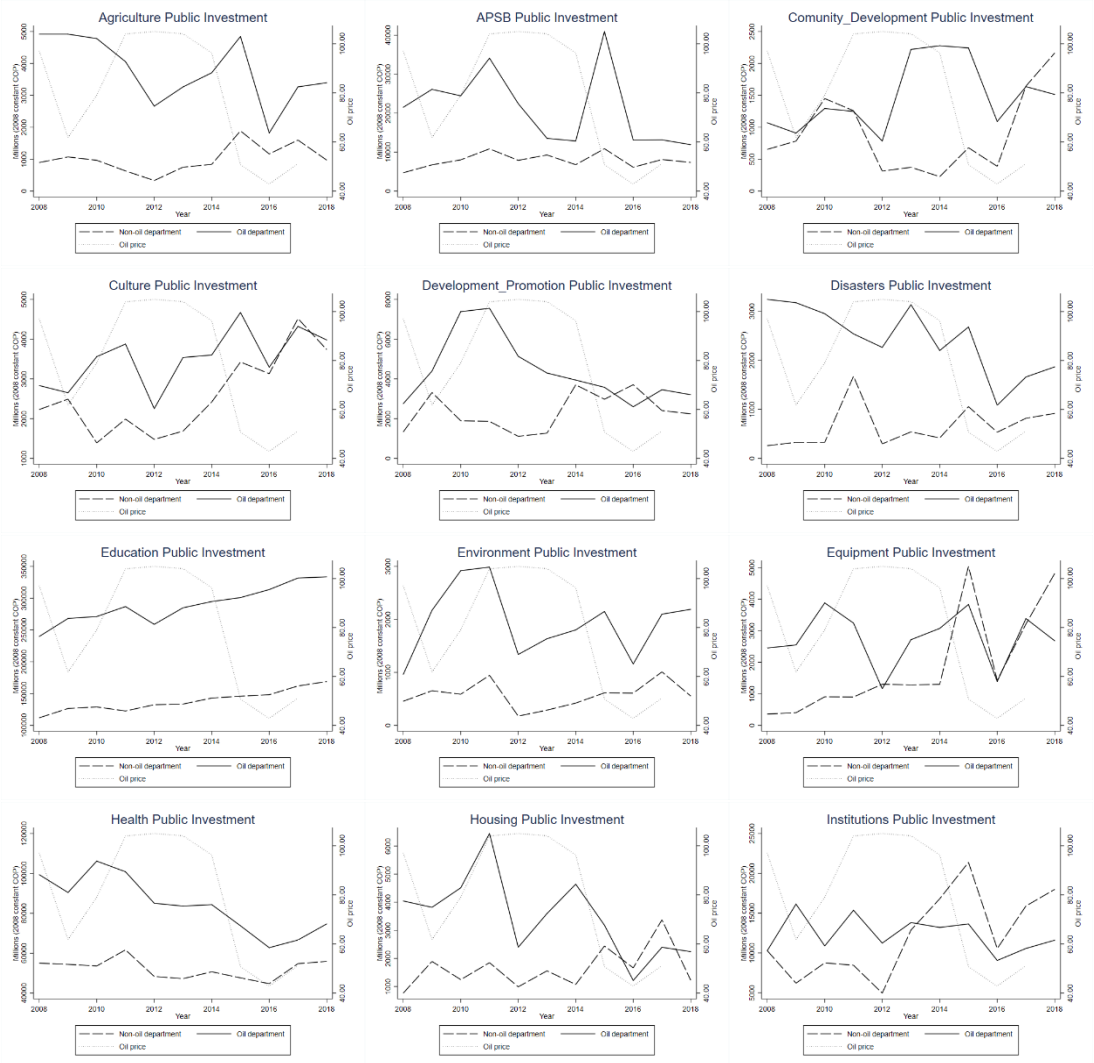
Appendix A. Data sources

Table A1. Data sources.

