THREE ESSAYS ON THE ECONOMIC IMPACTS OF OIL AND GAS EXTRACTION: THE CASE OF INDONESIA

ABDUL NASIR

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Declaration

This thesis was written while I was studying at the Australian National University and the entire thesis is my own work.

Abdul Nasir
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Abstract

This thesis presents three empirical studies examining the economic impacts of natural resource extraction, particularly in the oil and gas sectors. The first study investigates the causal impacts of mining fiscal systems on generating resource rents from oil extraction using the fixed-effects panel model. This study covers 82 oil-producing countries over the period 1970-2015. The findings reveal that a resource rent tax, or its combination with gross royalty tax, outperforms a gross royalty tax alone in generating oil rent. However, the significantly positive impacts of this mining fiscal system are observed only in developing countries, particularly democratic nations and those with higher levels of freedom. These impacts are notably absent in developed nations, non-democratic countries or those with lower levels of freedom.

The second study investigates any causal relationship between oil extraction and local economic activities in Indonesian villages where oil wells have been drilled, indicating that oil exploration has been conducted in those villages. The identification strategy in this study relies on the randomness that significant amounts of oil could actually be found and later on commercially extracted in some of those wells. The dataset in this study covers 1,205 villages across Indonesia where oil exploration has been conducted during the period 1900-2012. The study observes the impacts of this oil extraction on the village's economic activities in 2016. The results reveal that the existence of oil extraction has a significantly negative effect on the number of small enterprises established in a village and the number of labourers working in them. Oil extraction, however, has heterogeneity impacts. Its negative effects on local economies only occur in major oil-producing regions, while in minor oil-producing areas, the impacts are absent. This study demonstrates that a natural resource curse can occur at the local level and may be influenced by local institutions.

The third study focuses on investigating the spillover effects of natural gas extraction on neighbouring economies, particularly at the district level in Indonesia. For the analysis, this study applies a range of panel difference-in-differences approaches, comparing non-gas-producing districts in rich-gas provinces as the treatment group and non-gas-producing districts in scarce-gas provinces as the control group for the period before and during the gas boom, 2002-2004 and 2005-2015, respectively. This setup exploits government intervention through the Natural Resource Revenue Sharing Scheme, wherein all districts in gas-producing provinces receive amount of revenues from gas production. The results show that non-gas-producing districts in rich-gas provinces have lower Gross Domestic Product (GDP) per capita compared to those in poor-gas provinces. Gas windfall also increases the poverty rate and the number of people living below poverty line. The findings provide evidence that gas windfall is a curse rather than a blessing for the local economies near gas-extraction sites.

List of Abbreviations

2SLS	Two-Stage Least Squares
BKPM	Badan Koordinasi Penanaman Modal (The Investment Coordinating Board)
BNPB	Badan Nasional Penanggulangan Bencana (the National Agency for Disaster Countermeasure)
BP	British Petroleum
BPS	Badan Pusat Statistik (Statistics Indonesia)
CBM	Coalbed Methane
CSG	Coal Seam Gas
DAU	Dana Alokasi Umum (General Allocation Fund)
DID	Difference-in-Differences
EY	Ernst & Young
GDP	Gross Domestic Product
GRT	Gross Royalty Tax
IDR	Indonesian Rupiah
IEA	International Energy Agency
INDO-DAPOER	Indonesia Database for Policy and Economic Research
IOCs	International Oil Companies
IV	Instrumental Variables
KUR	Kredit Usaha Rakyat (government fund for small enterprises)
LNG	Liquefied Natural Gas
NOCs	National Oil Companies

NRRSS	Natural Resource Revenue Sharing Scheme
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least-Squares
OPEC	Organization of the Petroleum Exporting Countries
PODES	Potensi Desa Survey (Village Potential Survey)
PRRT	Petroleum Resource Rent Tax
PSC	Production Sharing Contract
PwC	PricewaterhouseCoopers
RRT	Resource Rent Tax
TCF	Trillion Cubic Feet
UCDP	Uppsala Conflict Data Program

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Chapter 1
Introduction

1.1 Natural resources and economic development

It has been noted in the literature that natural resources are important assets for economic development, as advocated by generations of economists in the 18th and 19th centuries, including Adam Smith (1776) and David Ricardo (1817), respectively. The positive role of natural resource endowments in the economy was also endorsed by post-World-War II economists such as Rostow (1960) and Watkins (1963), among others. Both Rostow – in his theory on The Stage of Growth – and Watkins – in his analysis on A Staple Theory of Economic Growth – argue that natural resources are natural capitals and can be utilised to aid a country to develop its economy. According to this perspective, countries blessed with abundant natural resources are considered fortunate. Examples of countries with successful resource-led development include the United Kingdom, Germany, the United States, Canada, Norway, and Australia. These nations strategically exploited their natural resources to facilitate and boost their industrial development.

The belief that countries endowed with large natural resources are blessed, however, has been challenged by other economists. Prebisch (1950) and Singer (1950) posit that nations heavily reliant on natural resources tend to be less competitive compared to those with fewer such endowments. They argue that this phenomenon occurred because, in the long term, the prices of natural resources exhibit a downward trend relative to the prices of manufactured products. Consequently, countries primarily supported by unprocessed materials will experience a decline in their trade value overtime. This view is shared by subsequent economists, including Gelb (1988), Auty (1993) and Karl (1997).

Gelb (1988) provides a descriptive analysis, using oil rents as a proxy of natural resources. His findings revealed that those countries with large natural resources experienced a lower efficiency in their domestic capital formation during the oil booms in the early 1970s and 1980s. This perplexing phenomenon coined as 'the resource curse' by Auty (1993), delineates how countries possessing significant natural resource endowments struggle to capitalise these natural assets to uplift their economic developments. Consequently, they tend to experience lower economic performance compared to those with fewer natural resources. The inverse relationship between natural resources and economy aligns with the concept of the 'paradox of plenty', as described by Karl (1997). These parallel theories – resource curse and paradox of plenty – contribute to explaining that having significant natural wealth does not always lead to a better economic performance, as has occurred in many countries, such as those in South America, Africa and the Middle East.

