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

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Abstract

Theoretical and empirical studies have focused on measuring the relationship between oil price shocks and macroeconomic performance in developing countries. However, most of this research have failed to determine a 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 oil boom, brought by the rise in international oil prices, had positive and disproportionate effects of public investments on producing departments and municipalities. In particular, 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 were the sectors that benefited most: institutional strengthening, justice, equipment, and recreation and sports.

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1. Introduction

Natural resource booms are an area of economic research that has been broadly studied for several decades, mainly focused on developing countries because of their large share of natural resources on the total production. This implies a high dependence on international price variations and consequently that their economic performance is likely to be affected through several channels on different sectors of the national 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 the international price of commodities (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, among others, 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 in 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 make the most of the extra resources and maximizes the population's well-being. For example, investment in tradable goods, and prioritizing sectors with higher social returns such as health, education or attention to vulnerable population, have proven to increase the likelihood of a better exploitation 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 side effects, coming from the sudden variations in prices of commodities, 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 also doubts whether these resources were properly allocated.

The potential mismanagement of income windfall in Colombia has been one of the central issues in public discussions over the recent years (Anif, 2016). Nevertheless, to the best of our knowledge, there is not any empirical research for Colombia analysing which economic sectors benefited the most, or even if oil boom caused any effect on public investments. The only approach has been that of Marín *et al.* (2018) who mentioned timing coincidences between oil booms and increases in public investments, especially regarding sectors such as health, transportation and social services.

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. For example, 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 increases revenues and public investment.

This paper contributes to the literature in going a step forward and analysing if there is any evidence on whether the most recent oil boom in Colombia had a causal effect on local public investment. The focus of this analysis is then to measure if there was any disproportionate increase in public investment in oil producing departments as a result of increases in international oil prices. The empirical approach also considers legal framework changes in royalties in 2012 as a potential source of heterogeneous effects, 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 both departments during the oil boom. However, when considering a dynamic specification, we fail to demonstrate a causal effect on total public investment at the department level. For the municipality level analysis, the pattern is the opposite as in the baseline model we do not find any effect, while in the dynamic model we estimate a 0.051 oil price elasticity of public investment in oil producing municipalities for the first lag. This effect is smaller than the elasticity found by Spatafora and Warner (1995) in their cross-country analyses as they found a 0.57 oil price elasticity of national public investment. The difference between those estimates is potentially due as we employ a quasi-experimental approach, therefore our estimates consider causal relationships rather than spurious correlations. For the prioritize sectors at the department level, we found that oil price increases disproportionately affected investment on sectors with high social returns such as agriculture, attention to vulnerable population, culture, education and, recreation and sports. As well, oil producing departments increased investment on infrastructure due to oil price increases. However, in some sectors the evolution of public investment was pro-cyclical as investments had to be reduce after the falling of the oil price. Similarly, the same patters were found for the municipality analysis as sectors prioritize are related with high social returns and infrastructure development. For the municipality governments, there was an effort to increase investment on institutional strengthening which is a fundamental for long run economic development. However, the cyclicality also occurred in development promotion, environment, public services and, recreation and sports.

In our econometric specification, we consider the potential heterogeneity caused by legal framework reform, implemented in 2012, on public investments. For both, departments and municipalities, over most of the sectors a positive effect was found in the period after the reform. Additionally, for departments we found negative effects on particular sectors during the period prior the reform. For departments we found a negative effect prior the reform on for reclusion centres, culture, community development and development promotion. For the municipality analysis, our results do not suggest a negative effect in any sector. However, for institutional investment we found a positive effect on both periods, prior and after the reform. Those results are compelling as the reform aimed to distribute royalties' resources amongst every local government independently their producing condition.

Therefore, it is relevant that after the equalizer policy a disproportionate positive effect takes place in oil producing entities.

The remainder of this paper is organized as follows: Section 2 presents a brief review of the relevant literature on oil shocks, public investment and the Colombian context. Section 3 describes our methodological approach and a detailed description of the data used. Section 4 explains econometric results and computes oil price elasticities of public investment. 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.[2] However, this paper moves away from this approach as it focuses on the management of the resources generated during the oil booms. Some authors try 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 the current account deficit, while in the short run the effect on investment and the current account depends on the economy's fundamentals. On the other hand, Macklem (1993) finds 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 econometrics. 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 consequences. El-Anshasy *et al.* (2005), analysing the relationship

[2] The Dutch Disease is commonly known for its macroeconomic negative effects in countries with significant participation of natural resources on the 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 the international markets. Thus, natural resource producing countries are highly vulnerable because of their low production diversification, and hence vulnerable to volatility of the international price of commodities.

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 and also 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.[3] Further studies found decreasing GDP per capita in Latin American countries during boom periods (Sachs and Warner, 1999; Seymour, 2000).[4] 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 conditioned to economic policy rather than a curse of natural resources.

One question arising at this stage is what factors have been identified as the main determinants of public investments. Despite the large evidence of positive effects of public investment in the economy (Aschauer, 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, the main findings at this respect aim 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. Coherent with a common wisdom agreement about the decrease of public investment since the seventies, Easterly *et al.* (2007) found for Latin America that the reduction of public investment has not been offset by private investment, which reduces productive spending and hinders sustainable growth for a rapid reduction of poverty.

For Colombia, 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. Nevertheless, even though most of public spending goes to investment, outcomes might not reflect those figures, possibly because some current expenditures are included in capital spending account.

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

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-conditionate- 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. One of the underlying goals of the reform was to reinforce a system, which reduced inequalities amongst departments and municipalities, as all could perceive resources from minerals and hydrocarbons production. Local governments' participation in royalties depends now not only on the producer condition but also on their population size and poverty indicators. The way local governments can have access to these resources is by presenting projects to improve their residents' quality of life.

3. Methodology and data

3.1 Methodology

A difference-in-differences approach is used 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. The non-oil-producing departments and municipalities are used as the control group. 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 amount of resources, in Colombian pesos (COP), invested by each department and municipality. In this case, 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.[5] For the oil price we employ the one year lagged value as Colombian budgeting process impedes 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). 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.

Our empirical approach also deals with the change in the legal framework of royalties taking place in 2012. Before this year, royalties from mineral production were distributed only among municipalities and departments in which minerals were produced, conveyed and gathered. Additionally, royalties had specific destination investment sectors. From 2012 the SGR was implemented, under which 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 sectors where to invest the money. All this after the presentation and approval of projects that contribute to the improvement of individuals' socioeconomic conditions.[6] 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 where 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.

Commented [PVGJ1]: Aquí es importante decir qué sectores; seguro la pregunta va a surgir!!! Y seguramente nos van a preguntar si son los mismos sectores para los cuales encontramos efectos.

In order to determine whether changes in international oil prices disproportionately affected public investment in producing departments and municipalities, a difference-in-differences approach is used. The specification is given by:

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

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; $\text{Oil}_{\text{i,2008}}$ 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 carbon producing departments, a dummy variable equal to 1 from 2012 onwards to consider the legal framework change of royalties, population, central government transfers, and tax revenues in department/municipality i, region r and year t. $X_{i,r,t}$ also

[5] 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.

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

includes Colombian intervention interest rate for year t.[7] γ is our estimate of interest, which is not the price elasticity of public 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:

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

where $\varepsilon(\gamma, \text{Oil}_{\text{i,r,2008}})_{op,pi}$ 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:

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

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

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

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

In other words, one percent change in the international oil price causes a $0.35\gamma/0.063$ 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:

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

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.

4.2. Data

Our data on public investment 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). This dataset contains, among others, information on local government's public investment by sector from 2008 to 2017, which let us build a panel dataset for the 32 departments and 1100 municipalities.[8] The data is transformed from current

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

[8] 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

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).

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	349	.724	1.620	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

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.

Intervention interest rate	349	5.177	1.826	3.16	9.81
Royalties legal framework change	349	.642	.480	0	1
Carbon 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	12,108	.023	.170	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
Carbon producing departments	12,108	.548	.498	0	1

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).[9] A detailed summary of the whole data set is in Table 1. It is worth mentioning that for the estimation of the oil price elasticity the average oil production, in oil producing departments, is 34.100 barrels/day and 6.300 barrels/day for the mean oil producing municipality.

Figure 1. Total public investment in oil producing and non-oil producing departments/municipalities

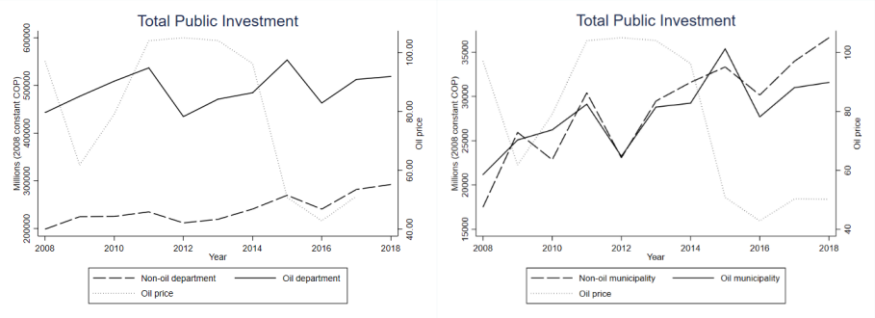


Figure 1 shows the dynamics of total public investment for oil and non-oil producing departments and municipalities, where a general upward trend is noticeable. The most evident difference between departments and municipalities is the large difference between producing and non-producing departments, 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).

A second characteristic has to do with the two deep drops of public investment, in 2012 and 2016. The first event coincides with the royalties' reform and might reflect the uncertainty faced by local governments with the upcoming changes. The second drop in 2016 seems to be more related with the international price drop 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. These potential delayed effects from oil prices on public investments are taken into account in the estimations.

[9] Detail information about variables, period, aggregation levels and sources are presented in Table 1 of Appendix 1.

A third characteristic has to do with the apparent 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. Supporting this assumption, Bonilla and Higuera (2017) found larger transfers from the national government to municipalities where mayors were part of the same political party of the President, suggesting a potential link between transfers and the electoral cycle. This cyclical behaviour has two potential sources. First is the so called "Ley de Garantías" (Law 996/2005), a regulation intending to avoid clientelistic practices, prohibiting direct public procurement during the 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 of cyclicality is that, during the first year of their administration, new elected governments focus their efforts towards the design and approval of their investment programs, while in the following years they implement and execute these policies increasing public investment.

Appendix E shows, by sector, the evolution of public investment. Although it is not possible to identify a unique pattern, we observe some interesting characteristics. First is that for 10 out the 18 sectors, public investment in oil producing departments is larger than in non-producing departments for the entire sample, which makes sense since producers receive more royalties. Second, there seems to be a generalized change 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 gaps between them 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. A third characteristic is that particular sectors, such as education and health, have a steadier pattern. Education, for example, has a consistent increasing trend, making evident the fact that education is a basic service still far from universal coverage.[10] Health, on the other hand has a slight decreasing pattern which is consistent with the almost universal coverage. A fourth characteristic is that the electoral cycle is less evidentwhen investment is disaggregated by sector.

