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The Economic Spillovers from Resource Extraction: A Partial Resource Blessing at the Subnational Level?

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The economic spillovers from resource extraction: a partial resource blessing at the subnational level?

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Abstract

We examine the economic consequences of resource extraction and associated revenue windfalls, measured at the subnational level. Our analysis focuses on variations across Indonesian districts and municipalities to estimate the spillover effects on economic activity, measured in terms of local GDP. Two important channels are identified: direct spillover effects from extraction activity, and the fiscal spillovers from local government spending associated with revenue windfalls from extraction activity. We use Indonesia's fiscal sharing rules to quantify and disentangle these two channels by application of an instrumental variable.

We show that the main economic gains accrue via transfers to, and spending by, local government. While direct project-level investments and production contribute to measures of overall GDP, these are found to be largely due driven by the value of oil extraction, with only limited evidence for a direct impact on non-oil GDP. In contrast to other works, it appears that regionally decentralized government spending can be growth-enhancing over the decade surveyed. We argue that resource endowments do contribute to increased economic activity at the subnational level in Indonesia, but may lower the overall growth effect of spending.

1 Introduction

The discovery of subsoil resources, such as oil, gas or solid minerals, is typically accompanied by much fanfare and optimism. Such a discovery can be thought of as a one-time increase in a nation's wealth, and may also raise the likelihood of subsequent discoveries. Governments, and it is almost always governments who are custodians of this wealth, must then navigate the myriad challenges for transforming these natural assets into sustained prosperity for the country's citizens.

Too often this path has proven to be problematic, with recorded growth rates over the previous three decades in resource rich countries lagging far behind their less resource dependent counterparts . This paradox of plenty has been a source of much debate among economists and policy makers. Important work has been conducted which examines the macroeconomic consequences of resource abundance and the perverse outcomes sometimes labelled the 'resource curse' (Sachs and Warner 1995, Auty 2001, Papyrakis and Gerlaugh 2004). Contributing factors range from suboptimal deals for resource extraction rights, corruption, weak governance to rent seeking activity in the resource sector, revenue volatility, Dutch Disease, and poor spending choices.

Much of the existing work examines the possible causes and dynamics of the 'resource curse' at the macroeconomic and cross-country level (see van der Ploeg 2011, for an overview). Counter examples indicate that resource windfalls can contribute to prosperity, such as in the case of Chile's mineral industry (e.g. Maxwell 2004, Ebensperger et al. 2005).[1] Other works have examined how gains from resource

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[1]In the case of Chile's minerals industry the government appears to have been able to manage the state-owned firm CODELCO and distribute copper revenues quite efficiently, while the growing labor force helped mitigate any Dutch

extraction are contingent on governance and institutional quality, at the cross country level (Collier and Hoeffler, 2008) and at the micro level (Cust and Harding 2013).

Studies about the way these factors operate within-country and at the subnational level have emerged only recently (e.g. Monteiro and Ferraz 2010, Caselli and Michaels 2012, Aragon and Rud 2012, Beine, Coulombe and Vermeulen 2012, Cust 2014). While resource rents accruing to government have historically been centrally concentrated, the regional picture matters for several reasons.

First, we are concerned with the drivers of positive or negative economic performance associated with resource wealth. Examination of the subnational and regional impacts of resource windfalls can help us identify the specific factors associated with the 'resource curse' and its observed causes.

Second, extraction activity is spatially concentrated. Where project related spillovers are associated with resource extraction we would expect these to accrue disproportionately to resource rich regions, their neighboring regions and the general locality of extraction. This is due to several specific factors including extraction activity, the bulk weight of a resource, transportation costs, local spending effects and inward investments.

Third, resource revenues are substantial, and thus the spending choices associated with resource windfalls are likely to be an important transmission channel. Where resource revenues are distributed regionally (such as via fiscal sharing rules), these windfalls will affect the regional economic picture. Many countries are now moving to a greater degree of fiscal decentralization, transferring resource revenues back to home districts of extraction activity, and increasingly shifting spending discretion to subnational government units (Zhang and Zhou 1998, and Arzaghi and Henderson 2005). Understanding how these units respond to increases in budget and resource windfalls in particular can help us better understand the challenges associate with this trend.

Such analysis requires a greater degree for spatial disaggregation than has typically been feasible with publicly available data. Early work includes that of Casselli and Michaels (2012) who look at the effect of oil revenues accruing to municipal authorities in Brazil.[2] They trace the impact on socio-economic indicators (or lack thereof) from increased public expenditure and inward investments. They find no significant impact on economic outcomes, but do detect evidence of GDP composition changes.

This paper extends this approach. We construct an annual panel dataset for Indonesia, with detailed project investment, government revenue and government spending data. This allows us to make specific comparisons of direct and indirect impacts across project and fiscal spending, and to disentangle these effects at the district level. The economic impacts of resource extraction are not only important via local labour markets, but also through associated capital outlay and transportation infrastructure which can change the regional economic landscape, creating new market opportunities in associated and non-associated activities, downstream processing and demand for local inputs.

Oil and gas extraction have three main beneficiaries. The first are the shareholders, typically private individuals and institutions located in urban centers at a distance from extraction or overseas. The second group are the government, who via equity stakes, contractual terms, and taxation can be recipients large quantities of rents generated by extraction[3]. This revenue can accrue to the center, or, as in the case of Indonesia, be shared with subnational administrative units following fiscal sharing rules. Such transfers can increase economic activity at the subnational level through spending effects. Third are the regions where extraction activity is located, who benefit through direct capital outlays, employment and wider external effects such as agglomeration benefits arising from transportation, downstream processing of extracted resources, or by use of the resource as an input in production.

This study directly compares the economic performance (defined as district-level economic output) across regions receiving different levels of government revenues and experiencing differing levels of extraction activity. The analysis investigates the effects at the district aggregate level and also draws on government statistics collected at the provincial levels.

The paper's contribution to the literature is threefold. First, it contributes to the growing work examining the capacity of local governments to manage resource windfalls and deploy these effectively

Disease-like side effects (e.g. Lagos 1997, Maxwell 2004). More recent research looks at the future of the Lithium industry in Chile (Ebensperger et al. 2005).

[2]The parliament and government in Brazil have been debating an increase in, and a more equal redistribution of, oil royalties across municipalities, including those that are not host to the oil production.

[3]Countries like Norway are able to capture over 80% of total revenues through their state owned company and taxes.

for sustainable development. Second, we provide the first systematic analysis that we are aware of, of the comparative channels for resource windfalls at the subnational level in Indonesia. Third, we deploy two identification strategies to disentangle the various channels of these effects.

The first empirical innovation is to exploit the fiscal sharing rules in decentralized Indonesia and the spatial variation in extraction activity. Here home districts and home provinces to resource extraction receive the biggest share of rents, followed by other districts in the home province in equal portions. The paper utilises exogenous changes in project investments controlling for government revenues to identify the level of direct (i.e. non-fiscal) spillovers.

The second identification strategy is based on a similar approach to the one used in the analysis of resource windfalls in Brazil (Caselli and Michaels 2013). Here it is possible to use offshore oil and gas production as an instrumental variable for government rents to proximate districts (following district revenue allocation rules, as in Brazil). This also allows a more precise examination of indirect regional agglomeration effects, since offshore wells are not physically located in an administrative district but may have some economic linkages to nearby regions (but not necessarily the home district in fiscal terms). Over 35% of our oil and gas wells are located offshore, providing rich variation across our oil-producing districts and the sources of their rents.

Lastly, the paper studies how central government resources i.e. oil revenues, as a share of total government receipts in a given year, as well as district-level government quality and investment climate, affect local spending outcomes as reflected in higher local economic activity and regional GDP.

We draw on government data on the flows of revenues transferred to provincial and district levels. We supplement this with data on budgets made out of those revenues as well as data on institutional quality. This allows us to examine in detail the channels through which these effects accrue and the relationship between oil rents and the quality of public spending.

The paper is organized as follows: Sections 2 and 3 present a discussion of the literature, and a presentation of the research questions respectively. Section 4 details the dataset, including summary statistics and discussion of the Indonesian context. Section 5 presents our identification strategy and empirical specifications. We discuss our results in Section 6 and Section 7 concludes.

2 Literature

The investigation of the spillover effects associated with resource extraction can be informed by the extensive literature on the dynamics of agglomeration benefits, and more widely New Economic Geography. First, projects have direct impacts, through job creation and capital expenditures in the resource and non-resource related economy. Further, the government revenues generated by resource extraction, and the associated regional government spending choices, create potential economic gains beyond the resource sector, such as via public infrastructure, welfare programmes and even personal enrichment. In this paper we distinguish between two types of spillovers: those arising from project related expenditures (in capital or labour terms), and those arising from public revenues and expenditure choices.

Clearly natural advantages such as resource deposits are key underlying drivers of new extraction activity and the chosen scale of that activity. However, the presence of such activity can have important effects on the underlying distribution of skills in a given locality. Human capital effects can have profound implications for the regional distribution of income and economic activity. For producer nations of natural resources, this is often especially true where extraction activity opens new opportunities to build downstream industries, associated infrastructure and transport facilities on the back of primary goods production. Investment related spillovers can take the form of oil refining, or mineral benefication. Other examples include steel and aluminium production, the generation of power from coal.

As noted by Nelson and Behar (2008) in their survey paper, temporary shocks, particularly where they effect the underlying skill base, can have dramatic agglomeration effects, in line with the models of Fujita, Krugman and Venables (1999). Such a shock in a basic two-region New Economic Geography model in which countries are *ex ante* identical can leave them in a Core-Periphery equilibrium *ex post*, in which all manufacturing is concentrated in one region. Nelson and Behar note the absence of work incorporating natural resources into this story but indicate that the presence of such a sector would likely interact with the agglomeration and dispersion forces at work.

The production externalities arising from proximity to raw material extraction generate pull factors for firm location decision. This combines with other factors such as transport infrastructure (possibly itself resulting from extraction activity) to create potential cluster effects. Over a period of time, these factors may create the necessary conditions for the emergence of agglomeration economies.

Several recent papers have examined the effects of natural resource prices or revenue shocks on regional economies where extraction activity takes place (Caselli and Michaels 2012, Angrist and Kugler 2008). Other recent works examine district-level effects, particularly in relation to the effect of resource extraction and prices on conflict and violence (Dube and Vargas 2006) and on local political elections (Monteiro and Ferraz 2010, Burgess et al. 2012), while other studies examine the effects of resource extraction on local employment and welfare (Aragon and Rud 2009) in a core-periphery framework (for a single large mine).