Variable name	Period	Aggregation level	Source
International oil price	2008-2017	International	IFS-IMF
Interest rate	2008-2017	National	Central Bank
CPI	December 2018	National	DANE
Population	2008-2017	Department/Municipality	DANE
Public investment by sector	2008-2017	Department /Municipality	CHIP-FUT
Central government transfers	2008-2017	Department/Municipality	DNP
Tax revenues	2008-2017	Department/Municipality	DNP
Average barrels per day	2008	Municipality	ANH-MME

Appendix B. Public investment trends
(Oil producing and non-producing local governments)

Figure B1. Public investment by sector in oil producing and non-oil producing departments



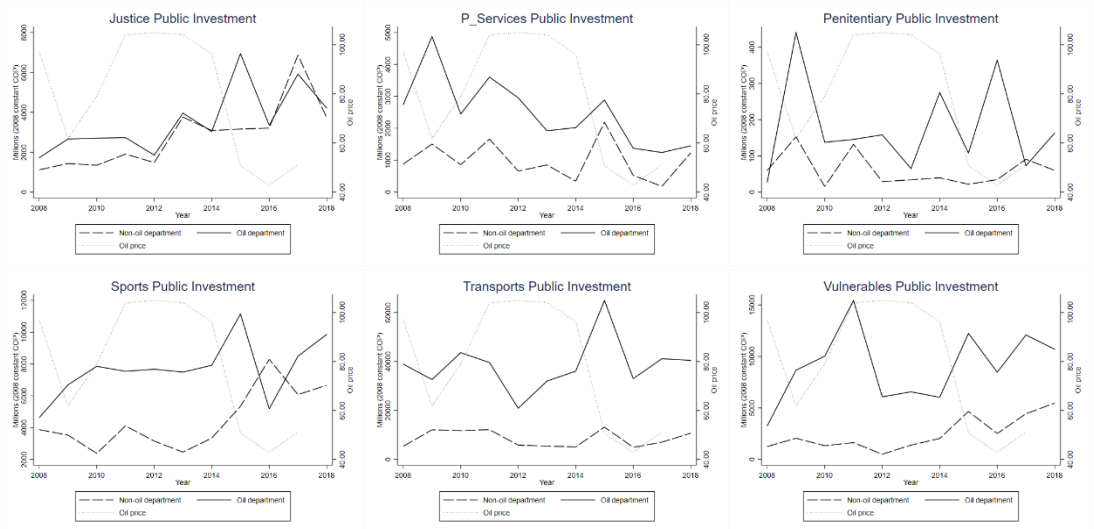
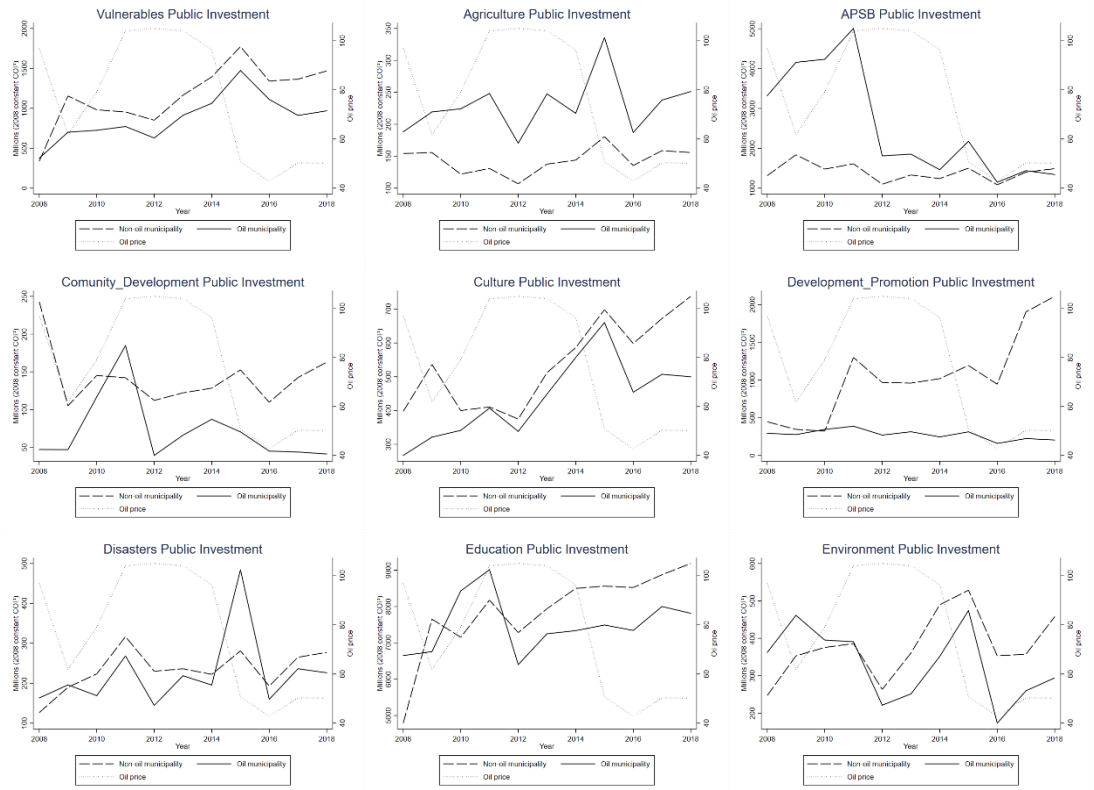
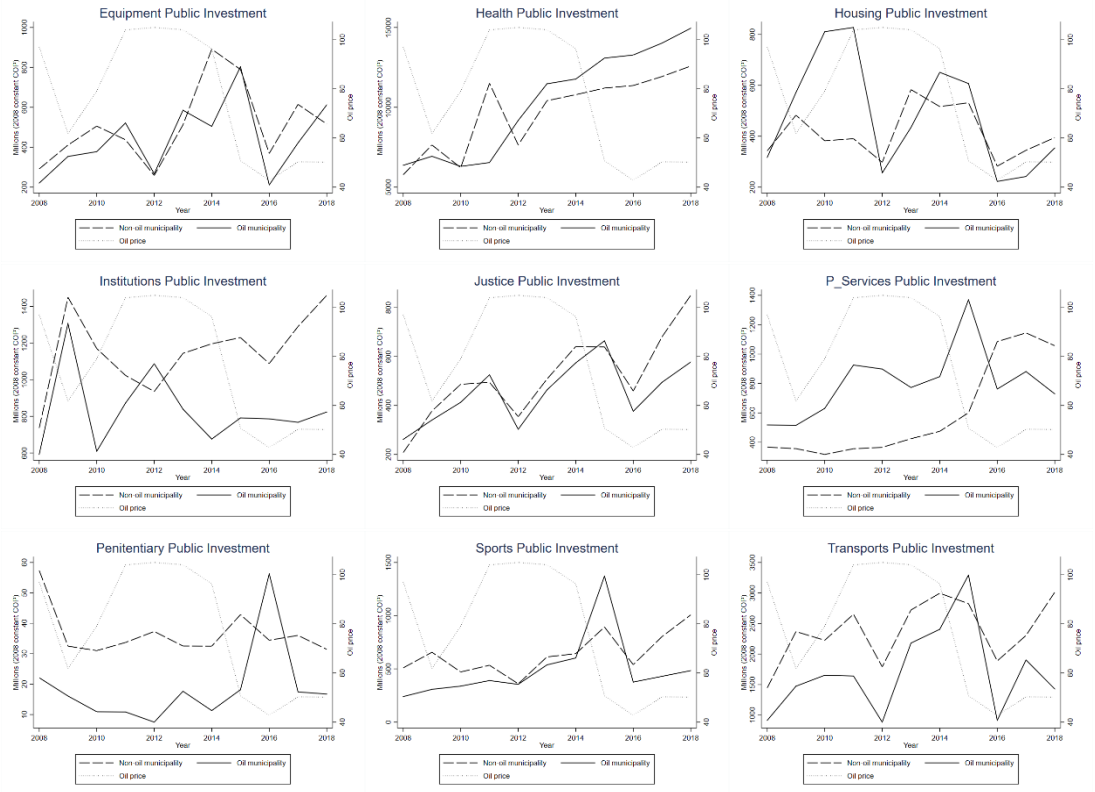