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, and then we move on to a two-period specification looking for the potential heterogeneous effects coming from the before and after new royalties' system. Finally, we aim to find lagged effects of oil price shocks on public investment. For both, the baseline and the dynamic specifications, we present results for sectors in which significant effects were found. The Appendix section shows results for the whole set of sectors.

4.1. Effects of oil price shocks on local public investment

Theoretically consistent, regression results suggest a positive association between the oil boom and public investment. Table 3 presents the first evidence of a causal relationship between the most recent oil boom in Colombia and local governments' public investment. The estimates are positive,

[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.

statistically significant and robust to different specifications. Additionally to total public investment, this positive, consistent and robust effect was also found in 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, is that they might have other sources of financing. For example, health and education have as their main financing source national transfers (SGP), the own-source revenues and the national government investments. Econometric results for all sectors, showing their robustness and consistency under several specifications, are reported in Appendix B.

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

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

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

At municipal level, no effect was found when considering all sectors at once (Table 4). Nevertheless, when socioeconomic sectors are taken one at the time four of them stand out. Local authorities seem to have prioritized the oil boom windfall by prioritizing justice, equipment, institutional strengthening, and sports and recreation. Even though it is not possible to determine it through these results, investment increases in some sectors for both, departments and municipalities, might be related to recent significant events such as the peace treaty with the guerrillas, and the increasing migration from Venezuela.

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

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

With the purpose of offering an economic 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 for the Colombian economy is oil production, it is expected that changes in international prices affect macroeconomic fundamentals, and public investment correspondingly. This in turn will affect socioeconomic variables and general development and the 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 production of oil (Meta), the results show 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
Vulnerable population	0.267	0
Recreation and sports	0.285	0.065
Agriculture	0.301	0
Transports	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 larger 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 are equipment, for municipalities (0.124), and transportation, for departments (0.325).[11] 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 be invested in sectors with the highest social returns (Spatafora and Warner, 1995; Seymour, 2000).

4.2. Heterogeneous effects: before and after the reform in royalties

So far, the changes implemented with the new royalties' system in 2012 have been taken into account by means of a corresponding dummy variable. Nevertheless, we believe that this reform is source of potential heterogeneous effects. Then, this sub-section presents estimation results with different samples: the entire sample, the period prior the reform (2008-2011), and the period after the reform (2012-2017). We present the results for the main specification where the effect after the reform are

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

Commented [PVGJ2]: Creo que la descripción de esta subsección podría organizarse mejor. La primera parte está bien. Para el resto a la hora de describir los resultados es importante

1.Distinguir entre los de departamentos y municipios
2. Mencionar que todos los que resultaron significativos son positivos, tanto antes como después de la reforma.
3. Importante incluir una columna con las elasticidades.
4. Las columnas de esta y todas las tablas son muy anchas, al igual que las filas. Creo que se puede aprovechar mejor el espacio si se ajustan las filas y columnas al texto. Además lo hace mejor para el lector. Tal como está es pesado y poco amigable.
5. El análisis debería centrarse en las elasticidades. Y ahí mencionar los sectores en donde son mayores y los que son menores, etc.

Escribiendo esto veo que solo se incluyeron los resultados para los que los efectos después de la reforma dieron positivos y significativos!! Y entonces no estamos mostrando parte de los resultados; por ejemplo lo que dieron negativos y/o antes de la reforma. Ahora creo entender el párrafo de arriba, pero todo es un poco confuso. Porque pareciera que los efectos que dieron significativos son todos los que se muestran, y que todos dieron positivos.

positive and significant. However, the whole set of results, for every sector and level of analysis, are shown in the Appendix section.[12]

The objective is to explore the potential heterogeneous effects before and after the royalties' reform in 2012. For departments, we found six sectors in which there is a positive effect of oil price after the reform: agriculture, attention to vulnerable population, recreation and sports, justice, transportation and total public investment. The larger elasticity found for the period after the reform was in agriculture, implying that for a 10% increase in the oil price, agriculture investment increases in 4.06%. The total effect shows that, in average for all sectors, a 10% increase in the oil price increases the total public investment in 0.8%.

For municipalities, effects were found in seven sectors: PWBS, recreation and sports, community development, equipment, disasters prevention, development promotion and total public investment. In this case, the average effect on the total public investment was 0.025, with the highest elasticity was on equipment (0.176). These results imply that after the reform, in these sectors there was a disproportional higher investment in producing than non-producing municipalities, due to oil price increases even if by means of the reform all municipalities received royalties.

These results are of major interest for policy decisions since they show that oil-producing local economies still have considerable incentives to continue producing since the 2012 reform, together with the oil boom, are related to disproportional increases in public investment when compared with the non-producing departments and municipalities.

Table 6. Heterogenous effects on departments' public investment before and after 2012 reform

Sectors	Oil production x log oil price (t-1)	Elasticity	Observations	R-square	Number of departments
Agriculture	0.882***	0.301	262	0.215	31
	(0.243)				
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	0.782***	0.267	187	0.094	32
	(0.269)				
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	0.835**	0.285	280	0.128	32
	(0.357)				
Pre reform	-0.282	0	92	0.094	32
	(0.569)				
Post reform	0.904**	0.308	188	0.169	32
	(0.428)				
Justice	0.593**	0.202	269	0.264	32
	(0.287)				
Pre reform	-0.909	0	84	0.083	31

[12] For departments, a negative effect during the pre-reform period was found for reclusion centres, culture, community development and development promotion. This means that before the reform, departments and municipalities were investing disproportionality lower than non-producing due to oil price variations even if those entities were restricted from royalties' resources.

	(1.524)				
Post reform	0.732**	0.250	185	0.330	32
	(0.299)				
Transport	0.953***	0.325	278	0.231	32
	(0.249)				
Pre reform	0.224	0	91	0.193	32
	(0.559)				
Post reform	1.031***	0.352	187	0.287	32
	(0.294)				
Total	0.221**	0.075	283	0.274	32
	(0.0934)				
Pre reform	0.0685	0	93	0.184	32
	(0.0920)				
Post reform	0.246**	0.084	190	0.309	32
	(0.109)				

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

Table 7. Heterogenous effects on municipality's public investment before and after 2012 reform

Sectors	Oil production x log oil price	Elasticity	Observations	R-square	Number of municipalities
PWBS	0.369	0	9,686	0.117	1,100
	(0.545)				
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	1.037**	0.065	9,746	0.174	1,100
	(0.483)				
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	1.018	0	7,178	0.017	1,091
	(1.038)				
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	1.970*	0.124	9,293	0.061	1,100
	(1.196)				
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	1.027	0	8,983	0.050	1,100
	(0.972)				
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)				
Development promotion	1.542	0	6,468	0.033	1,067
	(0.997)				
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)				
Total	0.172	0	9,771	0.263	1,100
	(0.143)				

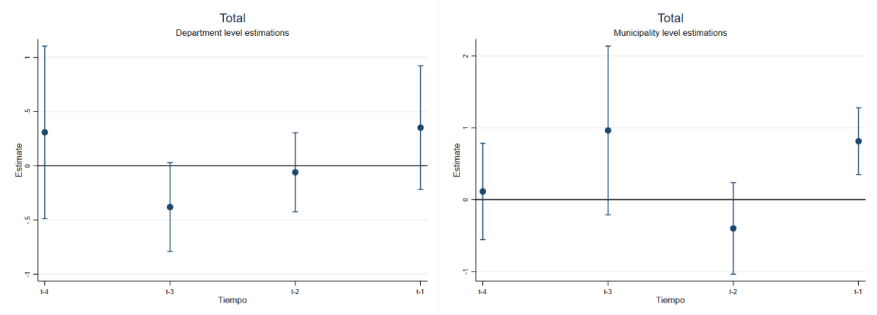
Pre reform	-0.116	0	3,183	0.056	1,099
	(0.275)				
Post reform	0.390**	0.025	6,588	0.256	1,100
	(0.162)				

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

4.3. *Lagged effects of oil price shocks*

In this sub-section we assess the potential lagged effects of oil boom on local public investment, on the grounds of the usual legal and political constraints faced by local governments when carrying out investment projects. The reason is that new elected governments have a first accommodation and planning stage after taking office before they are able to start performing investment projects. Then, it is possible that income windfall is not immediately executed, and for policy implications, it is essential to determine whether or not there are non-contemporary effects. Based on equation (7) we estimate models, by sector, including four lags of the oil price. This based on the fact that local governments design long-term development plans every four years, which is consistent with the electoral cycle.

Figure 2. Dynamic effects of oil price on total public investment



Note: For these figures we compute 95% confidence intervals.

As Figure 1 suggest, when including four lags, no effects of oil price on total public investment are found at the department level. However, for municipalities there is a statistically significant effect of oil prices only on period t-1. Results for the municipalities imply that a 10% change in oil price causes a 0.5% increase in total public investment the following period. For the rest of the sectors at the department level, Table 8 suggest positive effects on culture, environment and education. Moreover, it is possible to identify a positive effect of the first lag on attention to vulnerable population and agriculture. However, the second lag has a negative effect on both sectors.

Our interpretation of those results is that increases on those sectors were not sustainable if oil price does not continue growing over time. Therefore, as oil price fell, and those increases found in the first lag were based on higher oil prices, policy makers had to cut investment expansions in attention to vulnerable population and agriculture. Additionally, the evolution of public investment in Colombia is consistent with our main findings. The largest decrease of total public investment in Colombia occurred in 2016, thus from 2011 to 2014 the annual average oil price was above 95 USD and dropped in 2015 to 51 USD. Therefore, the increases in oil prices two years prior 2016, and the decrease on 2015 explained the drop of total public investment in 2016.

Table 8. Dynamic effects on departments' public investment

(1)	(2)	(3)	(4)	(5)	(6)

Commented [PVGJ3]: Me perdí mucho en esta subsección. Creo que hay que revisar con más calma cómo y qué resultados presentar.

Commented [I4R3]: Javier lo que intenté en esta sección fue empezar presentando los resultados para inversión total. En seguida mirar sector por sector, tanto para departamentos como para municipios y terminar haciendo un análisis de estos resultados en cuanto a las decisiones "óptimas" del uso de estos recursos.