The study of the relationship between natural resources and the economy has gained increased attention, particularly since Sach and Warner (1995) published a seminal empirical study in this field using a large cross-country setting. Their research provided evidence of the resource curse, highlighting that countries heavily dependent on natural resource exports tended to have low economic growth. However, the ongoing debate over whether natural resources are a curse or a blessing for economic development persists. Subsequent cross-country studies, including those by Gylfason et al (1999), Brückner (2010) and Sharma and Pal (2021), among others, support the existence of the resource curse. In contrast, other studies, such as those by Sala-i-Martin and Subramanian (2003), Mehlum et al (2006), Smith (2015) and more recently by Sharma and Paramati (2022), among others, yield opposing results. Similar to cross-country studies, within-country investigations on this topic also present mixed results. Some studies, such as those by Black et al (2005), Aragon and Rud (2013), and more recently by Mei et al (2022), highlight the positive impacts of natural resource extraction on the local economy. Conversely, negative effects are observed in other studies, such as those by Borge et al (2015), Muehlenbachs et al (2015), and Pellegrini et al (2021).

The investigations have expanded to explore potential mechanisms through which natural resource extraction influences economic development. It has been recorded within the literature that there are several potential channels in this relationship. First, the Dutch disease, as explained in several studies, such as those by Corden and Neary (1982), Corden (1984), Warr (1984) and Krugman (1987), particularly through two channels: (i) the spending effects—natural resource extraction causes the appreciation of real exchange rate, leading to a reduction in exports and hence hindered growth; and (ii) the resource movement effects—the positive income shock resulting from resource windfall that diminishes the competitiveness of non-resource related sectors and subsequently deteriorating non-resource sectors.

Second, institutional quality plays a crucial role, determining whether natural resources are a curse or a blessing for economic growth, as described in several studies, including Tornell and Lane (1999), Sala-I Martin and Subramanian (2003), Brunnschweiler (2008), Boschini et al (2013), and more recently, Antonakakis et al (2017) and Destek et al (2023). Indicators for institutional quality may include specific aspects, such as: (i) rent-seeking behaviours (Leite and Weidmann, 1999; Torvik, 2002); (ii) the quality of government (Manzano and Rigobon, 2001; Isham et al, 2005; and Brunnscweiler and Bulte, 2008); and (iii) corruption (Leite and Weidmann, 1999; Mehlum et al, 2006; Arezki and Brückner, 2011; and Brollo et al, 2013). Lastly, conflict is another significant factor, where natural resource endowments can potentially trigger civil wars (Collier and Hoeffler, 2004; Ross, 2004; Humphreys, 2005; Smits et al, 2016; and Andersen et al, 2017) and consequently, may affect the economy.

An important development in this field is the analysis of economic spillover effects of natural resource extraction, which are indirect impacts of natural resource production. This spillover can affect other economic sectors, known as industrial spillover, or influence local economies in surrounding areas, called as geographic spillover. Similar to the localised impacts of natural resources, the economic spillover effects of natural resource developments present mixed findings. Some studies, such as those by Marchand (2012), Aragon and Rud (2013), Brown (2014), and more recently by Alcott and Keniston (2018) report positive spillover impacts, while other studies, such as those by Cosgrove et al (2015), Fleming et al (2015), and Aragon and Rud (2016) support the negative spillover effects.

1.2 Research area: is oil and gas extraction a curse or a blessing?

This thesis specifically focuses on the oil and gas extraction sectors as proxies of natural resources and investigate their impacts on the economy. These sectors play significant role as driving force for economic development in many countries. As of 2015, they contributed to over one per cent of total GDP in at least 40 countries (World Bank, 2018). Both oil and gas can be used directly as energy sources or as raw materials for other industries. For instance, oil is crucial for the petrochemical industry, while gas is used in the fertilizer industry. Furthermore, these resources are also the primary sources of income for governments in many oil- and gas-producing countries, enabling them to finance their economic development programs.

Given the important roles of oil and gas in the economy, especially in countries with these natural resource endowments, numerous studies have been conducted to investigate their causal impacts on the economy. Studies on this topic have been provided in various settings, either in a cross-country or a within-country approach, focusing on specific local contexts. In both settings, the effects of oil and gas extraction on the economy were also rather mixed, mimicking the diverse economic impacts observed in studies of natural resource extraction in general.

Evidence of the resource curse, particularly in the oil and gas sectors, has been recorded in several cross-country studies. Examples include studies by Eregha and Mesagan (2016) and Antonakakis et al (2017). In addition, evidence of the resource curse has been observed in local settings, as indicated by studies conducted by Caselli and Michaels (2013), Jacobsen and Parker (2016) and Xue et al (2020), among many others. In contrast, other studies present opposing views, suggesting that these resources are a blessing rather than a curse. Alexeev and Conrad (2009), Arezki et al (2017) and Cassidy (2019), among many others, are examples of studies in a cross-country setting, while those by Michaels (2011), Fleming and Measham (2014), Allcott and Keniston (2018) and more recently, Gradstein and Klemp (2020) are examples of a within country approach.

In addition to the within-country setting, some analysts have taken a more specific approach by assessing particular types of natural resource, including oil and gas. A within-country approach offers a more favourable circumstance for analysing the impacts of natural resource extraction for at least two reasons, as outlined by James and Aadland (2011), van der Ploeg (2011) and Fleming et al (2015). First, it helps mitigate potential issues arising from unobserved confounding factors between natural resources and macroeconomic factors. This threat generally occurs in the cross-country studies and may affect the robustness of the estimation results. Second, this local setting allows for the exploitation of more specific local variations within a particular country, which can improve the empirical analysis. Focusing on a more specific type of natural resource is also beneficial, considering that different types of natural resources may have different behaviours and hence have varying impacts on the economy. This variation has been observed, as indicated by Sala-I Martin and Subramanian (2003), Boschini et al (2013) and Pelzl and Poelhekke (2021).

Gradstein and Klemp (2020) is an example of a study using oil as a proxy for natural resources. They investigate the effect of oil extraction on the local economy in Brazil and find that oil extraction causes higher local income per capita. Moreover, they also find positive economic spillover effect of this resource extraction, where municipalities with better access to oil fields tend to have higher income per capita. Other studies, such as those by Fleming et al (2015) and Mei et al (2022), both using gas as a proxy for natural resources, also reveal the positive impacts of this resource extraction. Fleming et al (2015) examine the impacts of coal seam gas development in southern Queensland, Australia, documenting that this resource generates higher income for the local economy. Similarly, Mei et al (2022) also demonstrate that shale gas production in Fuling District, China, has a significantly positive impact on regional GDP.