Similar empirical approaches in the literature include an analysis of the effect of dams in India by Duflo and Pande (2007). They utilize district-level panel data from India to investigate the differential effects of new hydroelectric dams. Given the nature of dam construction, it is relatively easy to identify the winners and losers from dam construction, namely those upstream or downstream of the construction respectively. This variation allows Duflo and Pande to compare the outcomes in agricultural output and poverty reduction between neighboring districts. They employ a Feasible Generalized Least Square approach (FGLS) and feasible IV estimation to take account of both district-level fixed effects and non-random dam placement. Their instrumentation strategy exploits the engineering constraints for dams, namely land gradient, and in particular the non-monotonic relationship between gradient and likelihood of dam construction.

Previous work looking at agglomeration economies in Indonesia have focused on manufacturing clusters and the degree of spatial correlation within sector classes (Deichmann, Kaiser, Lall and Shalizi 2005, Kuncoro and Wahyuni 2009, Arhansya 2010). However little work has investigated the role of the location of natural resource extraction. Deichmann et al. (2005) find some evidence for correlation between the location of wood processing and forestry land and similarly between food processing and crop cultivated land. Kuncoro and Wahyuni (2009) observe that Foreign Direct Investment (FDI) agglomerates in Java in order to benefit from both localization and urbanization economies present in Indonesia's most populous and densely populated island. Arhansya (2009) finds similar resuls and identifies that labor market pooling, followed by input-output relationships, are the key drivers of spatial concentration and Marshallian agglomeration externalities in Indonesia. To our knowledge, none of these studies explore the role of oil, gas and other subsoil resource extraction.

3 Research question

As with cross-country evidence for the resource curse, *ex ante* the abundance of oil and associated extraction activity could be a boon or brake on econoomic development. There are various transmission mechanisms operating at the regional economic level by which oil can have these various effects and it is a testable hypothesis how each of these channels may contribute to resource rich regions outperforming (or under-performing) their resource-poor counterparts.

The presence and increasing production of both onshore and offshore oil and gas, combined with the dramatic decentralization process, offer a fascinating natural experiment to examine the questions of how oil and gas rents effect the subnational economy, and the role of fiscal channels for these effects. Many countries have adopted explicit fiscal sharing rules for resource revenues. Indonesia, like Brazil, has such rules. This obliges central government to return a proportion of rents to the home province and home district of extraction activities. Casselli and Michaels (2013) use this sharing rule in Brazil to examine the effects of oil windfalls on living standards at the subnational level. The channel for these benefits, they posit, is via government disbursements. They limit the possible countervailing agglomeration benefits by examining coastal regions with offshore extraction activity. We take advantage of Indonesia's resource abundance and decentralization dynamics to shed light on the question of direct and fiscal spillovers from extractive activities.

Increases in resource extraction activity in a regional economy is likely to have a variety of economic consequences.[4] Agglomeration externalities, when present, can fundamentally alter the growth trajectory of a region and crowd-in other types of economic activity. In contrast, increased demand for local factors of production could cause short-run shortages and price inflation (Corden and Neary 1982), reducing the competitiveness of the traded goods sector activities in oil rich-regions. Concurrently, oil production generates large economic rents, a portion of which accrue to government, and may then be disbursed to the regional level. This disbursement can drive public investment and consumption which in turn can generate economic output and fiscal multiplier effects.

Our research questions can be summarized as:

- How does the presence of resource extraction effect the relative economic performance of resource rich and resource poor regions?
- What is the relative importance of project related spillovers and investments versus local government revenues on regional economic performance?

In order to address these questions, we utilize district-level panel data, combining information on levels of resource extraction in each district with government revenues accruing to each district.[5]

Our first research question relates to the overall direction and magnitude of economic outcomes and how they relate to the presence and scale of extraction activity in the district. Here we do not distinguish between the role of direct spillovers and government expenditures, but test the overall impact of extraction in the home districts of that activity. Where a district experiences an increase in oil production we would hypothesize that the district will benefit in a variety of ways. We anticipate increases in oil-related and overall economic activity in the district. With respect to non-oil sector GDP, however, two distinct outcomes are conceivable. On the one hand, a form of localised 'Dutch Disease' could squeeze existing traded-goods sectors and undermine agglomeration benefits. On the other hand, a resource boom could increase the domestic market size and skill base, encouraging infrastructure investments and agglomeration in non-oil sectors.

Our second research question seeks to distinguish between the role of oil production and government revenues generated in a given district by an extraction company. This question also relates directly to various channels through which benefits may accrue. In order to answer this question empirically, it is important for us to disentangle direct economic spillover effects from government spending effects associated with resource revenues. Understanding the impact on economic activity in districts that benefit only from offshore oil revenues with limited direct spillovers helps separate the fiscal from the agglomeration benefits of oil extraction. This is because in the case of offshore oil extraction, the host district that receives the larger share of fiscal benefit in accordance with the revenue sharing rules, is typically not the same as the district (if any) benefiting from agglomeration benefits such as downstream processing, transport and other related economic activity

Lastly, we examine how the composition of local government revenues, as well as the quality of local governance, affects district-level income. We study distinct sources of local government revenues, whether in the form of windfalls from resource extraction or from non resource tax and other revenues.

In summary, we shall exploit Indonesia's fiscal sharing rules to:

- Compare the direct effects of oil windfalls on GDP in oil-producing and non-oil-producing districts. We control for government revenues, population and production to examine the impact of project-related expenditures using detailed project expenditure data;
- Instrument for district-level government resource revenues using offshore oil drilling. The goal is to identify the dominant channel of benefits (i.e. government spending or agglomeration externalities). Here we control for total government receipts, although due to fiscal sharing rules these may strongly correlate with overall levels of oil production in the district;

[4] Unless otherwise stated we define resource extraction to include investments in and production of hydrocarbons: liquid crude oil, condensate and natural gas.

[5] We assume that government spending declines with political distance, whereby a district government would spend the bulk, if not all, of its budget within its own district jurisdiction.

- Investigate whether the composition of budgets differ between oil and non-oil districts and also as a function of the source of local government revenues e.g. between resource and non resource revenues. We control for population and district economic governance indicators.

See the sub-section on Empirical Specification and Identification Strategy for more details.

4 Data and Summary Statistics

This paper uses a new dataset, bringing together spatially disaggregated data across resource extraction activity, socio-economic survey data, government revenues, transfers and spending data, as well as other key measures. The panel dataset identifies district units as defined by the Indonesian Statistical Bureau BPS (*Badan Pusat Statistik*). It includes government statistics on regional GDP, population, district and provincial government revenues, expenditures and transfers, including those associated with different kinds of resource extraction and non resource-related activity.

Our resource data is drawn from the Wood Mackenzie Pathfinder database of oil and gas production. This dataset contains records on over 1200 individual oil and gas fields (fields typically contain multiple well sites). This data extends as far back as 1965 for some producing sites, however we utilize data running from 1999 to 2010. This historical production data and project expenditure data, both in terms of capital expenditure (capex) and operational expenditure (opex), is aggregated at the level of the relevant administrative district.

Around 35% of our total sample of production fields are located offshore in Indonesian waters. This data can be linked to the most proximate coastline and linked to its 'home district' as defined by the fiscal sharing rules. Linking offshore production (and associated revenues) to home regions allows us to employ this measure as an instrumental variable for government disbursements to the district otherwise isolated from direct project-related investments.[6] This is because the distance from the coast to the oil wells determines the extent to which the district benefits from fiscal transfers, whereas there need not be any oil-related activity present inside the coastal district.

Note in Figure 2 that the nation's oil production has decreased in recent years, as many of the country's oilfields deplete.

4.1 Indonesia's decentralization and government revenue sharing scheme

Following Indonesia's 1998 democratic reforms and the 1999 decentralization laws, direct elections of the country's president as well as of local government heads have been held in most districts, municipalities and provinces across the country. The country's Law 22 of 1999 on local autonomy and Law 25 of 1999 on fiscal balance granted local governments, in particular the second-tier districts and municipalities, greater autonomy to arrange their own economic, administrative and social policies, including local budgets.[7]

Prior to decentralization Indonesia's fiscal system was largely centralized, with about 80% of district revenues originating from central government funds, especially subsidies of autonomous regions SDO (*Subsidi Daerah Otonom*) and presidential instruction INPRES (*Instruksi Presiden*). The demands of regional stakeholders for greater shares in fiscal revenues associated with natural resource extraction activites in their jurisdictions were a significant driver of the country's decentralization.[8] The general legislative framework was provided by Law 25 of 1999.

Law 25 allows provincial, district and municipal governments to finance decentralization and their regional budgets from four main sources. The Balancing Funds (*Dana Perimbangan*) comprise the general allocation fund DAU (*Dana Alokasi Umum*), the special allocation fund DAK (*Dana Alokasi Khusus*), as well as natural resource and land tax sharing (*Dana Bagi Hasil*). The core of Indonesia's new system

[6]With the exception of large gas processing facilities such as LNG terminals, offshore oil and gas extraction typically has a relatively modest onshore investment footprint. However, to ensure we capture the pure fiscal effect, we control for specific facilities associated with oil activity.

[7]See Ford and Brodjonegoro 2004, Azis 2008, Duek, Brodjonegoro and Rusli 2010. Whenever unambiguous we use the term districts to denote both districts or municipalities.

[8]Barr et al. 2006.