Dependent variable	Total	Attention to vulnerable population	Culture	Environment	Education	Agriculture
Oil production x log oil price (t-1)	0.352	1.291**	0.573*	2.252**	-0.0670	1.954**
	(0.291)	(0.471)	(0.286)	(0.878)	(0.0855)	(0.733)
Oil production x log oil price (t-2)	-0.0608	-1.190*	-0.380	-1.286	0.157**	-1.042**
	(0.186)	(0.671)	(0.284)	(0.805)	(0.0646)	(0.409)
Oil production x log oil price (t-3)	-0.381*	-0.526	0.318	2.743***	-0.214	-0.321
	(0.209)	(1.230)	(0.408)	(0.916)	(0.244)	(0.805)
Oil production x log oil price (t-4)	0.309	-0.508	-0.134	0.796	0.0436	0.327
	(0.406)	(0.696)	(0.320)	(0.946)	(0.242)	(1.709)
Observations	185	185	185	155	185	170
R-squared	0.381	0.410	0.329	0.266	0.258	0.257
Number of municipalities	32	32	32	32	32	31

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

At the municipality level, there are also sectors in which positive effects where found (Table 9). However, the effect did not occur homogenously in terms of periods. For total, institutions and equipment investment, the effect was caused by the first lag. The second lag caused a positive increase of community development investment. While for transportation and disasters attention, the effect was generated at t-3. For the municipality analysis, it is relevant to mention that the effect on transportation investment is the largest of all the models with a 0.5 elasticity.

Table 9. Dynamic positive effects on municipalitys' public investment

Dependent variable	(1) Total	(2) Transportation	(3) Disasters attention	(4) Institutions	(5) Equipment	(6) Community development
Oil production x log oil price (t-1)	0.813***	1.156	2.289	1.886**	2.988*	0.0244
	(0.237)	(1.858)	(1.438)	(0.950)	(1.772)	(1.536)
Oil production x log oil price (t-2)	-0.400	-0.477	0.767	-0.114	-0.0196	3.729**
	(0.325)	(2.620)	(1.575)	(0.656)	(2.231)	(1.856)
Oil production x log oil price (t-3)	0.963	8.018**	6.620***	1.564	2.819	-0.776
	(0.599)	(3.180)	(1.956)	(1.388)	(2.969)	(1.791)
Oil production x log oil price (t-4)	0.114	-1.223	-0.473	-0.867	-1.298	-1.455
	(0.342)	(1.332)	(0.825)	(0.733)	(1.171)	(1.576)
Observations	6,588	6,547	6,025	6,547	6,251	4,852
R-squared	0.256	0.236	0.036	0.061	0.083	0.017
Number of municipalities	1,100	1,100	1,100	1,100	1,100	1,069

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

Commented [PVGJ5]: Solo los efectos positivos. Seguro van a preguntar porqué no se presentan los negativos también.

Commented [I6R5]: Se me ocurrió partir los resultados en dos tanto para las tablas como para la interpretación de los resultados. En esta solo incluí los positivos, mientras que en la otra Tabla 10, incluí los que tienen algún efecto negativo en los rezagos.

As well for departments, we found positive and negative effects in some sectors. Sectors in which our results suggest a positive effect on the first lag and a negative on the second are development promotion, public duties, environment and recreation and sports. Those results suggest a cyclicality of public investment as the policies implemented were not sustainable in time. Furthermore, for public duties and environment we found a positive effect of the third lag which in our view is theoretically challenging to interpret.

Table 10. Dynamic effects on municipality's public investment

Dependent variable	(1) Development promotion	(2) Public services	(3) Environment	(4) Recreation and sports
Oil production x log oil price (t-1)	5.446***	4.006***	3.855**	3.590***

	(1.523)	(1.086)	(1.632)	(1.106)
Oil production x log oil price (t-2)	-5.123**	-4.814***	-5.143**	-2.672***
	(2.605)	(1.143)	(2.082)	(0.954)
Oil production x log oil price (t-3)	2.196	4.421**	4.530**	3.056
	(2.886)	(2.222)	(2.296)	(1.945)
Oil production x log oil price (t-4)	0.221	0.702	-1.425	0.484
	(0.724)	(0.651)	(1.086)	(0.977)
Observations	4,376	5,944	5,782	6,577
R-squared	0.033	0.059	0.063	0.183
Number of municipalities	1,032	1,087	1,097	1,100

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

Results suggest, from an economic perspective, that fundamental sectors were prioritize with income windfall as their social returns are higher and economically significant. In addition, sectors related with infrastructure development increased their investment during the boom period.

From the dynamic specifications, the results imply that increases in revenues, due to oil price expansions, led to increases in public investment that were not sustainable in a medium-term horizon. Then, policy makers restricted investment two and three years after the boom, as the increases on the first period were not possible to finance. These findings are consistent with previous literature supporting the idea that governments tend to increase their spending during booms, but they do not design long-term planning considering that international natural resource prices could drop in the short term (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 how the most recent oil boom in Colombia, by means of changes in the international oil price, affect public investment in subnational governments. For departments we found positive effects for five out of eighteen sectors (recreation and sports, agriculture, transportation, vulnerable population attention and justice), while for municipalities positive and significant effects were found for four sectors (institutional strengthening, justice, equipment and, recreation and sports). The dynamic specifications suggest, in most of the cases, positive effects of the first lag on public investment. However, for some sectors in both municipal and departmental analysis, estimates show a negative effect of the second lag. This result suggests that public investment developments were run considering higher oil prices in the medium-term and led to unsustainability. Also, when considering different sample periods, in order to estimate heterogenous effects of the royalties' reform, it is worth mentioning that for most of the sectors positive effects were found for the period after the reform. These results are consistent with Spatafora and Warner (1995) who found a positive correlation between oil shocks and public investment.

This study contributes to the literature by computing for the first time the causal relationship between the oil boom and subnational investment in Colombian recent history. The main driver of this research is establishing if exogenous international variation that generate increases in revenues could be transferred in a welfare increase of individuals. The potential mechanism that we address in this paper is public investment. Obando and Adrian (2016) suggest that 90% of poverty reduction is related to economic growthOn the other hand, Fedesarrollo (2018) explores the causal relationship between the royalties' reform with welfare indicators. This paper allows us to establish that the transmission mechanism from income windfall is performing correctly, however, based on previous studies, it seems that the increase of public investment doesn't imply an improvement of economic and social conditions in the country. Considering our results, a potential explanation is that public investment

evolution is volatile and do not have an incremental trend, thus, those characteristics limit its impact on social and economic indicators.

Furthermore, results have two policy implications that should be considered for future natural resources booms. On the one hand, projects financed with income windfall should be sustainable over time. It is desirable that sectors with high social returns and infrastructure development are prioritized with income windfall resources, but it is fundamental that those expansions are independent with the fall of international prices in order to maintain their sustainability in time. On the other, based on the current context of Colombia, a reform to the royalties' framework is taking place. The underlying argument is that oil producing local governments do not have incentives to assume the costs of mineral production as resources are distributed amongst all territorial entities. However, our results suggest that even if royalties are distributed under equalizer principles, oil producing local governments are able to disproportionately invest more resources in fundamental sectors for economic and social development.

This paper builds on the current literature considering the causal relationship that previous studies did not intended to establish. Additionally, it permits to understand differentiated effects of oil prices in local public investment rather than national policies. However, there are several improvements and contributions to be done in further research. The central limitation of this study is the employment of public investment data because for some sector it accounts for expenditures that are not entirely investments. For example, salaries of public teachers are accounted as public investment in education. Coherently, further research should focus on developing estimations of economic and social indicators measuring the participation of public investment increases due to oil price shocks. In our perspective, it is essential to understand the consequences on economic and social indicators of those increases in public investment due to oil price shocks. The objectives in this sense are twofold. Firstly, it enables a broader understanding of the management of oil boom during this century and it permits to conclude wheatear or not individual's welfare improvement were caused, in part, by oil price changes.

Even if public investment has proven to have positive consequences on the economy, it is a challenging task for underdeveloped and developing countries considering their low fiscal surpluses, their high vulnerability to international shocks and that public investment is the adjustment device 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 undermining of its impact in social and economic development.

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Appendix Section

Appendix A

Table A.1. 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	DANE
Public investment by sector	2008-2017	Department	CHIP-FUT
Central government transfers	2008-2017	Department	DNP
Tax revenues	2008-2017	Department	DNP
Average barrels per day	2008	Municipality	ANH-MME

Appendix B: Baseline model for departments

Table B.1. The effect of oil price shocks on agriculture investment

Dependent variable	(1) Agriculture	(2) Agriculture	(3) Agriculture	(4) Agriculture
Oil production x log oil price (t-1)	0.253***	0.993***	0.882***	0.882***
	(0.0745)	(0.227)	(0.243)	(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 B.2. The effect of oil price shocks on PWBS investment

Dependent variable	(1) PWBS	(2) PWBS	(3) PWBS	(4) PWBS
Oil production x log oil price (t-1)	0.190***	-0.0474	0.0828	0.0828
	(0.0369)	(0.230)	(0.265)	(0.265)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	276	276	276	276
R-squared		0.031	0.064	0.064
Number of departments	32	32	32	32

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

Table B.3. The effect of oil price shocks on attention to vulnerable population investment

Dependent variable	(1) Attention to vulnerable population	(2) Attention to vulnerable population	(3) Attention to vulnerable population	(4) Attention to vulnerable population
Oil production x log oil price (t-1)	0.125	0.391	0.782***	0.782***
	(0.0760)	(0.292)	(0.269)	(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 B.4. The effect of oil price shocks on penitentiary centres investment

Dependent variable	(1) Penitentiary centres	(2) Penitentiary centres	(3) Penitentiary centres	(4) Penitentiary centres
Oil production x log oil price (t-1)	0.0335	-1.004	-1.656**	-1.656**
	(0.101)	(0.962)	(0.660)	(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 B.5. The effect of oil price shocks on culture investment

Dependent variable	(1) Culture	(2) Culture	(3) Culture	(4) Culture
Oil production x log oil price (t-1)	0.0237	0.0295	0.136	0.136
	(0.0761)	(0.116)	(0.154)	(0.154)
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		0.181	0.302	0.302
Number of departments	32	32	32	32

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

Table B.6. The effect of oil price shocks on recreation and sports investment

Dependent variable	(1) Recreation and sports	(2) Recreation and sports	(3) Recreation and sports	(4) Recreation and sports
Oil production x log oil price (t-1)	0.173***	0.865**	0.835**	0.835**
	(0.0503)	(0.331)	(0.357)	(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.7. The effect of oil price shocks on community development investment

Dependent variable	(1) Community development	(2) Community development	(3) Community development	(4) Community development

Oil production x log oil price (t-1)	0.122**	0.173	0.274	0.274
	(0.0607)	(0.356)	(0.324)	(0.324)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	233	233	233	233
R-squared		0.054	0.096	0.096
Number of departments	32	32	32	32

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

Table B.8. The effect of oil price shocks on education investment

	(1)	(2)	(3)	(4)
Dependent variable	Education	Education	Education	Education
Oil production x log oil price (t-1)	0.0428	-0.120**	-0.0151	-0.0151
	(0.0292)	(0.0452)	(0.0677)	(0.0677)
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		0.134	0.203	0.203
Number of departments	32	32	32	32