The extraction of gas resource, however, had not always been a blessing for local economies. Several studies revealed the negative effects of this resource on local economic activities. Gopalakrishnan and Klaiber (2013) provide evident that shale gas extraction in Pennsylvania, the US, has a negative impact on property values in the surrounding areas. Similar results were also recorded in other studies in the US, such as those by Muehlenbachs et al (2015) and Balthrop and Hawley (2017), in the case of gas production in Pennsylvania and Texas, respectively. It is also possible that this resource extraction has no significant impact on economy, as recorded in some previous studies. Cosgrove et al (2015) and Paredes et al (2015), both studies were conducted in New York and Pennsylvania, the US, find that gas extraction in these regions has no significant impacts on wages and local income, respectively.

In the case of Indonesia, oil and gas have also contributed significantly to the country's economic development. During the oil boom periods, particularly in the 1970s and 1980s, the oil sector provided substantial income for the state revenue, contributing more than 10 per cent to the total GDP.[1] Similarly, gas is also an important natural wealth for the country and its production has surpassed oil production since 2000. It should also be noted that the decline in

[1] Author's calculation based on Ministry of Finance data.

oil production since the late 1990s has been substituted by an increase in gas production. Both oil and gas are important sources of government revenues, not only for the central government, but also for local economies, particularly since the implementation of the Natural Resource Revenue Sharing Scheme (NRRSS) in the early 2000s.

Despite the significant contribution of oil and gas to the economy, empirical studies on this topic remain limited. Qualitative studies exploring the relationship between oil and gas and the country's economy have been conducted by using aggregate country-level data, such as those by Arndt (1983), Gelb (1988), Usui (1996) and Seda (2014). The drawback of these studies is that they did not assess the causal effect of oil and gas on the economy, nor did they account for variations within the country. In addition, these studies may be biased due to the potential influence of macroeconomic variables and other unobserved heterogeneity at the country level (van der Ploeg, 2011; James and Aadland, 2011; Fleming et al, 2015). A few empirical studies have assessed the local economic effects of oil and gas resources, including those conducted by Cust and Rusli (2014), and more recently, by Hilmawan and Clark (2019) and Pelzl and Poelhekke (2021). All these empirical studies analyse the impacts of oil and gas extraction on district economies in Indonesia.

This study complements previous research by offering new empirical insights, particularly in the case of Indonesia (Chapters 3 and 4), which differ from earlier analyses in several ways. First, Chapter 3 focuses on the impact of oil and gas on economic activities at the village level, using the most disaggregated data level. Second, Chapter 4 analyses the local revenue spillover impacts of gas extraction on neighbouring districts. Furthermore, this chapter uses natural gas as the proxy of natural resources instead of the aggregate of oil and gas.

1.3 Thesis objectives

This thesis aims to provide empirical analysis to determine whether oil and gas extraction is a curse or blessing for economic development. There are three main empirical research studies in this thesis, presented in Chapter 2, Chapter 3, and Chapter 4. Chapter 2 is the first main topic in this thesis analysing the relationship between mining fiscal systems and rent generation. This is a cross-country investigation, covering 82 oil-producing countries during the period 1970-2015.[2] These countries represent various oil regions, including North and South America, Europe, Africa, the Middle East and Asia Pacific, as well as different economic groups, comprising both developed and developing countries. Specifically, this chapter aims to examine the impacts of the two main groups of mining fiscal systems widely applied in the oil extraction sector across countries, namely resource rent tax (RRT) and gross royalty tax (GRT), on generating oil rent.

The second and the third empirical studies are conducted within a country setting, in the case of Indonesia, as represented in Chapter 3 and Chapter 4. Chapter 3 aims to investigate the impacts of oil extraction on local economic activities, particularly at the village level in Indonesia. This is achieved by comparing villages with commercial oil production and villages with unsuccessful oil drillings. The local economy in this context is proxied by the number of small enterprises and the number of workers in these enterprises in 2016. The study covers 1,205 villages across Indonesia where oil exploration activities were conducted during the period 1900-2012. Chapter 4 focuses on assessing the local economic spillover impacts of gas extraction on neighbouring economies, specifically at the district level in Indonesia. The dataset includes 97 non-gas producing districts located in gas-producing provinces. This setting exploits the government policy on re-distributing gas revenue to the local governments through the Natural Resource Revenue Sharing Scheme. Districts located in rich-gas provinces receive a higher share of this gas windfall compared to those in poor-gas provinces and this chapter explores whether an increase in revenue from gas windfall affects the district GDP per capita.

[2] The term oil related to Chapter 2 and Chapter 3 includes natural gas.

1.4 Research questions, empirical approaches, and results

1.4.1 Chapter 2

The main research question in this chapter revolves around whether adopting a certain type of mining fiscal system, specifically RRT, or transitioning from GRT to RRT could result in generating more rents or not. For a more detailed analysis, several additional questions are explored. First, do mining fiscal systems have heterogeneity effects on generating oil rents? This question is asked to consider the possibility that the mining fiscal system could have different effects across countries with different levels of institutional qualities and economic development status. Lastly, what factors may play an important role in the relationship between the mining fiscal system and rents? The question aims to uncover possible channels through which the mining fiscal system affects rents.

In terms of empirical analysis, this chapter exploits the randomness associated with the adoption of a mining fiscal system by a new oil-producing country or changing from GRT to RRT. A panel fixed-effects method is applied for the main analysis. The main findings of the analysis provide important evidence suggesting that the RRT system, which is a profit-based tax, is a better fiscal system, compared to the GRT system, which is a production-based tax. It is revealed that the adoption of the RRT system or its combination with GRT produces more rents. The study also uncovers that the RRT system has different effects on generating rents, depending on institutional qualities, specifically the level of democracy and freedom.

The finding is reasonable since the distribution of oil rents is managed through institutional arrangements involving the government and oil companies. Therefore, it is expected that countries with high levels of democracy and freedom would have better capacity to manage the oil extraction sector and implement the mining fiscal system compared to non-democratic countries and those with a lower level of freedom. Another notable evidence presented in this chapter is that the RRT system is associated with higher oil drilling and oil production. This suggest that oil companies may invest more in exploration and production activities under the RRT system, leading to increased oil production and higher rent generation.