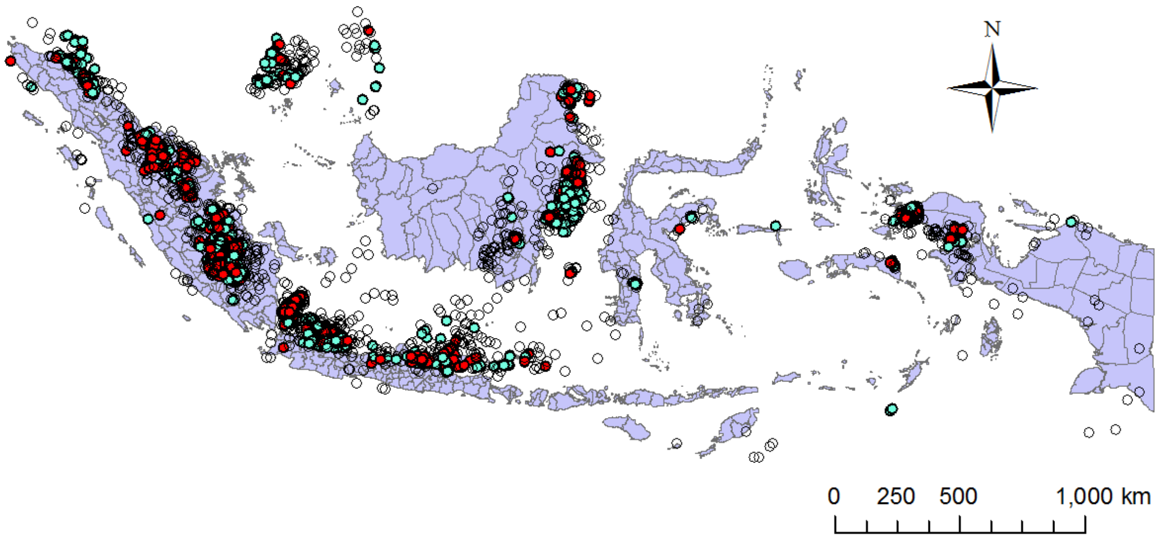

Figure 1: The distribution of oil and gas wells in Indonesia -

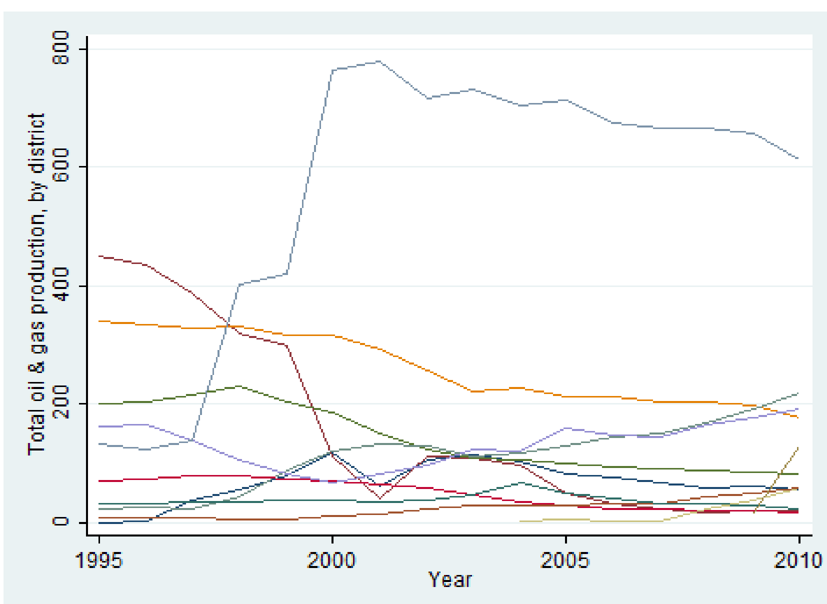

Figure 2: Oil production by district

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of inter-governmental transfers is the general allocation fund DAU. Every year the central government reserves about 25% of its national budget for the DAU.[9] DAU (and DAK) are meant to close the fiscal gap for each subnational level of government. The natural resource revenue sharing scheme defines how oil and gas, timber and mining royalties are to be re-divided among Indonesia's central, provincial and district governments under regional autonomy (see Section 4.2 for more details). Besides the Balancing Funds, the three other sources of district revenues include local taxes, levies and regional government-owned firms; regional borrowing from domestic sources; and other legal sources.

Greater fiscal autonomy, together with the devolution of power and authority from the central to local governments, has had unexpected consequences. On the one hand, the uneven distribution of resource endowments and revenues across the country has resulted in increased interregional disparity. Compared to historically much lower shares of government receipts, since 1999 individual districts home to resource extraction have become better financed, receiving approximately 6%, 12% and up to 32% shares of government revenues for oil, gas and mining output, respectively.[10] Together with a variety of new extraction-related local government revenue sources, and the country's unique post decentralization fiscal allocation scheme, this has led to increasing income disparity between resource-rich and resource-poor districts.[11]

The general allocation fund DAU and the special allocation fund DAK were supposed to help cover fiscal imbalances and reduce fiscal capacity and fiscal gap differences among poor and rich provinces. In practice, local governments in resource-rich regions have developed strategies to maintain or even increase their DAU and DAK allocation. Usui et al. (2003) discuss how fiscal decentralization in Indonesia started with a revenue instead of expenditure based allocation system. Comprising resource revenue and tax sharing as well as DAU and DAK, revenue allocation in turn exacerbated regional inequality, especially in view of regional disparity in resource endowment. As a consequence, although the increase in resource revenue sharing did help reduce the previous "vertical imbalance" by creating better fiscal balance between the centre and the regions, it also contributed to an increase in the "horizontal imbalance" and increased disparity in the fiscal balance among regions.

On the other hand, the district-level increase in natural resource revenue sharing is argued to have contributed to the proliferation of new districts, municipalities and in some cases even new provinces. The incentive for local governments to carve out more autonomous, smaller jurisdictions with their own revenues and (at least partially) discretionary budget potential is strong. Indonesia had 26 provinces and around 310 districts and municipalities in 1998. By the end of 2008, the number of districts and municipalities had increased to more than 490, grouped into 33 provinces (Fitrani et al. 2005 and Brata 2008).

As a result, Indonesia's decentralization has brought both benefits and challenges. On the political side decision making now involves local communities, for example through direct local elections. However, while direct elections promote local government accountability and reforms (TAF 2008), they also increase the prevalence of local patronage and government-business collusion on the subnational level (Duek and Rusli 2010). Moreover, Brata (2008) points out that the proliferation of new districts, being one consequence of decentralization, has resulted in inefficient local governments, increased administrative cost as well as higher inequality in income and lower human development index score (HDI).

On the fiscal side higher centre-local revenue sharing and budgetary autonomy increase local spending flexibility. Nevertheless, while it is not unjustified that districts enjoy higher shares of fiscal windfalls from their indigenous resource extraction-related activities, the challenge for the government is to address the weaknesses in the design and implementation of the fiscal equalization program, especially the DAU and DAK, which are supposed to reduce both vertical and horizontal inequality (see Hofman et al. 2006).

4.2 District level data

Our data on government revenues and expenditures is drawn from official records. This data contains reported resource revenue shares for 303 government districts from the period 1999-2010, as well as district government revenues (including local and shared taxes, general and special allocation funds) and

[9] The proportion of the special allocation fund DAK, which covers case-specific needs, is generally smaller than DAU.
[10] See section 4.2 below for details.
[11] See Asanuma and Bodjonegoro 2000, Barr et al. 2006, Duek and Rusli 2010.

expenditures (including opex and capex for administration and public goods) for the years 2005, 2006, 2009 and 2010. Government receipts are broken down by source and explicitly include those revenues drawn from resource extraction.

We use data about district-level economic characteristics including district size, population, regional GDP, sectoral GDP composition, and other measures of socio-economic development drawn from survey data. We also draw on a survey of district-level governance collected by the Asia Foundation and the Regional Autonomy Watch.

In Table 1 *oil* and *any* dummies indicate the presence of oil respectively oil or gas production in a district. The two *offshore* dummies denote production within 3 and 12 mile distances from the coastline, while *invest* and *refine* dummies represent project investment and downstream processing or transport facilities. *PRODUCTION* figures (including *onshoreprod3m* and *offshoreprod3m*) are in thousands of barrels of oil and liquids per day (bpd) respectively millions of standard cubic feet of gas per day (mmcfd). *CAPEX* and *OPEX*, as well as *investment* and *opinvestment* denote capital expenditures and operating expenditures, general and extraction project-related investment outlays are presented in millions of USD.

In Table 2 we distinguish between oil-producing and non oil-producing districts. We show total subnational i.e. district GRDP in billions of IDR, its log oil and log non-oil component. The variables *iloglocgovrecrev* and *lnrevoilgas, DAU* and *DAK* denote total district government revenues respectively government oil and gas revenue receipts, as well as the general and special allocation funds, all measured in thousands of IDR. It can be seen that the mean resource revenue receipts and population are higher, while mean general and special allocation funds are lower, in oil-producing districts.[12]

Table 1: Summary statistics

Variable	**Mean**	**Std. Dev.**
Oil dummy	0.061	0.24
Any Investment dummy	0.079	0.271
Offshore Oil dummy 3miles	0.012	0.107
Offshore Oil dummy 12miles	0.017	0.131
Investment dummy	0.032	0.175
Refinery dummy	0.017	0.131
Oil Production (thousand barrels per day)	0.986	10.246
Gas Production (million cubic feet per day)	9.98	140.709
Total Production (thousand boe per day)	12.935	171.265
Capital Expenditure (million USD)	2.436	25.411
Operating Expenditure (million USD)	0.576	5.291
Onshore Oil Production	2.46	38.765
Offshore Oil Production 3miles	0.731	10.376
Investment (million USD)	0.03	0.28
Operating investment(million USD)	0.006	0.053
N	2076	

4.2.1 Government revenues and expenditures

Due to limitations in BPS data collection, complete sets of district government revenues and expenditures are only available for the years 2005 (actual), 2006 (as forecasted in 2005), 2009 (actual) and 2010 (as estimated in 2009).

Indigenous district and municipal incomes comprise 2005, 2006 and 2009, 2010 BPS data on local taxes, levies, redistributions, local government corporation income as well as other local income such as interest, etc.

Balancing funds. These include tax and non-tax sharing as well as the general and special allocation funds, DAU and DAK. Non tax sharing comprises natural resource revenue shares pertaining to the districts or municipalities of origin, their corresponding provinces of origin and other districts and

[12]The higher population in oil producing districts may be an indication of agglomeration benefits of extraction activity.

Table 2: Summary statistics (Continued)

Variable	Mean	Std. Dev.	N
Oil=0			
GDP (thousand IDR)	737544.697	1771347.42	1693
Log GDP	12.517	1.3	1693
Log non-oil GDP	12.437	1.292	1693
Log total gov receipts	19.929	0.467	1672
Log gov oil and gas revenues	7.698	7.548	1693
Population	485275.889	572010.560	1677
General Allocation funds (IDR)	329816857.25	164227209.494	823
Special Allocation funds (IDR)	39507234.06	19237984.368	823
Oil=1			
GDP (thousand IDR)	1618505.717	2035429.021	127
Log GDP	13.642	1.187	127
Log non-oil GDP	13.207	1.173	127
Log total gov receipts	20.071	0.541	119
Log gov oil and gas revenues	16.671	5.28	127
population	532003.937	381356.059	127
General Allocation funds (IDR)	281370882.4	166381467.3	60
Special Allocation funds (IDR)	32374746.2	20224840.7	60

municipalities within the same home provinces. We use 2005, 2006 and 2009, 2010 BPS data, of which (actual) 2005 and 2009 figures coincide with the resource revenue share figures described in section 4.2.

Administrative and public goods expenditures. These comprise administrative and public service expenditures for the years 2005, 2006 and 2009, 2010 from BPS. Administrative expenditures are split into personnel, goods and services, official travel, maintenance and capital investments. Public service expenditures comprise personnel, goods and services, official travel, maintenance, capital expenditure, sharing funds and financial aids. The largest local government expenditure components are typically administrative personnel, as well as public service personnel and capital expenditures.

4.2.2 Gross Regional Domestic Product (GRDP)

We use data published by the BPS. Following the United Nation's SNA 1993/2008 approach, BPS compiles GRDP data across districts, municipalities and provinces as well as national GDP figures using both the production and the expenditure approach.