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

Table B.9. The effect of oil price shocks equipment investment

	(1)	(2)	(3)	(4)
Dependent variable	Equipment	Equipment	Equipment	Equipment
Oil production x log oil price (t-1)	0.116	-0.0470	0.569	0.569
	(0.128)	(0.711)	(0.762)	(0.762)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	194	194	194	194
R-squared		0.045	0.151	0.151
Number of departments	30	30	30	30

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

Table B.10. The effect of oil price shocks on institutional strengthening investment

	(1)	(2)	(3)	(4)
Dependent variable	Institutional strengthening	Institutional strengthening	Institutional strengthening	Institutional strengthening
Oil production x log oil price (t-1)	0.0159	-0.153	-0.243	-0.243
	(0.0557)	(0.296)	(0.287)	(0.287)

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		0.087	0.148	0.148
Number of departments	32	32	32	32

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

Table B.11. The effect of oil price shocks on justice investment

	(1)	(2)	(3)	(4)
Dependent variable	Justice	Justice	Justice	Justice
Oil production x log oil price (t-1)	0.144*	0.448	0.593**	0.593**
	(0.0836)	(0.299)	(0.287)	(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.12. The effect of oil price shocks on environment investment

	(1)	(2)	(3)	(4)
Dependent variable	Environment	Environment	Environment	Environment
Oil production x log oil price (t-1)	0.132	0.789	1.125	1.125
	(0.119)	(0.620)	(0.797)	(0.797)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	237	237	237	237
R-squared		0.097	0.217	0.217
Number of departments	32	32	32	32

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

Table B.13. The effect of oil price shocks on public duties investment

	(1)	(2)	(3)	(4)
Dependent variable	Public duties	Public duties	Public duties	Public duties
Oil production x log oil price (t-1)	0.505***	0.986*	0.573	0.573
	(0.111)	(0.491)	(0.578)	(0.578)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X

Observations	192	192	192	192
R-squared		0.086	0.116	0.116
Number of departments	29	29	29	29

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

Table B.14. The effect of oil price shocks on disasters attention investment

	(1)	(2)	(3)	(4)
Dependent variable	Disasters attentions	Disasters attentions	Disasters attentions	Disasters attentions
Oil production x log oil price (t-1)	0.237***	-0.0225	0.181	0.181
	(0.0743)	(0.275)	(0.296)	(0.296)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	256	256	256	256
R-squared		0.121	0.205	0.205
Number of departments	32	32	32	32

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

Table B.15. The effect of oil price shocks on development promotion investment

	(1)	(2)	(3)	(4)
Dependent variable	Development promotion	Development promotion	Development promotion	Development promotion
Oil production x log oil price (t-1)	0.104	-0.105	0.0225	0.0225
	(0.0761)	(0.442)	(0.435)	(0.435)
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		0.087	0.113	0.113
Number of departments	32	32	32	32

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

Table B.16. The effect of oil price shocks on health investment

	(1)	(2)	(3)	(4)
Dependent variable	Health	Health	Health	Health
Oil production x log oil price (t-1)	0.0460	-0.0257	0.0462	0.0462
	(0.0354)	(0.124)	(0.127)	(0.127)
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		0.307	0.340	0.340
Number of departments	32	32	32	32

Robust standard errors in parentheses

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

Table B.17. The effect of oil price shocks on total investment

Dependent variable	(1) Total	(2) Total	(3) Total	(4) Total
Oil production x log oil price (t-1)	0.0818***	0.167*	0.221**	0.221**
	(0.0250)	(0.0827)	(0.0934)	(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 B.18. The effect of oil price shocks on transports investment

Dependent variable	(1) Transports	(2) Transports	(3) Transports	(4) Transports
Oil production x log oil price (t-1)	0.207**	0.855***	0.953***	0.953***
	(0.0841)	(0.262)	(0.249)	(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

Table B.19. The effect of oil price shocks on housing investment

Dependent variable	(1) Housing	(2) Housing	(3) Housing	(4) Housing
Oil production x log oil price (t-1)	0.324***	0.805	0.584	0.584
	(0.0815)	(0.870)	(0.841)	(0.841)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	230	230	230	230
R-squared		0.054	0.090	0.090
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. The effect of oil price shocks on agriculture investment

Dependent variable	(1) Agriculture	(2) Agriculture	(3) Agriculture	(4) Agriculture
Oil production x log oil price (t-1)	0.399***	-0.114	-0.00224	-0.00224
	(0.127)	(0.647)	(0.656)	(0.656)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,511	9,511	9,511	9,511
R-squared		0.037	0.050	0.050
Number of municipalities	1,097	1,097	1,097	1,097

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

Table C.2. The effect of oil price shocks on PWBS investment

Dependent variable	(1) PWBS	(2) PWBS	(3) PWBS	(4) PWBS
Oil production x log oil price (t-1)	0.648***	0.532	0.369	0.369
	(0.0870)	(0.566)	(0.545)	(0.545)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,686	9,686	9,686	9,686
R-squared		0.094	0.117	0.117
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. The effect of oil price shocks on attention to vulnerable population investment

Dependent variable	(1) Attention to vulnerable population	(2) Attention to vulnerable population	(3) Attention to vulnerable population	(4) Attention to vulnerable population
Oil production x log oil price (t-1)	0.388***	0.427	0.573	0.573
	(0.0867)	(0.394)	(0.403)	(0.403)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,712	9,712	9,712	9,712
R-squared		0.163	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.4. The effect of oil price shocks on penitentiary centres investment

Dependent variable	(1) Penitentiary centres	(2) Penitentiary centres	(3) Penitentiary centres	(4) Penitentiary centres

Oil production x log oil price (t-1)	0.175	-0.183	0.152	0.152
	(0.197)	(0.595)	(0.539)	(0.539)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	2,701	2,701	2,701	2,701
R-squared		0.041	0.060	0.060
Number of municipalities	770	770	770	770

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

Table C.5. The effect of oil price shocks on culture investment

	(1)	(2)	(3)	(4)
Dependent variable	Culture	Culture	Culture	Culture
Oil production x log oil price (t-1)	0.252***	0.101	0.473	0.473
	(0.0561)	(0.302)	(0.300)	(0.300)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,757	9,757	9,757	9,757
R-squared		0.198	0.237	0.237
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.6. The effect of oil price shocks on recreation and sports investment

	(1)	(2)	(3)	(4)
Dependent variable	Recreation and sports	Recreation and sports	Recreation and sports	Recreation and sports
Oil production x log oil price (t-1)	0.0957	0.979**	1.037**	1.037**
	(0.0894)	(0.463)	(0.483)	(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.7. The effect of oil price shocks on community development investment

	(1)	(2)	(3)	(4)
Dependent variable	Community development	Community development	Community development	Community development
Oil production x log oil price (t-1)	0.236*	0.790	1.018	1.693
	(0.140)	(1.012)	(1.038)	(1.039)
Controls	X	X	X	X

Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	7,178	7,178	7,178	7,178
R-squared		0.011	0.017	0.017
Number of municipalities	1,091	1,091	1,091	1,091

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

Table C.8. The effect of oil price shocks on education investment

Dependent variable	(1) Education	(2) Education	(3) Education	(4) Education
Oil production x log oil price (t-1)	0.406***	-0.185	-0.226	-0.226
	(0.100)	(0.248)	(0.256)	(0.256)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				
Observations	9,767	9,767	9,767	9,767
R-squared		0.057	0.080	0.080
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.9. The effect of oil price shocks equipment investment

Dependent variable	(1) Equipment	(2) Equipment	(3) Equipment	(4) Equipment
Oil production x log oil price (t-1)	0.0808	1.758	1.970*	1.970*
	(0.146)	(1.175)	(1.196)	(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.10. The effect of oil price shocks on institutional strengthening investment

Dependent variable	(1) Institutional strengthening	(2) Institutional strengthening	(3) Institutional strengthening	(4) Institutional strengthening
Oil production x log oil price (t-1)	0.248*	1.250**	1.715***	1.715***
	(0.135)	(0.619)	(0.625)	(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.11. The effect of oil price shocks on justice investment

	(1)	(2)	(3)	(4)
Dependent variable	Justice	Justice	Justice	Justice
Oil production x log oil price (t-1)	0.359***	0.710	0.996*	0.996*
	(0.105)	(0.612)	(0.604)	(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

Table C.12. The effect of oil price shocks on environment investment

	(1)	(2)	(3)	(4)
Dependent variable	Environment	Environment	Environment	Environment
Oil production x log oil price (t-1)	0.423***	0.668	0.887	0.887
	(0.139)	(0.729)	(0.787)	(0.787)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	8,605	8,605	8,605	8,605
R-squared		0.019	0.045	0.045
Number of municipalities	1,099	1,099	1,099	1,099

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

Table C.13. The effect of oil price shocks on public duties investment

	(1)	(2)	(3)	(4)
Dependent variable	Public duties	Public duties	Public duties	Public duties
Oil production x log oil price (t-1)	0.315***	0.842	0.948	0.948
	(0.108)	(0.776)	(0.807)	(0.807)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	8,784	8,784	8,784	8,784
R-squared		0.046	0.062	0.062
Number of municipalities	1,096	1,096	1,096	1,096

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

Table C.14. The effect of oil price shocks on disasters attention investment

	(1)	(2)	(3)	(4)
Dependent variable	Disasters attention	Disasters attention	Disasters attention	Disasters attention

Oil production x log oil price (t-1)	0.453***	0.497	1.027	1.027
	(0.133)	(0.826)	(0.972)	(0.972)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	8,983	8,983	8,983	8,983
R-squared		0.019	0.050	0.050
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.15. The effect of oil price shocks on development promotion investment

Dependent variable	(1) Development promotion	(2) Development promotion	(3) Development promotion	(4) Development promotion
Oil production x log oil price (t-1)	0.677***	1.304	1.542	1.542
	(0.176)	(0.930)	(0.997)	(0.997)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	6,468	6,468	6,468	6,468
R-squared		0.025	0.033	0.033
Number of municipalities	1,067	1,067	1,067	1,067

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

Table C.16. The effect of oil price shocks on health investment

Dependent variable	(1) Health	(2) Health	(3) Health	(4) Health
Oil production x log oil price (t-1)	0.130***	-0.167	0.0799	0.0799
	(0.0487)	(0.114)	(0.119)	(0.119)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,745	9,745	9,745	9,745
R-squared		0.322	0.334	0.334
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.17. The effect of oil price shocks on total investment

Dependent variable	(1) Total	(2) Total	(3) Total	(4) Total
Oil production x log oil price (t-1)	0.263***	0.0459	0.172	0.172
	(0.0426)	(0.118)	(0.143)	(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.18. The effect of oil price shocks on transports investment