1.4.2 Chapter 3

The primary research question in Chapter 3 is whether oil production spanning the years 1900 to 2012 caused positive or negative impacts on village economic activities in 2016. Economic activities, in this setting, are represented by the number of small enterprises and the labourers working in these enterprises. To answer this question, approximately 7,600 onshore oil drilling activities in 1,205 villages across the country were analysed to identify oil-producing villages and non-oil-producing villages. Other questions in this section are: (i) Does oil extraction yield varying effects on local economic activities in the villages located in rich-oil regions and in scarce-oil regions? This question considers the prospect that the distinct levels of oil dependency may cause different impacts; (ii) Does this resource extraction generate similar or disparate impacts on other local economic sectors? This question seeks to assess the spillover effects of oil production among the economic sector, widely known as the industrial spillover effects; and (iii) To what extent do local institutions influence how oil extraction affects local economy? Local institutions in this context are exemplified by the local fund and training programs designated to support small industries by the local government at the village level.

The identification strategy for establishing a causal impact in this setting relies on the premise that the discovery and production of oil are essentially random, contingent upon exploratory oil drilling. In this analysis, the primary estimation model employed is the two-stage least squares–2SLS or instrumental variable (IV) model with oil discovery serving as the instrument for oil production. The main finding of this chapter is that oil extraction decreases both the number of small enterprises and the number of workers in them. This may indicate the presence of a resource curse, as the extraction of oil demonstrates negative impacts on local economies.

The chapter further reveals that the adverse effects of oil extraction occurred only in regions characterised by a high level of oil production. In regions with limited oil production, the impacts are not statistically significant. The results may imply that the resource curse in this study setting manifests itself primarily when there is a high dependency on oil, particularly in major oil-producing regions. Additionally, the study documents that oil extraction induces spillover effects into certain economic sectors. It has significantly negative impacts on both the number of small enterprises and workers in either the services sector or education sector, while in the manufacturing sector its effect disappears. Furthermore, the chapter discloses another noteworthy finding, indicating that the local institution capacities may influence how oil extraction affects the local economy.

1.4.3 Chapter 4

The main research question addressed in this section is: Does gas windfall have positive or negative spillover impacts on the neighbouring areas? Unlike the spillover effects examined in Chapter 2, the economic spillover analysed in this chapter falls into the category of geographic spillover effects rather than industrial spillover. Notably, the economic spillover impact in this context is not a natural spillover that is generally determined by markets. Instead, it is induced by government policy, specifically through the NRRSS. Hence, it can be referred to as 'unnatural spillover effect' or revenue spillover impact. Other questions are also explored, that is, whether gas windfall has heterogeneity effects, and whether it causes significant impacts on other socioeconomic outcomes—poverty rate, number of people living below poverty line, and household expenditure.

The identification in this setting relies on the assumption that gas prices in the international market are exogeneous. In the main estimation, the de Chaisemartin and D'Haultfoeuille (2022) model is applied taking into consideration potential problems arising from dynamic and heterogeneous treatment effects. The main findings show that non-gas producing districts located in rich-gas provinces exhibit lower economic performance, compared to those in scarce-gas provinces. This implies that the windfall from gas causes a negative spillover effect on the surrounding areas, turning it into a curse rather than a blessing for the communities in these areas. Importantly, the negative impact of gas extraction, however, exists only in the Java region, but in outer islands its effect is indifferent. The chapter also reveals that the negative spillover effect of this gas windfall becomes stronger in the long run, while in the short period, the effect is not statistically significant.

Another important finding is that gas windfall, in fact, deteriorates quality of life in the neighbouring areas. It is uncovered that gas windfall contributes to an increase in the poverty rate and the number of people living below the poverty line, while concurrently showing no significant impacts on household expenditure. Another discovery seems to suggest that the negative spillover effect of gas windfall may be related to how local governments allocate this additional gas revenue. Although not statistically significant, gas windfall has a negative association with non-personnel expenditure and a positive relationship with personnel expenditure.

1.5 Thesis contributions

This thesis represents an extension of the existing literature on the relationship between natural resources and economic development, with a specific focus on contributing empirically to the debate on the natural resource curse within the context of oil and gas extraction sectors. The empirical analysis offered in this thesis explores the economic impacts of oil and gas extraction on the economy both in a cross-country setting and in a within-country approach. Moreover, the thesis also reveals the spillover effects of resource extraction and identifies various potential channels through which these resources affect the economy. An essential component of the empirical analysis is the presentation of a unique oil and gas dataset, playing a key role in enhancing the depth and specificity of the research.

Chapter 2 of the thesis makes distinct contributions, notably providing a new dataset encompassing mining fiscal systems employed in the oil extraction sector across countries from 1970 to 2015. This may be the first attempt in compiling and categorising mining fiscal systems applied in the oil sector worldwide, drawing from an assessment of various sources. Furthermore, the chapter unveils new evidence regarding the causal relationship between the adoption of mining fiscal systems and the generation of resource rent, by taking into account different levels of democracy and freedom, and economic development. This empirical evidence is crucial as most of previous studies in this field were based on qualitative analysis. Lastly, the chapter also contributes by presenting evidence suggesting that a profit-based mining fiscal system, such as the resource rent tax (RRT) may amplify the efforts of oil companies in drilling oil wells and producing oil. This, in turn, leads to the generation of more rents, thereby shedding light on the potential impact of specific systems on the activities and outcomes of oil companies.

Chapter 3 stands out for its key contributions, notably through the utilisation of a unique dataset that captures individual oil well drilling activities at the village level—the most granular level of government administration in Indonesia. This approach represents a significant advancement, offering a highly disaggregated perspective that adds depth to the analysis. In addition, this chapter presents novel evidence of the resource curse phenomenon at the village level, specifically within the context of a developing country, as exemplified by the case of Indonesia. This localised examination adds a valuable layer of understanding to the broader discourse on resource curse, often studied at higher administrative levels. Moreover, the chapter also reveals supporting evidence that institutions may play an important role in mediating the impacts of resource extraction on the local economy, as commonly observed in cross-country or country level analyses. The evidence contributes to a more comprehensive understanding of the intricate relationships between resource extraction, local institutions, and economic outcomes.