Using the production approach, these figures are calculated based on the value added generated by productive factors of labor, land and capital. In terms of industrial origin the data is divided into agriculture, livestock, forestry and fishery; mining and quarrying (which includes oil, gas and mining), manufacturing; electricity, gas and water; construction; trade, hotel and restaurant; transportation and communication; finance, real estate and business services; and services. On the expenditure side GRDP and GDP data comprise private and government consumption, gross fixed capital formation as well as export and import data. Sectoral data, including for oil and gas is based on reported value-added.[13] [14]

We use GRDP data in current prices for 487 districts and municipalities, and 33 provinces, for the years 1998-2009.

[13]See also notes on GDP and export-import statistics in Strategic Data, 2010/2011, National Statistics Agency (BPS), Jakarta, pp. 72-82.

[14]McCulloch and Malesky (2011) discuss some of the problems of using district-level GRDP. We therefore plan to expand our analysis to include district- and village-level surveys, as well as human development (HDI) data, in a subsequent study.

4.2.3 Population

District and municipal-level data is available from BPS on an annualized basis. However direct census data was only collected for 2000 and 2010, with additional survey data for 2005. We therefore use linear interpolation for the remaining and interim years.

4.2.4 Regional economic governance

Regional Autonomy Watch KPPOD (*Komite Pemantauan Pelaksanaan Otonomi Daerah*) and The Asia Foundation (TAF) conducted four surveys of district-level economic performance and governance in 2007, 2008, 2010 and 2011.[15] The survey evaluates regional economic governance across nine dimensions. This Economic Governance Index (EGI) covers a total of over 440 districts in Indonesia. The districts are surveyed on characteristics such as land availability, business licensing practices, local government - business interactions, capacity of regional heads, local taxes and other transaction costs, as well as measures of local security aspects and means of conflict resolution and regulations.

4.3 Oil and gas contracts and government revenue sharing

Most companies now operating in Indonesia do so under the terms of a Production Sharing Contract (PSC).[16] The first PSCs were signed in the mid 1960s. Various changes were made over the years. The production sharing agreement is between the contractor and the government, and lasts about 30 years. Day to day operations of projects are then managed under the auspices of a regulator, SKK Migas, which is part of the Ministry of Energy and Mining Resources (MEMR).[17] When the contractor is successful in exploration and makes a commercial discovery, a plan of development must be submitted and approved by the regulator. Upon start of production the government through the regulator reimburses the contractor for approved capital and operating costs.

Signature and production bonuses are levied for the exploration and production periods respectively. The terms of the PSC typically include the government's share of revenues from oil and gas production, which the government receives both in form of monetary and in-kind benefits: bonuses, First Tranche Petroleum (FTP), Domestic Supply Obligation (DMO) for oil, and more recently, gas, as well as a fraction of profits, income and witholding taxes. The government typically receives about 65%-80% of an extraction project's lifecycle revenues.[18]

The portions of oil and gas revenues retained by the government are then allocated between central and regional governments. The oil and gas revenue shares are split and redistributed to the district of origin, in which the oil and gas production takes place (if onshore) or which are governed by special resource revenue allocation rules (if offshore, or considered special autonomy regions like Aceh and Papua), as well as to other districts and municipalities in the province of origin. If a contract area straddles several districts the home district allocation is calculated based on the proportion of reserves or production. Table 3 summarizes the centre-local fiscal revenue distribution that were amended following the decentralization law 25 of 1999:

[15] The two main ones took place in 2007 and 2011. See TAF 2008.

[16] Other existing contracts include Technical Assistance Contracts (TAC) and Cooperation Contracts (KSO) between companies and the national oil company, Pertamina.

[17] The former upstream oil and gas regulator, BP Migas, formed by the 2001 Law 22 governing the oil and gas industry, was recently renamed SKK Migas and integrated back into the MEMR. See Appendix A.

[18] For an overview of Indonesia's oil and gas sector and it's regulatory and fiscal regime see Wood MacKenzie Indonesia Country Overview.

Table 3: Fiscal sharing rules relating to resource revenues

Revenue Source	Old sharing arrangement	Major change	New sharing a
Oil revenues a,b	100% Centre	Assignment of revenues after tax deduction to regional governments	85% Centre 3
Liquid Natural Gas	100% Centre	Assignment of revenues after tax deduction to regional governments	70% Centre 6
Mining land rents	65% Centre 19% Prov 16% Dist	Continued with new sharing arrangement	20% Centre 1
Mining royalties	30% Centre 56% Prov 14% Dist	Continued with new sharing arrangement for districtss/municipalities in province of origin	20% Centre 1

Distribution of oil, gas and mining revenues (Source: Ford and Brodjonegoro 2003, p. 26, updated by authors)

Notes: (a) Additional shares of oil and gas revenues for the provinces of Nanggroe Aceh Darussalam (former Aceh) and Papua are stipulated in the Special Autonomy Laws 18/2001 21/2001, respectively. In particular, under Law 18/2001, provincial shares of natural resource revenues in Aceh include 70 percent of gas and oil revenues, and 80 percent of revenues from forestry, fisheries, and general mining. Increased oil and gas revenues are reduced after eight years. Under Law 21/2001, Papua also receives 70 percent of natural oil and LNG taxes and 80 percent of forestry, fishery and general mining. Oil and gas revenues, however, are decreased to 50 percent after 25 years. (b) According to Law 33/2004 (which replaced Law 25/1999), the share of oil and liquid natural gas revenues has been changed so that the central government (the ”Centre” above) would receive 84.5 percent and 69.5 percent of oil and gas revenues, respectively. The share of the regions remains the same. The difference of 0.5 percent of the oil and gas revenues will be allocated for basic education, from which provinces will receive 0.1 percent, originating districts will receive 0.2 percent, and other districts within the provinces will get 0.2 percent.

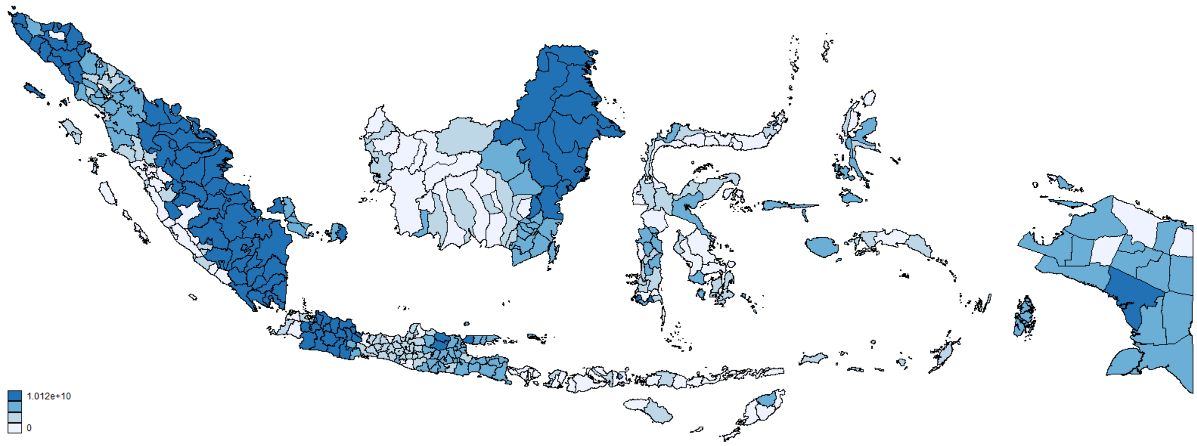

Figure 3: District government oil revenue receipts

Resource revenue sharing rules drive the allocation of oil and gas, mining and other royalties, taxes and bonuses across the different districts and provinces. This data is collected by BPS, with input from the relevant ministries e.g. the Ministry of Mines and Energy. We use numbers from 1999-2009.

Individual districts home to resource extraction have become better financed, receiving approximately 6%, 12% and up to 32% shares of government revenues for oil, gas and mining output, respectively. Together with other districts and municipalities in the same province, the provinces of origin receive up to 15%, 30% and 80% of oil, gas respectively mining government revenues.

An offshore oil and gas field is linked to a home district if it is located within a distance of 3 miles to the closest coastline. If the field is between 3 and 12 miles from the closest coastline, the nearby province is designated as home province and recipient of funds. Beyond 12 miles the entire project revenues are allocated to the central government.

Figure 3 shows that the resource and therefore resource revenue-rich regions are located primarily in the islands of Sumatra, Java, the Eastern regions of Kalimantan and West Papua.

5 Empirical Specification and Identification Strategy

We can examine both the direct effects of oil production on regional economy performance and the indirect effect via government revenues. Further, we can exploit the offshore characteristics of around 35% of our oil production activity to instrument for district oil revenues in those coastal districts defined as home regions to the offshore oil according to Indonesian fiscal sharing rules.

The validity of our estimation strategy depends critically on the ability to identify exogenous increases in government funds and project related expenditures. In the case of project related investment, this will depend on two types of decisions taken by private agents. First, the location of oil project investments will be determined by the presence of oil deposits. Here, while the distribution of oil reserves across Indonesia is likely to be random with respect to other economic characteristics, we may worry that the process of oil discovery is endogenous to province and district-level characteristics. We thus try to control for district fixed effects. Furthermore, subject to oil being discovered in the district, the decision to proceed with extraction related investments may also be impacted by regional characteristics, such as the investment environment and local taxes.

We investigate the effect of oil-related investments, and oil-related revenue windfalls, on economic output at the district level. We can express the relationship between oil and economic output as:

$$Y_{it} = \gamma_1 Oil_{it} + \gamma_2 G_{it} + \mathbf{X}'_{it}\delta_1 + \alpha_t + \beta_i + \epsilon_{it}. \tag{1}$$

Here Y_{it} gives a measure of nominal economic output, defined at the district level i for year t, and measured as GDP in local currency units in terms of total district GRDP, non-oil GRDP and composition of GRDP. Our Oil_{it} variables and dummies capture some time-varying measures of project related extraction activity and investment, while G_{it} denotes total government revenue generated inside the district for a given year. $\mathbf{X}'_{it}$ is a vector of other time-varying district-level controls, including population. We also examine time period dummies α_t and time invariant district fixed effects β_i.

Our annual panel dataset allows us to exploit the time-variation in our oil and oil revenue windfall data. This allows us to re-write the static specification in terms of short-run dynamics, and enables us to estimate the multiplier effects of oil investments and fiscal windfalls on economic output:

$$\frac{Y_{it} - Y_{it-1}}{Y_{it-1}} = \gamma_3 \frac{Oil_{it} - Oil_{it-1}}{Y_{it-1}} + \gamma_4 \frac{G_{it} - G_{it-1}}{Y_{it-1}} + \mathbf{X}'_{it}\delta_1 + \alpha_t + \xi_{it} \tag{2}$$

where Y_{it}, Oil_{it}, G_{it} and $\mathbf{X}'_{it}$ follow the same definitions as in (1). The district fixed effects are substracted out. The key parameters of interest are now γ_3 and γ_4 which capture the impact of project investments and the government spending multiplier respectively. This specification allows us to estimate the contemporaneous change in output associated with oil-extraction, as a measure of the short-run cyclical impact of spending.