Dependent variable	Transports	Transports	Transports	Transports
Oil production x log oil price (t-1)	0.00455	0.451	-0.0107	-0.0107
	(0.149)	(0.846)	(0.801)	(0.801)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	9,708	9,708	9,708	9,708
R-squared		0.126	0.179	0.179
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.19. The effect of oil price shocks on housing investment

	(1)	(2)	(3)	(4)
Dependent variable	Housing	Housing	Housing	Housing
Oil production x log oil price (t-1)	0.503***	0.216	0.616	0.616
	(0.172)	(0.988)	(1.054)	(1.054)
Controls	X	X	X	X
Department fixed effects		X	X	X
Time fixed effects			X	X
Linear time trend				X
Observations	8,672	8,672	8,672	8,672
R-squared		0.062	0.088	0.088
Number of municipalities	1,096	1,096	1,096	1,096

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

Appendix D: Dynamic models for departments

Table D.1. The effect of oil price shocks on agriculture investment

Dependent variable	(1) Agriculture	(2) Agriculture	(3) Agriculture	(4) Agriculture
Oil production x log oil price (t-1)	0.882***	1.260***	1.902***	1.954**
	(0.243)	(0.294)	(0.449)	(0.733)
Oil production x log oil price (t-2)		-0.894**	-1.491**	-1.042**
		(0.355)	(0.554)	(0.409)
Oil production x log oil price (t-3)			0.298	-0.321
			(0.620)	(0.805)
Oil production x log oil price (t-4)				0.327
				(1.709)
Observations	262	232	201	170
R-squared	0.215	0.226	0.234	0.257
Number of municipalities	31	31	31	31

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

Table D.2. The effect of oil price shocks on PWBS investment

Dependent variable	(2) PWBS	(3) PWBS	(4) PWBS	(5) PWBS
Oil production x log oil price (t-1)	0.0828	0.220	0.666	-0.184
	(0.265)	(0.446)	(0.589)	(0.752)
Oil production x log oil price (t-2)		-1.257***	-2.035***	0.891
		(0.405)	(0.380)	(0.566)
Oil production x log oil price (t-3)			-1.314	-3.725**
			(1.828)	(1.818)
Oil production x log oil price (t-4)				2.138
				(1.659)
Observations	276	244	214	183
R-squared	0.064	0.097	0.155	0.176
Number of municipalities	32	32	32	32

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

Table D.3. The effect of oil price shocks on attention to vulnerable population investment

Dependent variable	(2) Attention to vulnerable population	(3) Attention to vulnerable population	(4) Attention to vulnerable population	(5) Attention to vulnerable population
Oil production x log oil price (t-1)	0.782***	1.255***	2.117**	1.291**
	(0.269)	(0.326)	(0.795)	(0.471)
Oil production x log oil price (t-2)		-1.305**	-2.254*	-1.190*
		(0.608)	(1.107)	(0.671)
Oil production x log oil price (t-3)			0.387	-0.526
			(1.483)	(1.230)
Oil production x log oil price (t-4)				-0.508
				(0.696)
Observations	282	250	217	185
R-squared	0.294	0.326	0.365	0.410
Number of municipalities	32	32	32	32

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

Table D.4. The effect of oil price shocks on penitentiary centres investment

Dependent variable	(2) Penitentiary centres	(3) Penitentiary centres	(4) Penitentiary centres	(5) Penitentiary centres
Oil production x log oil price (t-1)	-1.656**	-1.734**	-2.434*	-2.719**
	(0.660)	(0.629)	(1.180)	(1.176)
Oil production x log oil price (t-2)		0.354	0.724	0.698
		(0.792)	(1.248)	(1.731)
Oil production x log oil price (t-3)			-1.423	-1.038
			(1.041)	(1.447)
Oil production x log oil price (t-4)				-0.527
				(1.092)
Observations	77	64	54	44
R-squared	0.295	0.331	0.358	0.418
Number of municipalities	21	20	19	18

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

Table D.5. The effect of oil price shocks on culture investment

Dependent variable	(2) Culture	(3) Culture	(4) Culture	(5) Culture
Oil production x log oil price (t-1)	0.136	0.195	0.607***	0.573*
	(0.154)	(0.184)	(0.182)	(0.286)
Oil production x log oil price (t-2)		-0.0101	-0.434*	-0.380
		(0.174)	(0.224)	(0.284)
Oil production x log oil price (t-3)			0.405	0.318
			(0.484)	(0.408)
Oil production x log oil price (t-4)				-0.134
				(0.320)
Observations	283	250	217	185
R-squared	0.302	0.320	0.330	0.329
Number of municipalities	32	32	32	32

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

Table D.6. The effect of oil price shocks on recreation and sports investment

Dependent variable	(2) Recreation and sports	(3) Recreation and sports	(4) Recreation and sports	(5) Recreation and sports
Oil production x log oil price (t-1)	0.835**	0.663*	0.971*	0.801
	(0.357)	(0.368)	(0.507)	(0.631)
Oil production x log oil price (t-2)		0.273	-0.136	0.195
		(0.279)	(0.391)	(0.579)
Oil production x log oil price (t-3)			0.135	-0.309
			(0.656)	(0.863)
Oil production x log oil price (t-4)				0.361
				(0.770)
Observations	280	247	215	183
R-squared	0.128	0.139	0.160	0.181
Number of municipalities	32	32	32	32

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

Table D.7. The effect of oil price shocks on community development investment

Dependent variable	(2) Community development	(3) Community development	(4) Community development	(5) Community development
Oil production x log oil price (t-1)	0.274	0.240	0.426	0.517
	(0.324)	(0.401)	(0.650)	(0.743)
Oil production x log oil price (t-2)		0.741	0.601	-0.264
		(0.473)	(0.676)	(0.728)
Oil production x log oil price (t-3)			0.425	1.230
			(0.920)	(1.051)
Oil production x log oil price (t-4)				-0.708
				(0.934)
Observations	233	204	179	150
R-squared	0.096	0.116	0.131	0.194
Number of municipalities	32	32	32	32

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

Table D.8. The effect of oil price shocks on education investment

Dependent variable	(2) Education	(3) Education	(4) Education	(5) Education
Oil production x log oil price (t-1)	-0.0151	-0.108	0.0426	-0.0670
	(0.0677)	(0.125)	(0.157)	(0.0855)
Oil production x log oil price (t-2)		0.113	-0.0452	0.157**
		(0.215)	(0.255)	(0.0646)
Oil production x log oil price (t-3)			-0.0303	-0.214
			(0.219)	(0.244)
Oil production x log oil price (t-4)				0.0436
				(0.242)
Observations	283	250	217	185
R-squared	0.203	0.207	0.244	0.258
Number of municipalities	32	32	32	32

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

Table D.9. The effect of oil price shocks equipment investment

Dependent variable	(2) Equipment	(3) Equipment	(4) Equipment	(5) Equipment
Oil production x log oil price (t-1)	0.569	1.288***	2.661***	2.317
	(0.762)	(0.405)	(0.816)	(1.473)
Oil production x log oil price (t-2)		-1.555	-2.687	-2.530
		(1.271)	(1.773)	(2.945)
Oil production x log oil price (t-3)			1.108	1.059
			(2.314)	(2.432)
Oil production x log oil price (t-4)				-0.628
				(1.298)
Observations	194	173	150	129
R-squared	0.151	0.172	0.192	0.182
Number of municipalities	30	30	28	28

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

Table D.10. The effect of oil price shocks on institutional strengthening investment

	(2)	(3)	(4)	(5)

Dependent variable	Institutions	Institutions	Institutions	Institutions
Oil production x log oil price (t-1)	-0.243	-0.276	-0.314	-0.483
	(0.287)	(0.268)	(0.468)	(0.372)
Oil production x log oil price (t-2)		-0.179	-0.184	-0.0328
		(0.378)	(0.445)	(0.336)
Oil production x log oil price (t-3)			-0.637	-0.639
			(0.910)	(0.873)
Oil production x log oil price (t-4)				-0.298
				(0.701)
Observations	280	248	217	185
R-squared	0.148	0.180	0.197	0.248
Number of municipalities	32	32	32	32

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

Table D.11. The effect of oil price shocks on justice investment

	(2)	(3)	(4)	(5)
Dependent variable	Justice	Justice	Justice	Justice
Oil production x log oil price (t-1)	0.593**	0.500	0.465	1.525
	(0.287)	(0.366)	(0.652)	(1.400)
Oil production x log oil price (t-2)		0.461	0.371	-1.041
		(0.438)	(0.894)	(1.975)
Oil production x log oil price (t-3)			-0.259	0.628
			(0.770)	(1.294)
Oil production x log oil price (t-4)				0.387
				(0.593)
Observations	269	242	210	180
R-squared	0.264	0.282	0.307	0.338
Number of municipalities	32	32	32	32

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

Table D.12. The effect of oil price shocks on environment investment

	(2)	(3)	(4)	(5)
Dependent variable	Environment	Environment	Environment	Environment
Oil production x log oil price (t-1)	1.125	0.528	1.440	2.252**
	(0.797)	(0.997)	(1.147)	(0.878)
Oil production x log oil price (t-2)		1.109	0.159	-1.286
		(0.734)	(1.010)	(0.805)
Oil production x log oil price (t-3)			1.661*	2.743***
			(0.877)	(0.916)
Oil production x log oil price (t-4)				0.796
				(0.946)
Observations	237	209	181	155
R-squared	0.217	0.243	0.261	0.266
Number of municipalities	32	32	32	32

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

Table D.13. The effect of oil price shocks on public duties investment

	(2)	(3)	(4)	(5)
Dependent variable	Public duties	Public duties	Public duties	Public duties
Oil production x log oil price (t-1)	0.573	0.786	1.163	0.980
	(0.578)	(0.910)	(1.373)	(2.064)

Oil production x log oil price (t-2)		-0.751	-1.208	-2.088
		(1.024)	(1.511)	(2.590)
Oil production x log oil price (t-3)			0.911	1.679
			(1.119)	(1.582)
Oil production x log oil price (t-4)				-1.511**
				(0.705)
Observations	192	166	139	113
R-squared	0.116	0.098	0.130	0.207
Number of municipalities	29	29	29	29

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

Table D.14. The effect of oil price shocks on disasters attention investment

	(2)	(3)	(4)	(5)
Dependent variable	Disasters attention	Disasters attention	Disasters attention	Disasters attention
Oil production x log oil price (t-1)	0.181	0.609*	0.225	0.762
	(0.296)	(0.342)	(0.606)	(1.371)
Oil production x log oil price (t-2)		-1.144***	-0.841	-0.994
		(0.401)	(0.700)	(1.269)
Oil production x log oil price (t-3)			-2.326	-2.225
			(1.790)	(2.328)
Oil production x log oil price (t-4)				1.437
				(1.476)
Observations	256	226	193	167
R-squared	0.205	0.240	0.297	0.311
Number of municipalities	32	32	32	32