Figure B2. Public investment by sector in oil producing and non-oil producing municipalities




Equipment Public Investment
Health Public Investment
Housing Public Investment
Institutions Public Investment
Justice Public Investment
P_Services Public Investment
Penitentiary Public Investment
Sports Public Investment
Transports Public Investment
Millions (2008 constant CO^{2})
Oil price
Year
Non oil municipality
Oil municipality
Oil price

Appendix B. Baseline model for departments

Table B.1 Total

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.0818*** (0.0250)	0.167* (0.0827)	0.221** (0.0934)	0.221** (0.0934)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	283	283	283	283
R-squared		0.178	0.274	0.274
Number of departments	32	32	32	32

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

Table B2. Agriculture

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.253*** (0.0745)	0.993*** (0.227)	0.882*** (0.243)	0.882*** (0.243)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	262	262	262	262
R-squared		0.100	0.215	0.215
Number of departments	31	31	31	31

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

Table B3. Attention to vulnerable population

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.125 (0.0760)	0.391 (0.292)	0.782*** (0.269)	0.782*** (0.269)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	282	282	282	282
R-squared		0.149	0.294	0.294
Number of departments	32	32	32	32

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

Table B4. Penitentiary centres

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.0335 (0.101)	-1.004 (0.962)	-1.656** (0.660)	-1.656** (0.660)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	77	77	77	77
R-squared		0.137	0.295	0.295
Number of departments	21	21	21	21

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

Table B5. Recreation and sports investment

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.173*** (0.0503)	0.865** (0.331)	0.835** (0.357)	0.835** (0.357)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	280	280	280	280
R-squared		0.052	0.128	0.128
Number of departments	32	32	32	32

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

Table B.6 Justice

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.144* (0.0836)	0.448 (0.299)	0.593** (0.287)	0.593** (0.287)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	269	269	269	269
R-squared		0.149	0.264	0.264
Number of departments	32	32	32	32

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

Table B.7 Transportation

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.207** (0.0841)	0.855*** (0.262)	0.953*** (0.249)	0.953*** (0.249)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	278	278	278	278
R-squared		0.175	0.231	0.231
Number of departments	32	32	32	32

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

Appendix C. Baseline models for municipalities

Table C.1 Total

Dependent variable	(1) Total	(2) Total	(3) Total	(4) Total
Oil production x log oil price (t-1)	0.263*** (0.0426)	0.0459 (0.118)	0.172 (0.143)	0.172 (0.143)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,771	9,771	9,771	9,771
R-squared		0.225	0.263	0.263
Number of municipalities	1,100	1,100	1,100	1,100

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

Table C.2 Recreation and sports

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.0957 (0.0894)	0.979** (0.463)	1.037** (0.483)	1.037** (0.483)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,746	9,746	9,746	9,746
R-squared		0.122	0.174	0.174
Number of municipalities	1,100	1,100	1,100	1,100

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

Table C.3 Equipment

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.0808 (0.146)	1.758 (1.175)	1.970* (1.196)	1.970* (1.196)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,293	9,293	9,293	9,293
R-squared		0.043	0.061	0.061
Number of municipalities	1,100	1,100	1,100	1,100

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

Table C.4 Institutional strengthening

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.248* (0.135)	1.250** (0.619)	1.715*** (0.625)	1.715*** (0.625)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,677	9,677	9,677	9,677
R-squared		0.089	0.100	0.100
Number of municipalities	1,100	1,100	1,100	1,100

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

Table C.5 Justice

Dependent variable	(1)	(2)	(3)	(4)
Oil production x log oil price (t-1)	0.359*** (0.105)	0.710 (0.612)	0.996* (0.604)	0.996* (0.604)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,718	9,718	9,718	9,718
R-squared		0.161	0.209	0.209
Number of municipalities	1,100	1,100	1,100	1,100

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