Chapter 4 significantly contributes to the ongoing debate surrounding the impacts of natural resource extraction on neighbouring economies. Specifically, the chapter uncovers the economic spillover effects of gas extraction on the neighbouring areas in a local setting, particularly within a developing economy. More importantly, this chapter introduces ‘unnatural spillover effects’, distinct from those determined by market forces of supply and demand. Instead, these effects are driven by institutional intervention, specifically government policy on natural resource revenue sharing. Additionally, this chapter sheds light on the negative spillover impacts of gas windfall on various socioeconomic conditions in the surrounding areas, such as poverty rate and number of people living below the poverty line. This further exploration adds depth to the understanding of multifaceted consequences of gas extraction on neighbouring economies, bringing attention to both the unconventional nature of spillover effects and their tangible implication for local communities.

1.6 Thesis structure

This thesis is structured into five chapters. Chapters 2–4 present the core research, which are the main research studies. Chapter 2 investigates the impacts of mining fiscal systems, applied in the oil sector, on the generation of oil rents across various oil-producing countries. Chapter 3 analyses the economic impacts of oil extraction on local economic activities at the village level in Indonesia. Chapter 4 examines the economic spillover effect of gas windfall on neighbouring economies, particularly at the district level in Indonesia. Chapter 5 presents the conclusion of the thesis, providing a succinct overview of the main findings from each research study and discussing potential future research on the causal relationship between natural resources and economic development.

Chapter 2
Mining fiscal systems and resource rents: evidence from oil-producing countries

2.1 Introduction

The oil sector plays an important role in the economic development of many countries. The resource rent from this sector contributes significantly to GDP, accounting for above one per cent in at least 40 nations in 2015 (World Bank, 2018).[3] Furthermore, in the 2000s, there were more than 30 countries where the oil share constituted from 10 to 97 per cent of the total government income (Boadway and Keen, 2010). These facts provide evidence that considerable revenue can be generated from this sector and used for public finance. As a source of revenue, oil will be vital in the upcoming decades for at least two reasons. First, oil will continue to be the dominant source of energy. It is predicted that this resource will provide approximately half of global energy by 2040.[4] Second, the use of oil in the petrochemical industry is projected to increase significantly and become a new key driver of the future demand of this commodity.[5]

To extract resource rent from the oil sector, governments have to implement certain types of fiscal systems, as most countries rely on private companies for producing this resource. A mining fiscal system serves as an agreement between government and mining companies, governing not only extraction activities, but also the sharing mechanism of resource rent generated from the exploitation of this resource. In this relationship, the government, as the

[3] The distribution of oil rents across countries in 2015 is displayed in Appendix, Figure A2.1.
[4] This projection was made by some institutions, such as IEA (2018a) and BP (2019).
[5] This was reported by IEA (2018b) and McKinsey (2019).

resource owner, can grant licences or other forms of exploitation rights to mining companies for the extraction of this resource and receive payments under several types of fiscal terms. Various types of mining fiscal systems have been applied in the oil sector. Implementation of these systems varies across countries, but typically remains consistent for oil extraction activities within the same country.

It has been argued in some studies, such as those conducted by Garnaut and Clunies-Ross (1975), Palmer (1980) and Fane and Smith (1986), that the choice of implementing a certain type of mining fiscal system dictates the amount of resource rent that a government can collect. In addition, the choice is also related to the uniqueness of oil as an exhaustible resource. Exploiting and collecting rent from this resource today represents the foregone future rent when it becomes no longer available (Hotelling, 1931). Therefore, in this context, applying the proper mining fiscal system is crucial for governments in oil-producing countries, particularly in developing countries where oil typically serves as the main engine of their economic growth.

Choosing an appropriate mining fiscal system that can generate significant oil rent, however, is not a simple task. Instead, it is a long-lasting challenge and has been a source of controversy. The debate over this issue has occurred across countries. For example, heated debates took place in Australia when a special tax, the Petroleum Resource Rent Tax (PRRT), was first adopted in 1984. More recently, mixed opinions arose in Indonesia when a new Production Sharing Contract (PSC) with a gross revenue split was applied in 2017.

A few researchers, such as Kemp (1992), Nakhle (2004) and Blake and Roberts (2006), attempt to provide analyses on the relationship between mining fiscal systems and oil profits. They compare mining fiscal regimes using a simulation technique, with different settings for oil price, production level, field size, investment level, or a combination of these variables. These studies, however, ignore characteristic variations related to the country-specific conditions, that is, geological, economic, social, and institutional aspects that could influence the estimation results. One empirical study, conducted by Black (2002), tests the impacts of royalty and bonus payments on owner revenue in oil lease contracts in the US using logit regression.[6] It should be noted that cross-country studies provide evidence of the impact of implementing a particular type of mining fiscal system on oil rent have been limited, if not missing.

This study, hence, aims to provide empirical evidence of the causal impact of adopting a certain type of mining fiscal system on the size of oil rent extracted utilising a longitudinal dataset of oil-producing countries. For this purpose, this study categorises various types of mining fiscal systems into two main systems that are widely used across countries: gross royalty tax (GRT) and resource rent tax (RRT). GRT is the payment based on either production or the value of production. RRT, on the other hand, is levied from realised net profit after all extraction costs have been recovered and a satisfactory return to the firm has been exceeded.

The main results show that the RRT system or its combination with the GRT system has a higher and significant impact than the GRT system alone on oil rent within the study period. This finding provides new empirical support that RRT is a more effective mining fiscal system for generating economic rent from natural resource extraction, as theoretically advocated by Garnaut and Clunies-Ross (1975). It is also found that the RRT system encourages companies to drill more exploration wells and produce more oil. This could be a possible explanation for why the RRT generates a higher impact than the GRT. However, it is noteworthy that the RRT system only exhibits a positive impact on generating oil rent in developing countries with better quality of democracy and those with greater levels of freedom. The RRT system does not have a significant effect in developed economies, non-democratic countries, and countries with lower freedom indexes.

[6] Black (2002) finds that share contract is better for high risks and high uncertainty oil fields, while fixed contract is more appropriate for those with low risk and low uncertainty.

The rest of this study is organised into several sections, as follows. The next section provides a literature review, briefly describing the theoretical and empirical analysis of mining fiscal systems, particularly in oil extraction. Section 2.3 describes data that explains variables and data sources and why they are used in this study. Section 2.4 presents the identification strategy and estimation model to explain the study design and model used for estimation. Section 2.5 presents estimation results and discussion of the findings, followed by the concluding section, which includes policy suggestions related to the findings.