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

Table D.15. The effect of oil price shocks on development promotion investment

	(2)	(3)	(4)	(5)
Dependent variable	Development promotion	Development promotion	Development promotion	Development promotion
Oil production x log oil price (t-1)	0.0225	0.531	2.158**	0.666
	(0.435)	(0.748)	(0.844)	(1.495)
Oil production x log oil price (t-2)		-1.287	-3.141***	-1.545
		(0.940)	(1.107)	(1.508)
Oil production x log oil price (t-3)			-0.815	-2.091**
			(1.237)	(0.996)
Oil production x log oil price (t-4)				-1.434
				(1.769)
Observations	269	238	205	175
R-squared	0.113	0.122	0.161	0.140
Number of municipalities	32	32	32	32

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

Table D.16. The effect of oil price shocks on health investment

	(2)	(3)	(4)	(5)
Dependent variable	Health	Health	Health	Health
Oil production x log oil price (t-1)	0.0462	0.0503	0.230	0.149
	(0.127)	(0.137)	(0.202)	(0.160)
Oil production x log oil price (t-2)		-0.168	-0.412**	-0.140
		(0.124)	(0.189)	(0.130)
Oil production x log oil price (t-3)			-0.0182	-0.241
			(0.238)	(0.227)

Oil production x log oil price (t-4)				0.233
				(0.309)
Observations	282	249	216	184
R-squared	0.340	0.318	0.268	0.158
Number of municipalities	32	32	32	32

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

Table D.17. The effect of oil price shocks on total investment

	(2)	(3)	(4)	(5)
Dependent variable	Total	Total	Total	Total
Oil production x log oil price (t-1)	0.221**	0.275**	0.499***	0.352
	(0.0934)	(0.124)	(0.127)	(0.291)
Oil production x log oil price (t-2)		-0.301***	-0.592***	-0.0608
		(0.0862)	(0.0749)	(0.186)
Oil production x log oil price (t-3)			0.0442	-0.381*
			(0.291)	(0.209)
Oil production x log oil price (t-4)				0.309
				(0.406)
Observations	283	250	217	185
R-squared	0.274	0.294	0.350	0.381
Number of municipalities	32	32	32	32

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

Table D.18. The effect of oil price shocks on transports investment

	(2)	(3)	(4)	(5)
Dependent variable	Transports	Transports	Transports	Transports
Oil production x log oil price (t-1)	0.953***	1.278***	1.359***	0.856
	(0.249)	(0.427)	(0.287)	(0.899)
Oil production x log oil price (t-2)		-0.748*	-0.850***	-0.493
		(0.415)	(0.282)	(1.053)
Oil production x log oil price (t-3)			-0.462	-0.597
			(0.642)	(0.937)
Oil production x log oil price (t-4)				-1.223
				(1.332)
Observations	278	246	213	182
R-squared	0.231	0.261	0.281	0.285
Number of municipalities	32	32	32	32

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

Table D.19. The effect of oil price shocks on housing investment

	(2)	(3)	(4)	(5)
Dependent variable	Housing	Housing	Housing	Housing
Oil production x log oil price (t-1)	0.584	0.807	1.890	1.300
	(0.841)	(1.082)	(1.481)	(2.236)
Oil production x log oil price (t-2)		-0.262	-1.335	-0.639
		(0.812)	(1.143)	(2.270)
Oil production x log oil price (t-3)			1.616	0.527
			(1.134)	(2.160)
Oil production x log oil price (t-4)				-0.584
				(0.583)
Observations	230	201	172	144

R-squared	0.090	0.089	0.116	0.130
Number of municipalities	32	32	31	31

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

Appendix E: Dynamic models for municipalities

Table E.1. The effect of oil price shocks on agriculture investment

Dependent variable	(1) Agriculture	(2) Agriculture	(3) Agriculture	(4) Agriculture
Oil production x log oil price (t-1)	-0.00224	0.289	1.192	0.823
	(0.656)	(1.071)	(1.188)	(1.316)
Oil production x log oil price (t-2)		-0.815	-2.004	-1.058
		(0.885)	(1.223)	(1.580)
Oil production x log oil price (t-3)			1.519**	1.551
			(0.743)	(1.240)
Oil production x log oil price (t-4)				0.186
				(0.632)
Observations	9,511	8,496	7,462	6,412
R-squared	0.050	0.055	0.058	0.063
Number of municipalities	1,097	1,097	1,097	1,097

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

Table E.2. The effect of oil price shocks on PWBS investment

Dependent variable	(2) PWBS	(3) PWBS	(4) PWBS	(5) PWBS
Oil production x log oil price (t-1)	0.369	0.965	3.175***	0.808
	(0.545)	(0.624)	(0.914)	(1.315)
Oil production x log oil price (t-2)		-1.925***	-4.370***	-0.570
		(0.503)	(1.057)	(1.663)
Oil production x log oil price (t-3)			0.900	-0.668
			(0.801)	(1.752)
Oil production x log oil price (t-4)				-1.068
				(0.715)
Observations	9,686	8,646	7,585	6,512
R-squared	0.117	0.132	0.132	0.098
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 E.3. The effect of oil price shocks on attention to vulnerable population investment

Dependent variable	(2) Attention to vulnerable population	(3) Attention to vulnerable population	(4) Attention to vulnerable population	(5) Attention to vulnerable population
Oil production x log oil price (t-1)	0.573	1.155**	2.257***	1.566
	(0.403)	(0.513)	(0.817)	(1.152)
Oil production x log oil price (t-2)		-0.793***	-1.979***	-0.768
		(0.260)	(0.529)	(0.787)
Oil production x log oil price (t-3)			1.168***	0.638
			(0.273)	(0.674)
Oil production x log oil price (t-4)				0.00760
				(0.345)
Observations	9,712	8,693	7,642	6,570
R-squared	0.263	0.308	0.321	0.312
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 E.4. The effect of oil price shocks on penitentiary centres investment

Dependent variable	(2) Penitentiary centres	(3) Penitentiary centres	(4) Penitentiary centres	(5) Penitentiary centres
Oil production x log oil price (t-1)	0.152	-2.586**	-3.860**	-6.096***
	(0.539)	(1.231)	(1.761)	(1.867)
Oil production x log oil price (t-2)		4.344***	6.355***	6.003***
		(1.441)	(1.827)	(1.750)
Oil production x log oil price (t-3)			-8.416*	0.820
			(4.898)	(7.048)
Oil production x log oil price (t-4)				-8.525***
				(3.258)
Observations	2,701	2,406	2,179	1,956
R-squared	0.060	0.067	0.073	0.074
Number of municipalities	770	742	724	711

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

Table E.5. The effect of oil price shocks on culture investment

Dependent variable	(2) Culture	(3) Culture	(4) Culture	(5) Culture
Oil production x log oil price (t-1)	0.473	0.325	0.684	0.503
	(0.300)	(0.355)	(0.453)	(0.489)
Oil production x log oil price (t-2)		0.269	-0.176	0.424
		(0.217)	(0.421)	(0.444)
Oil production x log oil price (t-3)			0.492	0.753
			(0.411)	(0.774)
Oil production x log oil price (t-4)				0.127
				(0.318)
Observations	9,757	8,716	7,654	6,581
R-squared	0.237	0.226	0.214	0.195
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 E.6. The effect of oil price shocks on recreation and sports investment

Dependent variable	(2) Recreation and sports	(3) Recreation and sports	(4) Recreation and sports	(5) Recreation and sports
Oil production x log oil price (t-1)	1.037**	1.546***	2.078***	3.590***
	(0.483)	(0.531)	(0.705)	(1.106)
Oil production x log oil price (t-2)		-0.142	-0.799	-2.672***
		(0.438)	(0.818)	(0.954)
Oil production x log oil price (t-3)			0.698	3.056
			(0.788)	(1.945)
Oil production x log oil price (t-4)				0.484
				(0.977)
Observations	9,746	8,711	7,651	6,577
R-squared	0.174	0.168	0.168	0.183
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 E.7. The effect of oil price shocks on community development investment

	(2)	(3)	(4)	(5)

Dependent variable	Community development	Community development	Community development	Community development
Oil production x log oil price (t-1)	1.018	-0.458	1.506	0.0244
	(1.038)	(1.321)	(1.705)	(1.536)
Oil production x log oil price (t-2)		2.794*	1.779	3.729**
		(1.532)	(1.769)	(1.856)
Oil production x log oil price (t-3)			0.614	-0.776
			(1.901)	(1.791)
Oil production x log oil price (t-4)				-1.455
				(1.576)
Observations	7,178	6,395	5,615	4,852
R-squared	0.017	0.015	0.015	0.017
Number of municipalities	1,091	1,086	1,081	1,069

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

Table E.8. The effect of oil price shocks on education investment

Dependent variable	(2) Education	(3) Education	(4) Education	(5) Education
Oil production x log oil price (t-1)	-0.226	-0.290	1.908***	0.0316
	(0.256)	(0.346)	(0.541)	(0.366)
Oil production x log oil price (t-2)		-0.765***	-3.295***	0.236
		(0.195)	(0.672)	(0.498)
Oil production x log oil price (t-3)			0.725	-0.524
			(0.771)	(0.776)
Oil production x log oil price (t-4)				-0.357
				(0.286)
Observations	9,767	8,725	7,664	6,586
R-squared	0.080	0.082	0.087	0.094
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 E.9. The effect of oil price shocks equipment investment

Dependent variable	(2) Equipment	(3) Equipment	(4) Equipment	(5) Equipment
Oil production x log oil price (t-1)	1.970*	2.271	2.528	2.988*
	(1.196)	(1.608)	(1.845)	(1.772)
Oil production x log oil price (t-2)		0.577	0.475	-0.0196
		(0.981)	(1.645)	(2.231)
Oil production x log oil price (t-3)			0.630	2.819
			(1.518)	(2.969)
Oil production x log oil price (t-4)				-1.298
				(1.171)
Observations	9,293	8,299	7,276	6,251
R-squared	0.061	0.067	0.074	0.083
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 E.10. The effect of oil price shocks on institutional strengthening investment

Dependent variable	(2) Institutions	(3) Institutions	(4) Institutions	(5) Institutions
Oil production x log oil price (t-1)	1.715***	1.502**	2.133**	1.886**

	(0.625)	(0.714)	(0.961)	(0.950)
Oil production x log oil price (t-2)		0.133	-0.398	-0.114
		(0.373)	(0.676)	(0.656)
Oil production x log oil price (t-3)			1.072	1.564
			(0.696)	(1.388)
Oil production x log oil price (t-4)				-0.867
				(0.733)
Observations	9,677	8,654	7,604	6,547
R-squared	0.100	0.098	0.082	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 E.11. The effect of oil price shocks on justice investment