5.1 Identification of project channel effects

We already control for district-level fixed effects to handle sources of unobserved regional characteristics, which might potentially lead to endogeneity in the presence of oil related investments. This allows us to control for between-district variations and identify the impact of oil investments based on temporal variations in size and presence of these investments.

We need to ensure we are measuring the impact of investments directly, and not capturing the spillovers associated with increased government revenues, which are positively correlated to the amount of oil extraction taking place in the district (see Figure 4). To do so, our dataset allows estimates using accurate project-related spending, rather than simply the presence of a project or proxying for the size of projects by the amount of oil extracted (see Figure 5).

5.2 Identification of fiscal channel effects

In order to identify the size of the fiscal multiplier, a common challenge faced in the literature is in isolating exogenous sources of variation in government spending (for example see discussion in Kraay 2010 of a novel method to estimate the fiscal multiplier effect using World Bank project spending). Here the challenge typically faced is that fiscal revenues and expenditures may be connected to other economic shocks in a region via automatic stabilizers and other government responses. Therefore, making causal inference on changes in government spending is challenging given this (sometimes mechanical) level of endogeneity. By contrast, our variation in oil production levels across time and space, and the connection between project revenues and government budgets, allows us to deploy an alternative approach.

While we can be confident that the source of variation in oil-related government revenues is directly tied to oil extraction in the home district and province via fiscal sharing rules, there are several additional concerns we must address. The first is that we may worry that the level of oil extraction - and hence government revenues - may be also associated with initial economic conditions of oil and non-oil regions prior to development, and other time-invariant unobserved differences across oil and non-oil districts. Our panel data allows us to account for time invariant district-level characteristics. Since around 40% (474 fields out of 1280) are discovered after 1991 we can assess the extent to which the economic performance differs prior to oil development and therefore isolate the post-oil impact. Furthermore around 20% of the fields started production post-2000, with around half of those fields onshore and half offshore. This degree of exogenous variation allows for a strong identification strategy using fixed effects estimator to examine the temporal variation in oil output and therefore government spending, once we have controlled for total government budgets.

Furthermore, identification depends upon the increases in government receipts (and spending) associated with oil windfalls. The central government seeks to compensate non-oil rich districts using its general

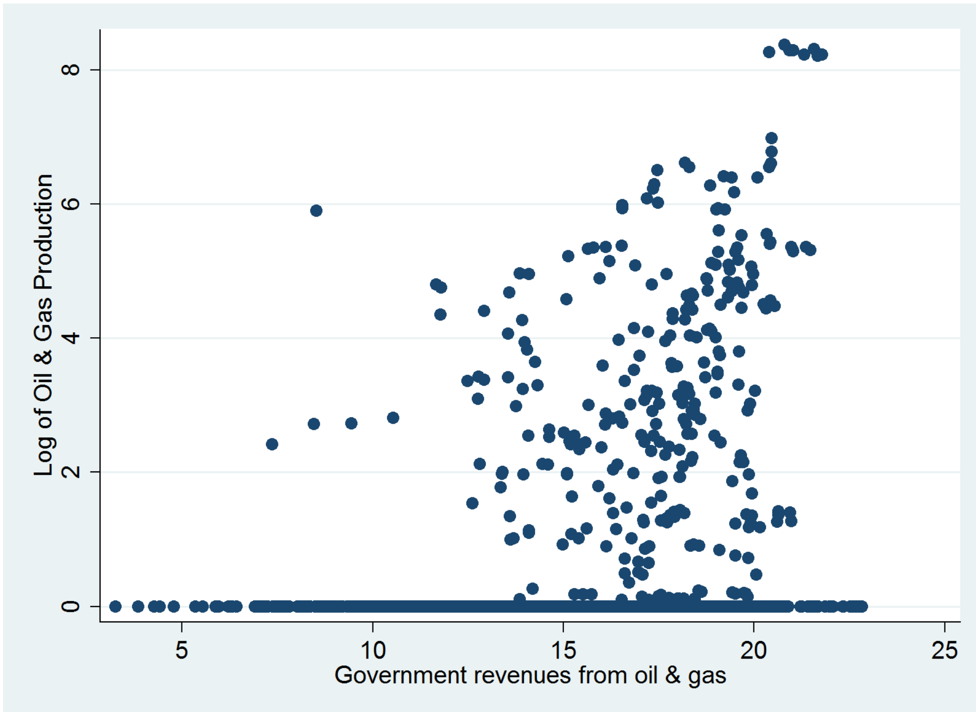

Figure 4: Oil production and government revenue

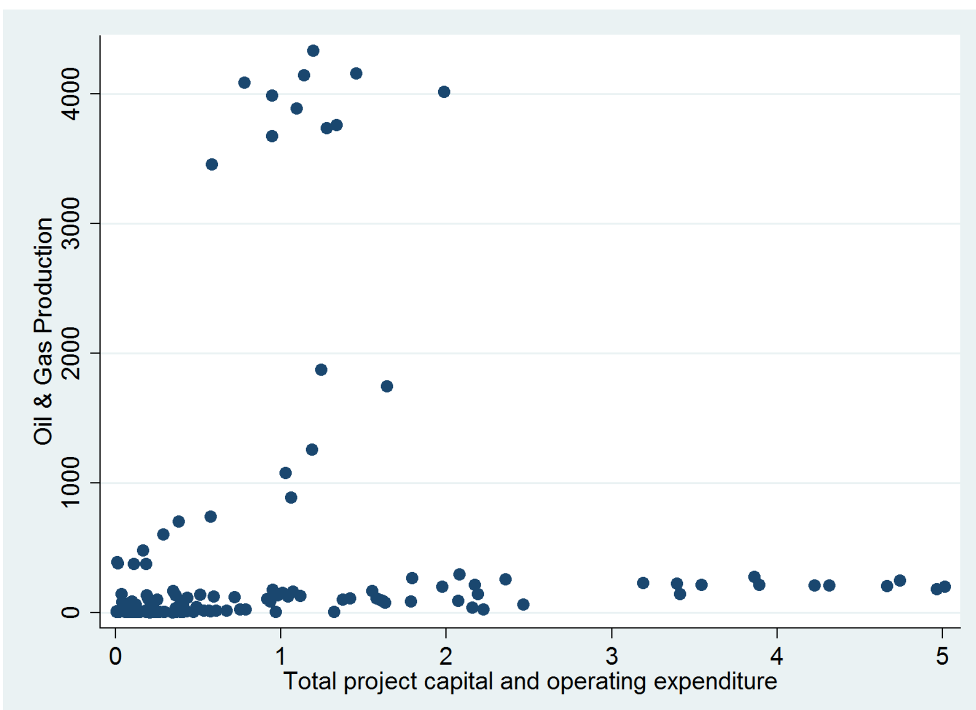

Figure 5: Oil field investment and production

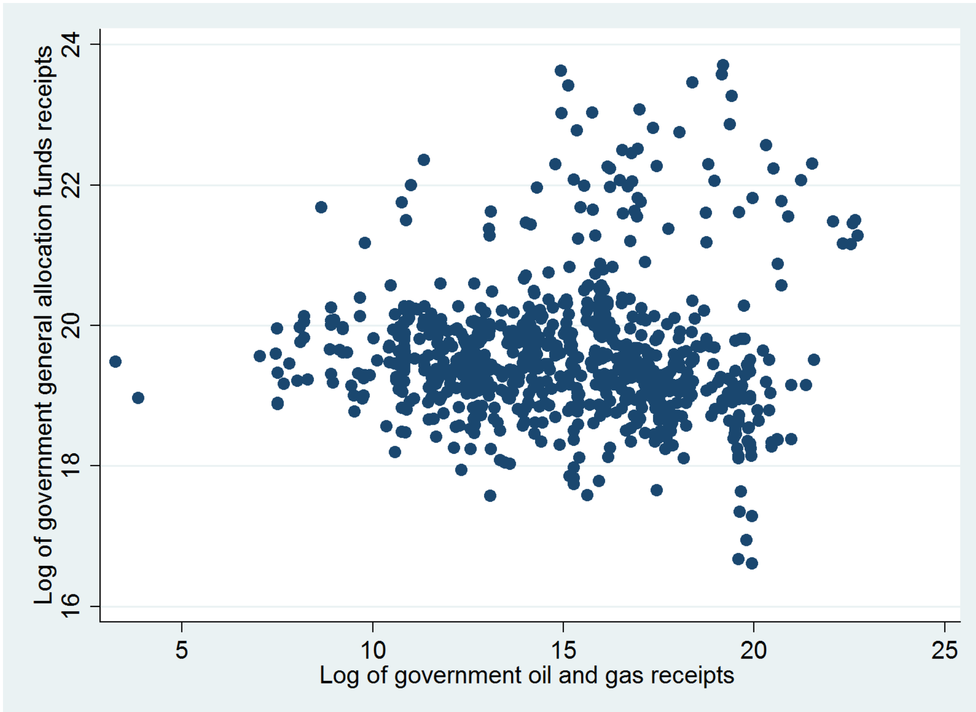

Figure 6: General allocation fund and oil revenues

or special allocation funds. Figure 6 illustrates the absence of correlation between the government receipts derived from oil revenues and the general allocation funds (DAU) received by district governments.

As mentioned above, this fund is intended for use as a 'top-up' to help district governments meet their budgetary outlays. In fact we find that the DAU correlates strongly with the district population, the latter being a driver of local expenditures and therefore fiscal deficit as well as DAU allocation, especially in the early days of fiscal decentralization.[19] We thus conclude that, while having to control for DAU and total local government revenues, these are at most only weakly linked to oil extraction related local government resource revenues.

5.2.1 Instrumenting strategy

Our fourth identification approach relates to the separate identification of oil project spillovers and the fiscal spending multiplier. Here we may be concerned that, for our sample of districts hosting onshore oil production, these districts experience contemporaneous increases in oil related investments and oil revenue windfalls. While we can directly estimate the effects associated with each of these (controlling for the other), we can also deploy an instrumental variable approach that allows us to isolate the fiscal effect.

This approach follows the one developed by Caselli and Michaels (2013) for estimating the impact of oil revenue windfalls in Brazilian municipalities. The authors exploit variations in offshore oil projection and fiscal sharing rules connecting these projects to coastal municipalities. This allows them to instrument for revenue windfalls at the level of coastal municipalities using the offshore oil wells most proximate to each district.