2.2 Literature review on mining fiscal systems

Mining fiscal systems, particularly in the oil sector, are usually classified based on their payment structures and tax instruments, such as GRT, RRT, brown tax, fixed fee, and income tax.[7] This study concentrates only on the GRT and RRT since they are the main mining fiscal systems widely applied in most oil-producing countries. As of 2015, the GRT system was used in at least 23 countries, while the RRT system or hybrid system, which contained the RRT instrument, was applied in at least 59 countries.[8] During the study period from 1970 to 2015, at least 47 countries had changed their fiscal systems from the GRT to the RRT or hybrid system.

GRT is a simple mining fiscal system and is also known as severance tax. The GRT system provides some benefits for governments. It is easy to calculate and collect, relatively stable, predictable, and can ensure minimum flow of revenue. With this regime, government will not worry about the possibility of mining companies overstating the costs. Governments can acquire economic and political advantages by securing royalty payments in the early period of oil extraction as soon as production starts. However, this mining fiscal system may distort investment and production decisions because it is calculated based on gross production or gross

[7] The GRT includes a quantum royalty based on production and ad valorem royalty based on the value of production, while the RRT is a fiscal system based on profit. These two fiscal systems were applied in either concession system or contractual agreements. Brown tax is roughly similar to state participation or joint venture, while fixed fee is mostly applied in oil service contracts. Income tax, in this case, is a general corporate income tax.

[8] This is based on author's analysis, and more detail is described in Appendix, Table A2.1.

value of production. It does not consider the cost of production and is applied whether or not the extraction is profitable. Therefore, this system may increase the uncertainty and risk of oil extraction projects.

RRT, on the other hand, is a cash flow tax and directly related to the project's profitability. It is also known as resource rent royalty (Watkins, 2001) and rate of return tax (Blake and Roberts, 2006). This fiscal system, as explained by Emerson (1999), is actually a variant of a brown tax. In a brown tax system, government needs to provide cash or a subsidy when a project has negative cash flow, while in the RRT losses are carried forward and are paid when the project has positive cash flow. Therefore, it is important to note that in the RRT system, initial investment—particularly capital and operating costs for finding, developing and producing oil—will be recovered once an oil project begins to generate profit. In PSCs, this reimbursement of costs is commonly referred to as cost recovery or cost oil. Similarly, in other oil lease agreements, such as in Australia, Norway, the Netherland and the UK, these costs can also be recovered (EY, 2019; Jarlsby, 2019).

The academic debate of the RRT system started in the middle of the 1970s in Australia, triggered by a seminal paper written by Garnaut and Clunies-Ross (1975). However, this mining fiscal system was already applied in the oil sector in Indonesia in 1966. This Indonesian classical PSC model can be classified as the RRT regime since production is shared between government and company after its expenditures are reimbursed through cost recovery. In a concession system, RRT empirically was also already implemented in the Netherlands in 1967, followed by Norway, the UK and Papua New Guinea in the mid-1970s. Despite having different names in these countries, the ways in which rents are shared between governments and firms are similar.

The advantage of the RRT system as an alternative to the GRT system is that it is relatively neutral to investment decisions because it is applied to a project's economic rent. In the RRT system a firm is able to deduct its expenditure from its revenue. Moreover, this mining fiscal system may provide a large share of the net profit without distorting companies' decisions in investing and undertaking their business activities. It is also more flexible in responding to the changes of variable factors, such as production and prices. Therefore, this mining fiscal system may be considered fairer than the GRT system in the distribution of rent.

The RRT system, however, could also create problems for government because it only provides revenue when the target payback or rate of return is achieved. Other critical problems of applying the RRT are the possibility of gold plating–unrelated expenditures are included in the costs of a project–and transfer pricing due to the presence of asymmetric information, where the government lacks information on the technical and commercial aspects of the oil extraction projects (Palmer, 1980; Baunsgaard, 2001; Johnston and Johnston, 2015). Moral hazard and adverse selection resulting from asymmetric information are not exclusive to the RRT in oil sector, but also to contracts in general, as analysed by Laffont and Tirole (1993). Moreover, this asymmetric information could cause problems in setting the threshold of the discount rate in the RRT. Setting the right threshold that makes the RRT system more neutral and less distorted is important. This is because, as explained by Fraser (1993) and Smith (1999), the RRT system theoretically can either have the same impact as other mining fiscal systems or have a different impact, depending on how the interest rate is set.

2.3 Data and sample description

This study covers 82 oil-producing countries over the period 1970-2015. Carefully investigated is whether the mining fiscal regime applied in each country was GRT or RRT. It is also noted that each mining fiscal system was applied either in a single system or in a hybrid system. The term hybrid in this context includes two mining fiscal systems: GRT and RRT. They were arranged either in a single fiscal regime or in different types of regimes but implemented at the same time. In this design, if a fiscal system applied RRT in a single or a hybrid mechanism, it is classified as RRT. Otherwise, it is classified as GRT. Data of mining fiscal systems, GRT and RRT, are constructed based on various sources, including Ernst & Young (EY), PricewaterhouseCoopers (PwC) and Deloitte. In addition, previous studies, reports, and oil laws and regulations in each country were carefully analysed in constructing mining fiscal systems data. GRT is coded as 0 in the dataset. RRT and hybrid fiscal regimes, which include GRT and RRT, on the other hand, are coded as 1.[9]

Oil rent data are obtained from the World Bank's World Development Indicator (2018).[10] Data of oil exploration wells is collected from the Statistics of petroleum exploration in the world outside the US and Canada through 2015, U.S. Geological Survey (Attanasi and Freeman, 2019), while data of oil production is sourced from the International Energy Agency – IEA Atlas of Energy (2019). Several control variables are used in the estimation models. First, economic and social variables include: GDP per capita, GDP growth, trade openness, non-oil rents, inflation, gross capital formation, population, population density and war. Second, geological variable: oil proved reserves. Lastly, institutional variables include the democracy index and freedom index. These control variables are commonly used in cross-country economic performance analysis.