	(2)	(3)	(4)	(5)
Dependent variable	Justice	Justice	Justice	Justice
Oil production x log oil price (t-1)	0.996*	0.441	1.897	1.528
	(0.604)	(0.936)	(1.384)	(1.834)
Oil production x log oil price (t-2)		0.830	-0.872	-0.0384
		(0.626)	(1.294)	(2.262)
Oil production x log oil price (t-3)			1.831***	1.619
			(0.592)	(1.603)
Oil production x log oil price (t-4)				0.191
				(0.531)
Observations	9,718	8,692	7,636	6,567
R-squared	0.209	0.167	0.150	0.154
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 E.12. The effect of oil price shocks on environment investment

	(2)	(3)	(4)	(5)
Dependent variable	Environment	Environment	Environment	Environment
Oil production x log oil price (t-1)	0.887	2.312***	3.540**	3.855**
	(0.787)	(0.750)	(1.476)	(1.632)
Oil production x log oil price (t-2)		-2.562***	-4.296**	-5.143**
		(0.898)	(1.915)	(2.082)
Oil production x log oil price (t-3)			1.722	4.530**
			(1.062)	(2.296)
Oil production x log oil price (t-4)				-1.425
				(1.086)
Observations	8,605	7,695	6,749	5,782
R-squared	0.045	0.052	0.061	0.063
Number of municipalities	1,099	1,099	1,099	1,097

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

Table E.13. The effect of oil price shocks on public duties investment

	(2)	(3)	(4)	(5)
Dependent variable	Public duties	Public duties	Public duties	Public duties
Oil production x log oil price (t-1)	0.948	2.248*	2.235*	4.006***
	(0.807)	(1.193)	(1.195)	(1.086)
Oil production x log oil price (t-2)		-2.346*	-2.761*	-4.814***
		(1.223)	(1.501)	(1.143)
Oil production x log oil price (t-3)			1.593	4.421**

			(1.048)	(2.222)
Oil production x log oil price (t-4)				0.702
				(0.651)
Observations	8,784	7,856	6,905	5,944
R-squared	0.062	0.059	0.050	0.059
Number of municipalities	1,096	1,094	1,090	1,087

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

Table E.14. The effect of oil price shocks on disasters attention investment

Dependent variable	(2) Disasters attention	(3) Disasters attention	(4) Disasters attention	(5) Disasters attention
Oil production x log oil price (t-1)	1.027	1.386*	1.445	2.289
	(0.972)	(0.757)	(1.201)	(1.438)
Oil production x log oil price (t-2)		0.853	1.394	0.767
		(0.683)	(1.066)	(1.575)
Oil production x log oil price (t-3)			2.260	6.620***
			(2.260)	(1.956)
Oil production x log oil price (t-4)				-0.473
				(0.825)
Observations	8,983	8,024	7,046	6,025
R-squared	0.050	0.032	0.033	0.036
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 E.15. The effect of oil price shocks on development promotion investment

Dependent variable	(2) Development promotion	(3) Development promotion	(4) Development promotion	(5) Development promotion
Oil production x log oil price (t-1)	1.542	3.009***	5.528***	5.446***
	(0.997)	(0.709)	(1.256)	(1.523)
Oil production x log oil price (t-2)		-1.622	-5.172***	-5.123**
		(1.101)	(1.357)	(2.605)
Oil production x log oil price (t-3)			2.555	2.196
			(1.741)	(2.886)
Oil production x log oil price (t-4)				0.221
				(0.724)
Observations	6,468	5,761	5,053	4,376
R-squared	0.033	0.031	0.031	0.033
Number of municipalities	1,067	1,057	1,045	1,032

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

Table E.16. The effect of oil price shocks on health investment

Dependent variable	(2) Health	(3) Health	(4) Health	(5) Health
Oil production x log oil price (t-1)	0.0799	-0.0579	0.589***	-0.106
	(0.119)	(0.141)	(0.212)	(0.169)
Oil production x log oil price (t-2)		-0.319*	-1.044***	0.173
		(0.183)	(0.299)	(0.217)
Oil production x log oil price (t-3)			0.550**	-0.0586
			(0.254)	(0.285)
Oil production x log oil price (t-4)				-0.0737
				(0.137)

Observations	9,745	8,708	7,648	6,575
R-squared	0.334	0.334	0.278	0.110
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 E.17. The effect of oil price shocks on total investment

Dependent variable	(2) Total	(3) Total	(4) Total	(5) Total
Oil production x log oil price (t-1)	0.172	0.0668	1.677***	0.813***
	(0.143)	(0.145)	(0.329)	(0.237)
Oil production x log oil price (t-2)		-0.390***	-2.245***	-0.400
		(0.100)	(0.349)	(0.325)
Oil production x log oil price (t-3)			1.400**	0.963
			(0.597)	(0.599)
Oil production x log oil price (t-4)				0.114
				(0.342)
Observations	9,771	8,728	7,666	6,588
R-squared	0.263	0.273	0.266	0.256
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 E.18. The effect of oil price shocks on transports investment

Dependent variable	(2) Transports	(3) Transports	(4) Transports	(5) Transports
Oil production x log oil price (t-1)	-0.0107	-0.259	0.322	1.156
	(0.801)	(1.049)	(1.492)	(1.858)
Oil production x log oil price (t-2)		0.681	0.190	-0.477
		(0.761)	(1.199)	(2.620)
Oil production x log oil price (t-3)			3.338	8.018**
			(2.198)	(3.180)
Oil production x log oil price (t-4)				-1.223
				(1.332)
Observations	9,708	8,672	7,615	6,547
R-squared	0.179	0.193	0.209	0.236
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 E.19. The effect of oil price shocks on housing investment

Dependent variable	(2) Housing	(3) Housing	(4) Housing	(5) Housing
Oil production x log oil price (t-1)	0.467	-0.0258	2.815**	1.173
	(1.166)	(1.238)	(1.167)	(1.812)
Oil production x log oil price (t-2)		-0.402	-3.151	0.690
		(1.118)	(2.709)	(3.489)
Oil production x log oil price (t-3)			4.601***	1.097
			(1.097)	(2.924)
Oil production x log oil price (t-4)				2.569
				(2.272)
Observations	7,866	6,915	5,965	5,014
R-squared	0.079	0.089	0.101	0.095
Number of municipalities	1,095	1,091	1,088	1,075

Robust standard errors in parentheses

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

Appendix F: Restricted models for departments

Table F.1. Heterogenous effects on public investment prior and after the royalties' reform

Sectors	Oil production x log oil price (t-1)	Observations	R-square	Number of departments
Agriculture	0.882***	262	0.215	31
	(0.243)			
Pre reform	0.266	87	0.360	31
	(0.511)			
Post reform	1.192***	175	0.247	31
	(0.350)			
PWBS	0.0828	276	0.064	32
	(0.265)			
Pre reform	0.475	89	0.021	32
	(0.909)			
Post reform	0.0628	187	0.094	32
	(0.414)			
Attention to vulnerable population	0.782***	282	0.294	32
	(0.269)			
Pre reform	-0.715	92	0.135	32
	(1.186)			
Post reform	0.985***	190	0.401	32
	(0.303)			
Reclusion centres	-1.656**	77	0.295	21
	(0.660)			
Pre reform	-3.666	33	0.272	15
	(2.769)			
Post reform	-1.954**	44	0.403	18
	(0.729)			
Culture	0.136	283	0.302	32
	(0.154)			
Pre reform	-0.798*	93	0.247	32
	(0.466)			
Post reform	0.373**	190	0.346	32
	(0.151)			
Recreation and sports	0.835**	280	0.128	32
	(0.357)			
Pre reform	-0.282	92	0.094	32
	(0.569)			
Post reform	0.904**	188	0.169	32
	(0.428)			
Community development	0.274	233	0.096	32
	(0.324)			
Pre reform	-1.914*	78	0.153	32
	(1.015)			
Post reform	0.362	155	0.183	32
	(0.417)			
Education	-0.0151	283	0.203	32
	(0.0677)			
Pre reform	0.159	93	0.069	32
	(0.211)			
Post reform	0.0246	190	0.259	32
	(0.0609)			
Equipment	0.569	194	0.151	30
	(0.762)			
Pre reform	-0.766	64	0.083	26
	(0.647)			
Post reform	1.153	130	0.170	28
	(0.947)			
Institutions	-0.243	280	0.148	32

	(0.287)			
Pre reform	-0.490	90	0.049	32
	(1.301)			
Post reform	-0.300	190	0.267	32
	(0.236)			
Justice	0.593**	269	0.264	32
	(0.287)			
Pre reform	-0.909	84	0.083	31
	(1.524)			
Post reform	0.732**	185	0.330	32
	(0.299)			
Environment	1.125	237	0.217	32
	(0.797)			
Pre reform	1.741	77	0.059	30
	(2.386)			
Post reform	0.992	160	0.249	32
	(0.782)			
Public services	0.573	192	0.116	29
	(0.578)			
Pre reform	-0.0397	75	0.233	28
	(1.208)			
Post reform	0.372	117	0.164	29
	(0.697)			
Disasters prevention	0.181	256	0.205	32
	(0.296)			
Pre reform	-0.760	84	0.095	32
	(0.875)			
Post reform	0.275	172	0.254	32
	(0.289)			
Development promotion	0.0225	269	0.113	32
	(0.435)			
Pre reform	-1.956**	89	0.074	32
	(0.889)			
Post reform	0.566	180	0.076	32
	(0.521)			
Health	0.0462	282	0.340	32
	(0.127)			
Pre reform	-0.0808	93	0.167	32
	(0.122)			
Post reform	0.0757	189	0.152	32
	(0.133)			
Total	0.221**	283	0.274	32
	(0.0934)			
Pre reform	0.0685	93	0.184	32
	(0.0920)			
Post reform	0.246**	190	0.309	32
	(0.109)			
Transport	0.953***	278	0.231	32
	(0.249)			
Pre reform	0.224	91	0.193	32
	(0.559)			
Post reform	1.031***	187	0.287	32
	(0.294)			
Housing	0.584	230	0.090	32
	(0.841)			
Pre reform	-1.403	83	0.189	32
	(1.535)			
Post reform	1.060	147	0.107	31
	(0.834)			

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

Appendix G: Restricted models for municipalities

Table G.1. Heterogenous effects on public investment prior and after the royalties' reform