For our instrumenting strategy to be valid we depend on the allocation of offshore sites to be exogenous to economic conditions in designated home regions and that sharing rules are sufficiently arbitrary that offshore oil benefits those regions only through government expenditures and not other channels. Like in Brazil, Indonesian fiscal sharing rules display a degree of arbitrariness, connecting offshore rents to home

[19]See Fitrani et al. 2005.

regions via proximity rules (3 miles of nearest coastal point), rather than landing offtake points, refineries or transportation hubs. We can therefore control for the landing points, processing and transportation hubs of offshore oil and gas (that do not fall in the designated home regions where agglomeration benefits might otherwise accrue).[20] Our dataset contains detailed information on the transportation methods and destinations of all oil and gas fields allowing us a sense of likely beneficiary districts via externalities effects as well as via government revenues.

Our alternative specification shows our instrumental variable (IV) estimation, whereby we estimate the effect of government oil-revenues, instrumented by offshore oil production, on district-level outcomes. Here we distinguish between onshore and offshore oil and gas production Oil^{ON}_{it-1} and Oil^{OFF}_{it-1}:

$$\begin{aligned} Y_{it} &= \gamma_6 Oil^{ON}_{it-1} + \gamma_7 \widehat{W}_{it-1} \\ &\quad + X'_{it}\delta_X + G'_{it}\sigma_G + \alpha_t + \beta_i + \eta_{it} \end{aligned} \tag{3}$$

And the first stage using the instrument of offshore oil revenues:

$$W_{it} = \gamma_5 Oil^{OFF}_{it-1} + X'_{it}\phi_X + G'_{it}\kappa_G + \omega_t + \nu_i + \zeta_{it} \tag{4}$$

Here we can interpret γ_5 as the coefficient capturing some exogenously determined revenue and its impact on district-level economic performance. Using offshore oil production and revenues shared with district-level governments, we are able to isolate the government revenue effect from the oil production externalities, to obtain an estimate for the impact of the marginal dollar of government oil windfall spending.[21]

6 Results

This section of the paper presents the results for each of our tested hypotheses. The tested hypotheses can be summarized as follows:

- A: The short run impacts of oil windfalls
- B: Analyzing project-related direct economic spillovers of oil extraction
- C: Identifying the impact of fiscal spending windfalls associated with oil revenues (using offshore instruments)
- D: The effect of the composition of public revenues (and spending).

We hypothesize that the location and extent of oil production will be positively associated with short-run changes in district GRDP due to overall spending effects via various channels. More specifically, the combined spending effect and resource movement effect from oil windfalls will raise district GDP, after controlling for oil-sector GRDP. Firstly, we hope that, controlling for government revenue windfalls, our measure of oil project-related expenditures allows estimation of the exogenous multiplier effect. Secondly, to capture the exogenous change in government revenues (and by proxy, expenditures) and thus identify the pure government spending effect on GRDP, we use an offshore instrumenting strategy. Lastly we compare the impact of oil production and oil revenue on total and non-oil gross regional domestic product (GRDP).

[20] We differentiate between offshore gas that is piped directly to the closest coastal facility, versus offshore gas, oil or liquids stored, processed and transported directly from floating facilities. A limited degree of correlation between proximity-based fiscal sharing and direct spillovers may occur only in the former case of locally piped gas.

[21] We also find a significantly positive correlation between district government revenues and spending, thus mitigating the effect that local public debt financing might have on local public spending.

6.1 (A) Identifying the short-run impacts of oil extraction

The location and extent of oil production will be positively associated with short-run changes in district GDP due to overall spending effects via various channels. The combined spending effect and resource movement effect from oil windfalls will raise district GRDP, after controlling for oil-sector GRDP. Here we estimate the reduced form specification, in both levels and changes over time, using (1):

$$Y_{it} = \gamma_1 Oil_{it} + \gamma_2 G_{it} + \mathbf{X}'_{it}\delta_1 + \alpha_t + \beta_i + \epsilon_{it}$$

and our dynamic specification for estimation of contemporaneous short-run effects (2)

$$\frac{Y_{it} - Y_{it-1}}{Y_{it-1}} = \gamma_3 \frac{Oil_{it} - Oil_{it-1}}{Y_{it-1}} + \gamma_4 \frac{G_{it} - G_{it-1}}{Y_{it-1}} + \mathbf{X}'_{it}\delta_1 + \alpha_t + \xi_{it}.$$

In Table 4 we estimate the effects of oil production and the revenues associated with oil production, on district-level GRDP. The coefficient estimate on our *L.any* (a lagged dummy variable indicating the presence of oil or gas production in the lagged period) indicates the total and non-oil GRDP impact of production initiation in the previous year. The variable *L.ilogocgovrecrev* represents the lagged total local government revenues, which includes taxes, resources and non resource revenues. We also control for district fixed effects and thus capture the impact of new projects starting, rather than the static impact of being an oil-producing district at the beginning of our time period. We do not explicitly distinguish between the lagged effect of production and project investment, versus the likely increase in oil-related government revenues at the district level. Thus we capture the general impact of new oil wealth during our time period.

Table 4: Estimation of spillover effects of oil

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	logsubgrdp	logsubgrdp	lognonoilsubgdp	lognonoilsubgdp	dlogsubgrdp	dlognonoilsubgdp
L.any	0.243***	0.0725	0.201***	0.0716	0.000805	0.00160***
	(0.0846)	(0.0512)	(0.0711)	(0.0514)	(0.000508)	(0.000496)
L.iloglocgovrecrev	0.592***	0.530***	0.588***	0.529***	-0.000721	-0.00266***
	(0.105)	(0.0981)	(0.105)	(0.0993)	(0.00123)	(0.000335)
egi_combinedindex	0.0131		0.0148*			3.92e-05
	(0.00815)		(0.00767)			(3.99e-05)
Constant	0.0786	2.115	-0.0522	2.045	0.0242	0.0605***
	(2.277)	(1.949)	(2.245)	(1.974)	(0.0245)	(0.00686)
Observations	1,220	1,220	1,220	1,220	1,220	1,220
R-squared		0.428		0.428	0.000	
Number of kode_kab	410	410	410	410	410	410
Year dummies	Yes	Yes	Yes	Yes	Yes	
District FE	No	Yes	No	Yes	No	
Robust SE	Yes	Yes	Yes	Yes	Yes	

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

Our estimates indicate a marked increase in overall GRDP including measures of oil-related GRDP (see column 1), despite controlling for total government receipts. This captures the value-added of the oil sector to the district economy, plus any related economic activity, less possible crowding out effects. The log-log relationship between oil (or gas) production and overall district GRDP (column 1) respectively non-oil GRDP (column 3) is positive and significant: a 1% increase in the probability of oil being produced in a district increases district-level GRDP, as well as non-oil GRDP, by approximately 0.2%. On the fiscal side a 1% increase in total government revenue (and accordingly, spending) increases overall, oil and non-oil GRDP by approximately 0.5-0.6%.

Adding the district fixed effects (columns 2 and 4), however, results in the loss in significance of the impact of oil production in the previous year, although the positive sign remains. One possible explanation is that oil extraction projects often follow long-term production contracts with relatively steady annual production volumes, so that the significant positive benefits of new oil projects typically result in a one-time step-up in economic activity.

Column 3 indicates positive and significant spillovers into non-oil GRDP. Interestingly, our coefficient on the measure of local government quality show a modest positive effect on non-oil GRDP. Column 4, which includes district fixed effects, shows that spillovers from new oil extraction projects into non oil-related economic activity is positive, though less significant. Columns 5 and 6 estimate the impact on changes in GRDP and non-oil GRDP. Here we find a modest effect of oil production on the growth rate in non-oil GRDP, indicating evidence for a positive sustained spillover effect.

Overall government revenues significantly increase overall as well as non oil-related GRDP, with and without district fixed effects. This is intuitive since government revenues are correlated with overall government spending, which in turn help boost economic activity. Lastly, the negative and significant coefficients of total government revenues on non oil-related GRDP growth rates could be due to the contemporaneous nature of the regression. Or alternatively, it could be an endogenous result of the local government trying to spend more or the central government allocating higher DAU funds to compensate for districts with lower GRDP growth rates.

6.2 (B) Estimating the channels: the impact of oil-project related investments on economic activity in non oil-related sectors, versus local fiscal spending

Controlling for government resource revenue windfalls, our measure of oil project related expenditures allows estimation of the exogenous multiplier effect. Here we estimate the channels of regional investments associated with oil extraction activities. For project-related spending we use a direct measure of project capital expenditures (capex) and operational expenditures (opex). This outlay may proceed oil extraction activity and otherwise be imperfectly correlated to the revenue generation, or volume of oil extraction at wellhead. Our measure of government expenditures is based on the district government revenues drawn from oil receipts. We tailor (1) to

$$Y_{it} = \gamma_8 Investment_{i(t-s)} + \gamma_2 G_{it} + X_{it}' \delta_{\mathbf{X}} + \alpha_t + \beta_i + \varkappa_{it} \tag{5}$$

where $s \in \{1, 2, 3\}$ denotes the one, two and three year lagged project-related spending. Now we directly estimate the size of the spending multiplier associated with oil revenue windfalls and project investments. Table 5 shows the separate estimates of output responses to project-level spending and to government spending associated with oil revenues. Our estimates on the effect of oil revenues and oil production are in log-log form and can thus be interpreted as elasticities.

Table 5 illustrates the separate impacts of lagged project related investment *L.lnopinvestment* (over the previous 3 years lagged) and the effect of oil-related government revenues *L.lnrevoilgas*. As measured previously, both are associated with an increased in overall GRDP, including oil-related GRDP, albeit with low significance levels especially in the presence of district fixed effects. We also observe that a 1% increase in oil project-related spending increases overall local GRDP by about 0.7% (column 1). However there is no significant evidence of channel-specific effects, once we look at non-oil GRDP, or the changes in GRDP over time.

Table 5: Estimation of spillover effects of oil: fiscal channel

VARIABLES	(1) logsubgrdp	(2) logsubgrdp	(3) lognonoilsubgdp	(4) lognonoilsubgdp	(5) dlogsubgrdp	(6) dlognonoilsubgdp
L.lnopinvestment	0.718**	0.230	0.295	0.114	-0.00387	-0.00112
	(0.319)	(0.144)	(0.209)	(0.111)	(0.00415)	(0.00532)
L.lnrevoilgas	0.00422***	0.000905	0.00184*	0.000800	-2.83e-05	-7.22e-06
	(0.00117)	(0.000963)	(0.000946)	(0.000962)	(3.30e-05)	(3.01e-05)
L.refine	1.387***		1.493***		0.00251	0.00197
	(0.332)		(0.388)		(0.00173)	(0.00172)
L.iloglocgovrecrev	0.587***	0.111	0.172**	0.0874	-0.00187***	-0.00215***
	(0.104)	(0.0714)	(0.0844)	(0.0634)	(0.000417)	(0.000396)
oL.refine		0		0		
		(0)		(0)		
Constant	0.857	-205.8***	0	-217.7***	0	0
	(2.075)	(22.19)	(0)	(20.13)	(0)	(0)
Observations	1,284	1,284	1,284	1,284	1,284	1,284
R-squared		0.661		0.689		
Number of kode_kab	433	433	433	433	433	433
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
District FE	No	Yes	No	Yes	No	No
Robust SE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

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

We notice that controlling for oil project expenditures yields inconsistent results. For example, the coefficients of lagged district governments' oil-related and overall revenues, *L.lnrevoilgas* respectively *L.ilogocgovrecrev*, lose significance and value upon introduction of district fixed effects. For total government revenues this is not the case in the regression depicted in Table 4. Nevertheless, the presence of major oil refinery or gas processing plants, *refine*, positively and significantly impacts GRDP.