Data regarding economies and populations are obtained from the World Bank (2018). Information on oil reserves is obtained from various sources, including the US Energy Information Administration (EIA) and British Petroleum (BP p.l.c.), known as BP. Data on war are obtained from Uppsala Conflict Data Program, the Department of Peace and Conflict Research (UCDP/PRIO dataset).[11] The democracy index is sourced from the Polity IV dataset

[9] Mining fiscal systems applied in each country during this study period are shown in Appendix, Table A2.1, and their distributions are displayed in Figure A2.2.
[10] Rent here is defined as the difference between market value and extraction cost.
[11] War here includes internal armed conflict and internationalised internal armed conflict and defined as "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths in a calendar year."

which is commonly used as one of the indicators of broad institutional quality. The value of the index ranges from -10 to 10 with -10 representing the most autocracy and 10 the most democratic. In the estimation, countries with a positive index are classified as democratic, while those with an index less than or equal to 0 are classified as non-democratic countries. The freedom index is acquired from the Freedom House dataset. This index contains two indicators: political rights and civil liberties. The index varies between 1 and 7, with 1 representing the highest degree of freedom and 7 the smallest degree of freedom. Countries with higher levels of freedom (partly free and free) are scaled from 1 to 5, while those with lower levels of freedom are scaled from 5.5 to 7.0. In the dataset, this index covers the period from 1972 to 2015. For a detailed overview of the data, variables and data sources are shown in Appendix, Table A2.2, while the descriptive statistics of all variables are presented in Table 2.1.

Table 2. 1 Summary statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Dependent variables					
Oil rents (% GDP)	2,748	7.156	12.764	0	83.543
Oil exploration wells (No. wildcat)	3,634	16.191	33.551	0	500
Oil production (million tonnes of oil equivalent)	2,645	60.101	157.523	0	1,219.1
Variable of interest					
Resource Rent Tax (0,1)	3,332	0.492	0.500	0	1
Main control variables					
Gross Domestic Product per Capita (US$)	3,249	9,469.638	14,492.84	84.273	103,059
Gross Domestic Product growth (annual %)	3,184	3.727	6.556	-62.075	149.973
Trade openness (% GDP)	3,166	73.389	42.864	6.320	531.737
Non-oil rents (% GDP)	3,772	2.723	5.672	0	57.293
Inflation rate (annual %)	2,959	37.953	498.388	-17.640	23,773.1
Population (million people)	3,752	40	111	0.109	1,300
Oil proved reserves (billion barrels of oil equivalent)	3,771	11.037	41.464	0	361.934
Democracy index (-10 – 10)	3,369	1.7129	7.563	-10	10
Additional control variables for robustness tests					
Population density (people per sq.km of land area)	3,706	91.746	140.023	0.823	1,779.32
Gross capital formation (% GDP)	3,054	23.472	11.888	0	219.069
War (0,1)	3,626	0.183	0.386	0	1
Political rights (1-7)	3,213	3.725	2.303	1	7
Civil liberties (1-7)	3,213	3.708	1.994	1	7

Notes:
Oil rents are used as the dependent variable in the main estimation, robustness tests, and heterogeneity analysis, while oil exploration wells and oil production are employed in the channel tests. Resource Rent Tax is coded as 1 if a country applied RRT or hybrid system (RRT and GRT), and 0 if a country applied GRT. The number of observations varies due to data availability.

2.4 Identification strategy and estimation model

2.4.1 Identification strategy

This study explores various mining fiscal systems worldwide during the period 1970-2015, with a specific focus on the adoption of the GRT and RRT systems. In general, most countries initially employed the GRT, as it was the only system known in the early stages of mineral extraction sector. In the 1970s, pioneered by Garnaut and Clunies-Ross (1975), economists began discussing the RRT as an alternative fiscal system for mineral resource extraction, including oil. Since then, many countries have adopted this new fiscal system. The process by which mining fiscal regimes were adopted by each country after the introduction of RRT is important in this study design. It is acknowledged that a country must have a certain motive to move from GRT to RRT or vice versa. However, the process of moving from one fiscal regime to another is complicated. It might be easier for a new oil-producing country to directly adopt RRT, but the evidence has not been consistent. It is hence argued in this study that a government's choice to shift from GRT to RRT or a mining fiscal system adopted by a new oil-producing country is a random process, particularly after controlling for several countries' indicators.[12]

Governments typically have sovereignty over their oil resources. Hence, they have the authority to apply a specific type of mining fiscal system to this sector. However, it is not obviously clear whether a government would prefer one mining fiscal system over another. Furthermore, when applying this mining fiscal system, governments have to deal with mining companies. Large mining companies generally have considerable influence, enabling them to advocate for the mining fiscal system of their preference. The outcomes of these interactions between governments and mining companies have been uncertain. International mining companies, mostly from developed nations, may also prefer a fiscal system similar to that

[12] The timing of the adoption of mining fiscal systems in each country is reported in the Appendix, Table A2.1.

applied in their home country. However, this has not been the case in this study setting. In fact, these companies invested in oil extraction activities across countries without considering whether they applied the same systems as those used in their home countries or not.[13] Finally, even if a government or a company could force the mining fiscal system of their preference, the timing to initiate it remains uncertain. In the case of contract renewals, the length varies, and for new contracts, the expiration period also varies from case to case. Therefore, during the study period, significant variations are observed in the adoption of mining fiscal systems. Some countries opted for GRT, while others decided to use RRT or changed their mining fiscal systems from GRT to RRT. These variations occurred across countries, not only in developing economies, but also in developed nations, and in both democratic and non-democratic countries.

Some may argue that another potential endogeneity problem may arise due to the possibility that governments decide to strategically adopt a certain type of mining fiscal system with the expectation of economic benefit. However, this scenario is highly unlikely in this study setting for several reasons. First, even though an economic motive could be a driver in choosing the mining fiscal system, it is challenging to predict an extraction cost and consequently difficult to calculate the resource rent from the project due to the high level of uncertainty and risks. Second, oil extraction is a long-term project, most spanning between 20 and 30 years. Third, the performance of extraction activities also relies on the effort of companies and their behaviour related to risks which are challenging to observe. Furthermore, resource rent not only depends on the production level and efficiency in the extraction process, but it is also determined by the oil price which is difficult to control or predict.