Sectors	Oil production x log oil price	Observations	R-square	Number of municipalities
Agriculture	-0.00224	9,511	0.050	1,097
	(0.656)			
Pre reform	0.230	3,099	0.005	1,088
	(0.826)			
Post reform	-0.0344	6,412	0.062	1,097
	(0.954)			
PWBS	0.369	9,686	0.117	1,100
	(0.545)			
Pre reform	-0.107	3,174	0.034	1,098
	(0.732)			
Post reform	1.015**	6,512	0.097	1,100
	(0.499)			
Attention to vulnerable population	0.573	9,712	0.263	1,100
	(0.403)			
Pre reform	-1.185	3,142	0.075	1,099
	(1.370)			
Post reform	1.070	6,570	0.312	1,100
	(0.707)			
Reclusion centres	0.152	2,701	0.060	770
	(0.539)			
Pre reform	1.452	745	0.015	401
	(2.046)			
Post reform	0.295	1,956	0.068	711
	(0.497)			
Culture	0.473	9,757	0.237	1,100
	(0.300)			
Pre reform	0.242	3,176	0.053	1,099
	(0.291)			
Post reform	0.508	6,581	0.195	1,100
	(0.405)			
Recreation and sports	1.037**	9,746	0.174	1,100
	(0.483)			
Pre reform	-0.628	3,169	0.063	1,099
	(0.487)			
Post reform	1.548***	6,577	0.182	1,100
	(0.511)			
Community development	1.018	7,178	0.017	1,091
	(1.038)			
Pre reform	-1.177	2,326	0.009	1,013
	(1.919)			
Post reform	2.453*	4,852	0.017	1,069
	(1.290)			
Education	-0.226	9,767	0.080	1,100
	(0.256)			
Pre reform	-0.614	3,181	0.081	1,099
	(0.554)			
Post reform	0.364	6,586	0.094	1,100
	(0.300)			
Equipment	1.970*	9,293	0.061	1,100
	(1.196)			
Pre reform	0.517	3,042	0.020	1,093
	(1.137)			
Post reform	2.790*	6,251	0.083	1,100
	(1.457)			
Institutions	1.715***	9,677	0.100	1,100

	(0.625)			
Pre reform	1.889*	3,130	0.006	1,099
	(1.129)			
Post reform	1.784***	6,547	0.061	1,100
	(0.674)			
Justice	0.996*	9,718	0.209	1,100
	(0.604)			
Pre reform	-0.228	3,151	0.172	1,096
	(0.361)			
Post reform	1.116	6,567	0.154	1,100
	(0.793)			
Environment	0.887	8,605	0.045	1,099
	(0.787)			
Pre reform	0.653	2,823	0.033	1,076
	(2.206)			
Post reform	0.845	5,782	0.062	1,097
	(1.000)			
Public services	0.948	8,784	0.062	1,097
	(0.807)			
Pre reform	1.956	2,840	0.030	1,057
	(2.402)			
Post reform	0.588	5,944	0.057	1,087
	(0.836)			
Disasters prevention	1.027	8,983	0.050	1,100
	(0.972)			
Pre reform	0.585	2,958	0.114	1,087
	(2.046)			
Post reform	1.438*	6,025	0.033	1,100
	(0.858)			
Development promotion	1.542	6,468	0.033	1,067
	(0.997)			
Pre reform	-1.073	2,092	0.012	913
	(2.026)			
Post reform	2.396***	4,376	0.032	1,032
	(0.875)			
Health	0.0799	9,745	0.334	1,100
	(0.119)			
Pre reform	0.798	3,170	0.012	1,099
	(0.674)			
Post reform	0.0108	6,575	0.110	1,100
	(0.120)			
Total	0.172	9,771	0.263	1,100
	(0.143)			
Pre reform	-0.116	3,183	0.056	1,099
	(0.275)			
Post reform	0.390**	6,588	0.256	1,100
	(0.162)			
Transport	-0.0107	9,708	0.179	1,100
	(0.801)			
Pre reform	0.0696	3,161	0.017	1,099
	(0.455)			
Post reform	-0.0461	6,547	0.233	1,100
	(1.105)			
Housing	0.467	7,866	0.079	1,095
	(1.166)			
Pre reform	0.181	2,852	0.028	1,072
	(1.994)			
Post reform	0.512	5,014	0.094	1,075
	(1.449)			

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

Appendix E: Public investment trends in oil producing and non-producing local governments

Figure E.1. Public investment by sector in oil producing and non-oil producing departments

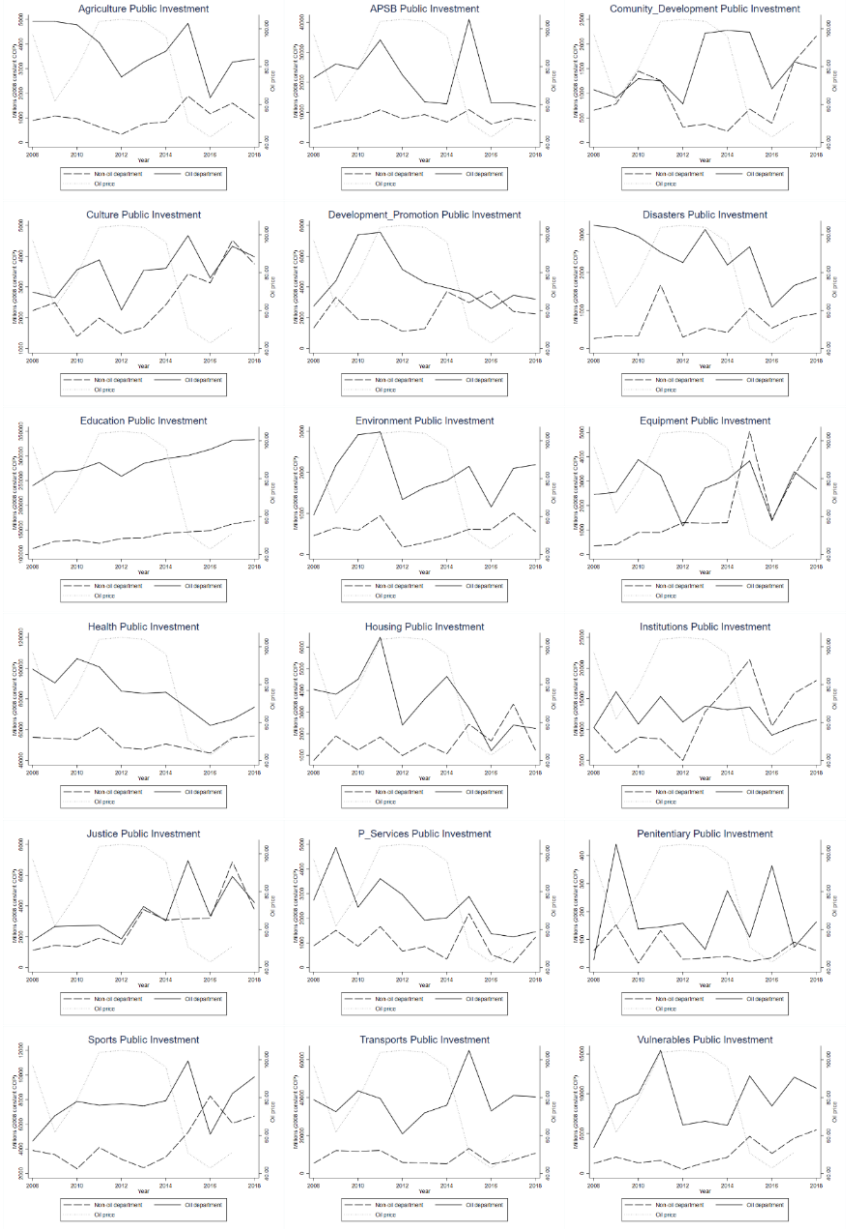
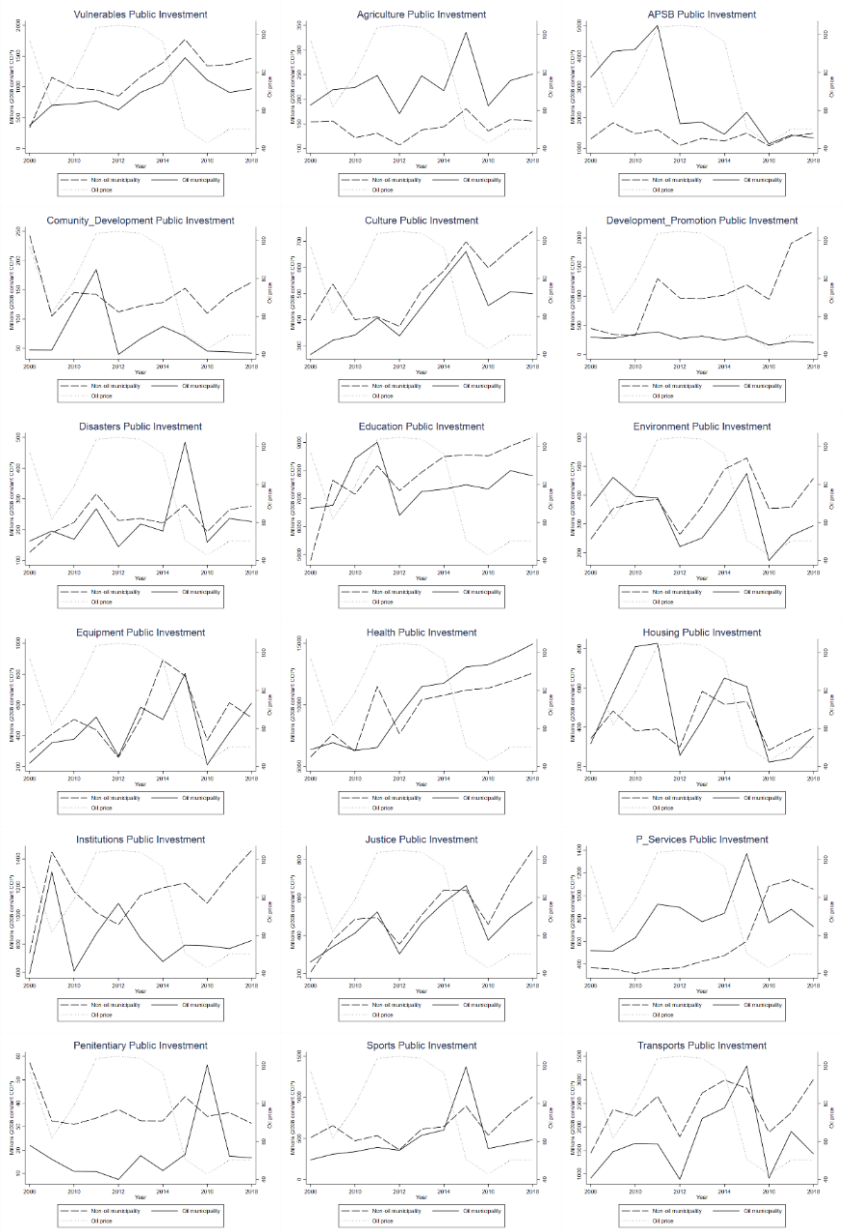


Figure E.2. Public investment by sector in oil producing and non-oil producing municipalities


Vulnerables Public Investment
Agriculture Public Investment
APSB Public Investment
Comunity_Development Public Investment
Culture Public Investment
Development_Promotion Public Investment
Disasters Public Investment
Education Public Investment
Environment Public Investment
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
Non oil municipality
Oil municipality
Oil price