We therefore suspect potential multi-collinearity between government oil revenues with oil project expenditures and investments, not unlike production. One way to address this is by using production dummies, *L.any*, instead of oil production volumes (see Table 4). More generally, these observations indicate that we should be concerned about cross-contamination of oil investment and oil revenue windfalls given the endogeneity concerns discussed previously. We therefore require an appropriate instrumenting strategy as an attempt to isolate a measure of the fiscal channel.

6.3 (C) Offshore instrumental variable

Our instrumental variable allows an alternative identification of the pure fiscal spending effect. Here we are able to isolate district government windfalls from project-related investments by exploiting variations in onshore and offshore oil extraction, and variations in the application of fiscal sharing rules.

Figure 7 shows variations in the offshore location of oil extraction. According to Indonesia's fiscal sharing rules, only those wells with a given distance band (3 miles) are associated to coastal districts. Outside this band, revenues accrue to the province (3-12miles) and the central government (¿12 miles) respectively. As such district 1 would only have wells associated which lie more than 12 miles from its coastline. District 2 has wells within 12 miles of its coast. District 3 has offshore oil wells with 12 miles and onshore processing facilities.

Here we distinguish between onshore and offshore oil and gas production Oil_{it-1}^{ON} and Oil_{it-1}^{OFF}, according to the relevant distance parameters specified by the fiscal sharing rule. We use (3)

$$\begin{aligned} Y_{it} &= \gamma_6 Oil_{it-1}^{ON} + \gamma_7 \widehat{W}_{it-1} \\ &\quad + X_{it}'\delta_X + G_{it}'\sigma_G + \alpha_t + \beta_i + \eta_{it}, \end{aligned}$$

while in the first stage the instrument of offshore oil revenues follows (4)

$$W_{it} = \gamma_5 Oil_{it-1}^{OFF} + X_{it}'\phi_X + G_{it}'\kappa_G + \omega_t + \nu_i + \zeta_{it}$$

where γ_5 is a coefficient capturing some exogenously determined government resource revenue and its impact on district-level economic performance. W_{it} is the measure of government revenues derived from (offshore) oil within 3 miles of the coast, whose lagged predicted value $\widehat{W}_{it-1}$ becomes the independent variable in the second stage regression.

First, our instrumental variable estimates are shown in Table 6 (first stage). The coefficients are consistent and highly significant, whether or not additional refinery dummies are included (second column). Second, the predicted fiscal windfall from offshore production is apparent from Table 7 (second stage). The top row, our oil revenue IV variable *lnrevoilgas*, estimates the impact of oil revenues on district GDP, subject to those oil revenues being associated only with offshore oil projects falling within 3 miles of the coastal district. Our estimated impact on total and non-oil GDP is significantly positive. A 1% increase in government revenues increases overall and non-oil GRDP by 0.18% respectively 0.1%. Where we control for the presence of downstream processing activity *refine*, our impact remains, indicating evidence for the causal effect of fiscal spending windfalls accruing to district governments. It should be noted that onshore production in districts that do not have offshore fields is only relevant for the second stage regression, since the first stage regression seeks to isolate the fiscal windfall only from offshore oil production.

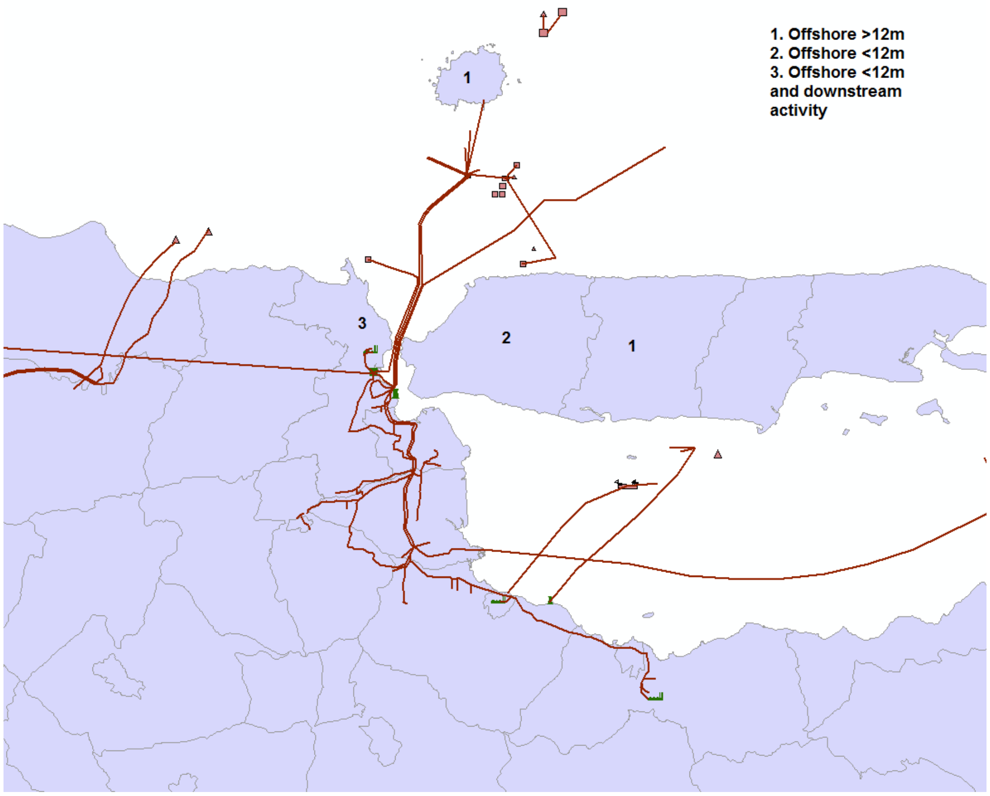

Figure 7: Offshore oil production and fiscal sharing thresholds

Table 6: Estimation of offshore oil IV: first stage

	(1)	(2)
VARIABLES	lnrevoilgas	lnrevoilgas
offshoreprod3m	0.0782***	0.0789***
	(0.0164)	(0.0163)
refine		5.786***
		(1.372)
Constant	291.0	286.9
	(348.9)	(347.2)
Observations	1,743	1,743
R-squared	0.015	0.025
Year dummies	Yes	Yes
District FE	No	No
Robust SE	Yes	Yes
Offshore IV	first stage	first stage

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Estimation of offshore oil IV: second stage

VARIABLES	(1) logsubgrdp	(2) logsubgrdp	(3) logsubgrdp	(4) lognonoilsubgdp	(5) lognonoilsubgdp	(6) dlogsubgrdp	(7) dlognonoilsubgdp
lnrevoilgas	0.00135*	0.172*	0.173*	0.0912**	0.0932**	0.000199	3.53e-05
	(0.000782)	(0.0932)	(0.0930)	(0.0423)	(0.0421)	(0.000251)	(0.000235)
onshoreprod3m	1.71e-05						
	(0.000103)						
refine	1.632***		0.604		1.049***		0.00109
	(0.403)		(0.828)		(0.376)		(0.00202)
Constant	-184.8***	-400.3***	-401.6***	-292.3***	-296.0***	8.036***	7.657***
	(11.32)	(154.8)	(154.7)	(91.01)	(91.38)	(1.174)	(1.166)
Observations	1,743	1,743	1,743	1,743	1,743	1,291	1,291
Number of kode_kab	452	452	452	452	452	434	434
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	No	No	No	No	No	No	No
Robust SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Offshore IV		Yes	Yes	Yes	Yes	Yes	Yes

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

Clearly our offshore instrumenting strategy is able to isolate the effect of oil-related fiscal spending, which in turn is driven by local district government sharing of overall royalties and taxes associated with each home district's oil extraction activity.

6.4 (D) The composition of public revenues (and spending)

Figure 8 illustrates the relationship between total government receipts in 2005, and the share of oil derived revenues in those receipts. Oil is positively associated with total government receipts, indicating the importance of the additional windfalls that accrue to oil-producing districts versus non-oil-producing districts.

As discussed earlier, although government uses the general and special allocation funds, DAU and DAK, to top-up district government budget deficits, there is little evidence that this is an effective compensating measure for non-oil districts.

We now analyze how the share of oil-related government revenues, controlled for total government revenues, affect economic activity. We expand (5) to include the oil share of government receipts

$$Y_{it} = \gamma_8 Investment_{it} + \gamma_9 GOil_{it} + \gamma_3 G_{it} + X'_{it}\delta_{\mathbf{X}} + \alpha_t + \beta_i + \epsilon_{it}.$$

Table 8 presents the results for estimating the effect of oil revenue windfalls on the composition of public spending, as measured by GDP and non-oil GDP. In addition to the same lagged oil project investment variable *L.lnopinvestment* in (5) above, we use a lagged measure of the oil share of total government revenues, *L.oilgasshare2*, while controlling for district fixed effects and contemporaneous total revenues, as well as the level of oil investments into a district. The coefficient is positive but not significant, while total government revenue is again highly significantly positive. We thus hypothesize that local government revenues are fungible and, regardless of the source, can be used to promote local and regional economic growth.

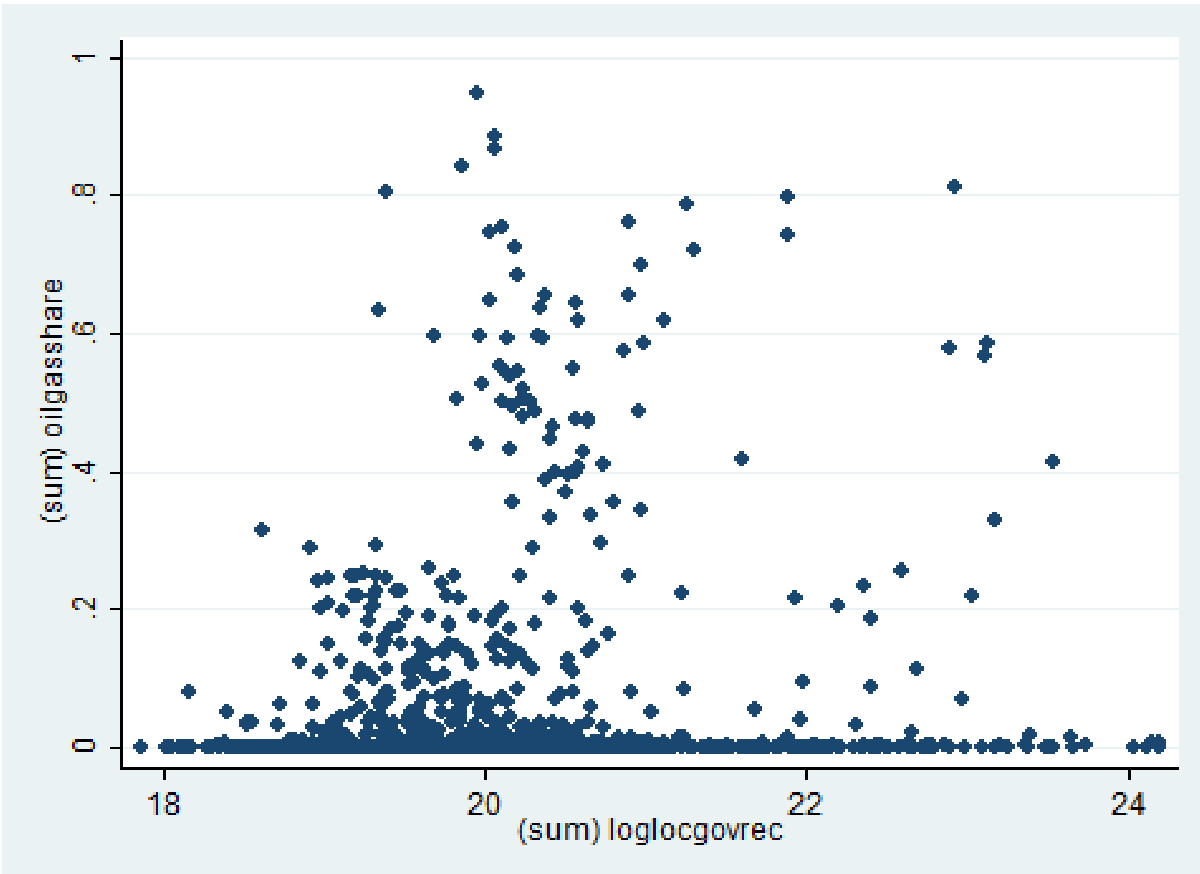

Figure 8: Oil share of local government receipts

Table 8: Estimation of quality of public spending- CHECK CONTROLS, POP?

VARIABLES	(1) logsubgrdp	(2) logsubgrdp	(3) lognonoilsubgdp	(4) lognonoilsubgdp
L.lnopinvestment	0.424	0.188	0.213	0.0697
	(0.299)	(0.157)	(0.230)	(0.126)
L.oilgasshare2	0.0686	-0.0300	0.0671	0.0199
	(0.136)	(0.136)	(0.100)	(0.100)
L.iloglocgovrec	0.884***	0.798***	0.878***	0.813***
	(0.0294)	(0.0277)	(0.0287)	(0.0274)
Constant	-5.033***	-3.309***	-5.016***	-3.704***
	(0.591)	(0.554)	(0.576)	(0.547)
Observations	1,288	1,288	1,288	1,288
R-squared		0.603		0.624
Number of kode_kab	433	433	433	433
Year dummies	Yes	Yes	Yes	Yes
District FE	No	Yes	No	Yes
Robust SE	Yes	Yes	Yes	Yes

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

7 Conclusions

Our initial results point to some key findings. There is evidence for modest direct spillovers arising from oil and gas production activity at the district-level (as distinct from the impacts of government revenue windfalls). However, the main benefits, defined in terms of district GRDP, appear to accrue via the fiscal channel. There is strong evidence of this impact estimated via our instrumenting strategy.

Interpretation of our results depends crucially on the estimates of GDP and non-oil GDP. Where we estimate the impact on our full sample using measures of district-level GRDP, we capture both the within-sector and non-oil sector impacts. This includes the net export revenues accruing to the oil sector associated with extraction activity. As would be expected increased oil production and increased oil project investment raise the level of overall GDP in the district. This implies increases in the size of the oil sector, and the less than complete crowding-out of other activities.

When we restrict our sample (and due to data limitations, also the number of years covered) to include non-oil GDP, we find an attenuated response. Estimates now capture the spillover effect outside the oil sector. Our key estimates remain strongly positive for both measures of fiscal spending quantities, albeit being less driven by the oil share of local government revenues. This implies that the level of fiscal windfalls matter more than the composition of government revenues for overall economic outcomes at the district-level.

While we use the offshore instrument to isolate the fiscal impact of oil extraction, Indonesia's unique oil revenue sharing scheme can be used to isolate the direct spillover effects in districts bordering with the home districts home of oil extraction (see Appendix 2 on neighborhood effects). We also briefly describe how we could examine the interaction between the quality of local institutions and economic governance, and the oil spillovers (see Appendix 3 for a brief discussion).

Lastly, our analysis at present tells us little about how the spillover benefits accrue within the districts and across the oil and non-oil sectors, nor how fiscal windfalls drive spending choices. Our analysis can thus be extended to look at government expenditure data and spending patterns to try to explore exactly how this result is emerging. All these insights are important once we look beyond subnational income and economic growth towards the impact of local government income and spending behavior on the subnational-level human development index (HDI) measures such as health, education.

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9 Appendix

9.1 Appendix 1: Indonesia oil and gas sector background

The natural resource sector, together with geographic and ethnic factors, was among the main drivers of the decentralization process. It includes oil and gas, coal and metals mining, as well as forestry, fishery and agricultural production, and typically makes up more than one quarter of the country's GDP and half of the country's exports.

The oil, gas and mining industries are economically and politically significant, since they contribute three quarters of the natural resources GDP and two-thirds of natural resource sector exports. The associated industries play a special role in the political and fiscal decentralization dynamics of the country.

In fact, resource-rich regions have historically been rather vocal about their ability and desire to gain more administrative and fiscal autonomy.

In Indonesia, natural resources are considered national assets and controlled by the government. The oil and gas industry was governed by a series of laws for more than four decades. Among them were Law 44 of 1960 on oil and gas exploration and production activities, Laws 2 and 15 of 1962 on domestic oil obligations, and Law 8 of 1971 regarding the state-owned oil and gas company Pertamina. In 2001, Indonesia's oil and gas Law 22 superseded a significant part of the historical legal regime in the industry.

Oil and gas Law 22 defines upstream business activity as exploration and exploitation, which include exploration of potential oil and gas reserves, drilling wells, the construction of transportation, storage and processing facilities and the processing of natural gas into liquefied natural gas. Indonesian and foreign companies may engage in upstream business activity as long as they fulfil financial, regulatory, technical and operational requisites. Law 22 established an upstream oil and gas sector regulatory body (*BP Migas*) to replace the national oil company's (Pertamina's) historical regulatory and supervisory function, as well as its role as government representative countersigning production sharing contracts. However *BP Migas*, the upstream regulatory body, was recently integrated back into the Ministry of Mines and Energy (MEMR), under the directorate general of oil and gas, and renamed *SKK Migas*. In contrast to the more decentralized mining industry regulation, the role of BP Migas in granting exploration and development licenses, counter-signing cooperation contracts and monitoring project expenditures remains largely under central government control.

9.2 Appendix 2: Impact of Economic Governance Index

When government revenue sources are fungible, as we observe in Table 8, one wishes to assess the quality of district government spending decisions. One possible indicative measure of the quality of public spending is the economic governance index (EGI).[22] We anticipate that districts that score higher on the EGI scale, which are considered to be conducive for business investment and demonstrate more effective governance and institutional quality, would make better use of the resources and the fiscal windfalls they receive. Table 9 indicates, however, that the overall EGI coefficient is positive and significant only for the non-oil sector GDP.[23] This can be rationalized as follows. McCulloch and Malesky (2011), using the EGI and its components, observe a complex interaction between economic growth and governance on the district-level in Indonesia. On the one hand, their analysis shows that only the availability of local infrastructure strongly and consistently drives economic growth. On the other hand, higher corruption often correlates positively with higher economic growth, presumably because more rapidly growing economies offer more opportunities for rent seeking. Therefore, a more refined and expanded analysis is required to better understand the potential endogeneity and reverse causality problems affecting the interaction between subnational-level oil extraction, economic governance and economic growth. We therefore plan to study the impact of oil extraction using the appropriate components of EGI as well as complementary dependent variables such as HDI.

9.3 Appendix 3: Analysis of neighboring effects

To further disentangle direct spillovers we could undertake an analysis of economic performance indicators in neighboring districts adjacent to districts with active resource extractive activities, compared to economic performance in other more remote districts within the same province. We hypothesize that neighboring districts, provided they are not significantly larger or richer than the home district, will benefit disproportionately more from direct economic spillover effects than other less proximate districts in the same province, even though all receive identical revenue shares. We expect that where economic spillovers dominate fiscal spending effects, neighboring districts will benefit proportionately more from being close to oil production than more distant districts.

[22] More broadly one is interested in the quality and composition of government spending.

[23] Interacting the EGI with oil production, investments and government fiscal revenues indicates positive but insignificant effects.

Formally, any positive spillover effect above and beyond that in the other districts, controlling for the neighboring district's own oil extraction and government revenues, must be a result of direct project channel effects. We plan to use the following regression:

$$\begin{aligned} Y_{nit} - \overline{Y}_{jt} &= \gamma_0 Oil_{it} + \gamma_{1n} Oil_{nt} + \gamma_{2n} G_{nt} + \mathbf{X}'_{nt}\delta_{1n} + \beta_n \\ &+ \sum_j \left(\gamma_{1j} Oil_{jt} + \gamma_{2j} G_{jt} + \mathbf{X}'_{jt}\delta_{1j}\right) + \alpha_t + \epsilon_{it} \end{aligned} \tag{6}$$

where n denotes the neighboring districts to home district i (which could be one or more), and $j = -n-i$ all the other non n districts in the same home province excluding the home district i. $\overline{Y}_{jt}$ represents the average Y_{jt} across all other districts $j = -n - 1$. With G_{nt} and X'_{nt} we control for government revenues, oil extraction, other controls (e.g. district area, population) and fixed effects of the neighboring district. Concurrently G_{jt} and X'_{jt} denote revenue, oil extraction and similar controls across all other non-neighboring districts in the home province that share the same fiscal benefit arising out of the home district's oil extraction activity. The key coefficient is thus γ_0: If it is positive and significant, then oil extraction in the home district does contribute positively to economic activity in the neighboring district, above and beyond that of the other districts in the province.