Even though the possibility is relatively small, there is still potential endogeneity due to possible reverse causality during the 1970s. The reasons are as follows. First, since the early

[13] For example, ExxonMobil from the US with the GRT regime, and BP from the UK with the RRT regime, invested in oil projects in many countries with the same system as or different systems from those applied in their home countries.

stages of the oil industry until the 1970s, OECD countries had the potential power to influence oil prices through consumption channels and a monopoly on technology.[14] During this period, oil extraction was monopolised by a very small numbers of companies, mostly owned by developed economies.[15] Second, in the 1970s OPEC countries also had a very strong position in determining oil prices by controlling oil supply.[16] In addition, there was a wave of oil nationalism in the form of ownership control in the 1960s and 1970s, while in the later periods the form was changed to mainly regulatory control (Stanislaw, 2009; Arbatli, 2018), including the adoption of mining fiscal systems. According to the data provided by Guriev et al (2011) and Arbatli (2018), there were 99 cases of expropriation during the 1960s and 1970s, while in the period from 1980 to 2012 there were only 13 cases. To ensure the robustness of this study's main results, the model is tested using the period from 1980 to 2015.

2.4.2 Estimation model

To identify the effects of mining fiscal systems on oil rents at the country level, this study applies the following fixed-effects panel specification:

$$y_{it} = \beta RRT_{it-5} + \gamma X_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \qquad (1)$$

where y_{it} denotes oil rents of individual countries i at year t (t=1970-2015) as the outcome variable. RRT_{it-5} is the variable of interest, a measure of a mining fiscal system adopted in country i at period *t-5*. It is a dummy variable, coded as 1 for RRT and 0 for GRT. In the estimation this variable uses a lag of five years to consider the time lag between adopting a mining fiscal system and producing oil. This time lag, which varies from three to seven years in general, is applied to cover the whole process of oil extraction: leasing or signing an

[14] OECD: Organisation for Economic Co-operation and Development.
[15] These companies are known as The Seven Sisters: Anglo-Persian (now BP); Gulf Oil (now Chevron); Royal Dutch Shell; Standard Oil Company of California (now Chevron); Standard Oil Company of New Jersey (Now part of ExxonMobil); Standard Oil Company of New York (now part of ExxonMobil); and Texaco (now Chevron). Prior to World War II, they controlled approximately 85 per cent of world oil production (Al-Attar and Alomair, 2005), and in the 1970s they controlled around 70 per cent of production from 70 per cent of oil reserves (Stanislaw, 2009).
[16] OPEC: Organization of the Petroleum Exporting Countries.

agreement, exploration, appraisal, development and production. X_{it} is a group of control variables that includes GDP per capita, GDP growth, trade openness, oil reserves, population and democracy index. α_i and λ_t are individual country fixed effects and time fixed effects, respectively, while ε_{it} is the random error term. The parameter of interest, β, captures the average effects of applying RRT on oil rents. In the regression, standard errors are clustered by country, considering that errors may be independent across countries but correlated within country.

The estimation model (1) is also used for further additional tests. First, robustness checks include: (i) placebo test for testing potential reverse causality between oil rents and mining fiscal systems by applying the adoption of RRT in the future (RRT_{it+n} where n = year), instead of a RRT lag of five years (RRT_{it-5}). Statistical significance of the β coefficient would be evidence of reverse causality; (ii) test for omitted variable bias by using additional control variables (investment, population density, war, political rights and civil liberties); (iii) test for reverse causality between the outcome variable and covariates by using lagged explanatory variables (X_{it-1}), except for population; and (iv), test for potential reverse causality between oil rents and fiscal systems by excluding 1970s in the estimation. Second, tests for heterogeneity by using sub-samples of the dataset based on income, democracy and freedom classifications. Third, tests for possible channels that may help explain how mining fiscal systems influence oil rents. In these tests, the number of oil exploration wells (wildcat) and oil production are used as the outcome variable (y_{it}). Variable of interest, RRT_{it}, is applied for the exploration well channel because there is no time lag for exploration activities, while for the production channel, similar to the main estimation model, it used a five-year lag (RRT_{it-5}). These two variables can serve as channels if they have correlation with the variable of interest (RRT), and their inclusion in the regression should reduce the magnitude of the RRT coefficient or become statistically insignificant (Acheampong et al, 2021; Zhang et al, 2021).

2.5 Estimation results

2.5.1 Main results

Table 2.2 shows the main estimation results. All columns use the full dataset, covering 82 oil-producing countries. Columns 1 and 2 present the results of regression without controlling for country fixed effects and year fixed effects, respectively. Column 3 is the estimation results without any control variables, while column 4 is with full control variables.

Table 2. 2 Main estimation results

Dependent variable	**Oil rents**			
Models	(1)	(2)	(3)	(4)
L5.RRT	0.386 (0.379)	0.266 (1.006)	0.915 (0.849)	1.460** (0.637)
Country FE	No	Yes		
Year FE	No		Yes	
Control variables	No			Yes
N	2,485	2,485	2,485	2,202
R-squared	0.035	0.035	0.041	0.164

Notes:
The dependent variable for all specifications is oil rents. The main variable of interest is a five-year lag of mining fiscal systems. Control variables: per capita GDP, GDP growth, trade openness, non-oil rents, inflation, population, oil reserves and democracy index. The number of observations (N) in column 4 is reduced due to the inclusion of control variables. Standard errors are clustered by country.
** indicates significance at 5 per cent.

Without controlling for country and year fixed effects, the impacts of applying RRT on oil rents are not statistically significant, as shown in columns 1 and 2, respectively. The impact is also indifferent when estimating without control variables (column 3). However, by controlling for the country's indicators, the RRT system has a significantly positive impact on oil rents at 5 per cent level (column 4). This means that the RRT regime has a higher impact than the GRT regime in generating resource rents; that is, adopting RRT generates oil rents approximately 1.5 percentage points higher than GRT. Column 4 is used as the main estimation result in this study. Overall, the findings suggest that the RRT system, either in a single system or in a hybrid model is the more suitable mining fiscal system compared to the GRT system for producing more rents in the oil extraction sector.

The findings provide evidence that the RRT, as a profit-based mining fiscal system—more responsive to profit—enhances the performance of oil and gas extraction sector. This supports the arguments provided by economists, including Garnaut and Clunies-Ross (1975) and, more recently, Calder et al (2014), Jarlsby and Pereire (2019) that a more neutral mining fiscal system, such as the RRT, has a more favourable impact on resource rent generation. In contrast, the GRT may discourage investment, as it can be regressive, particularly when profits are low. It is also proved that the distinct economic characteristics of the RRT and GRT systems result in different effects on oil rent generation. This may help explain why the RRT system, compared to the GRT system, has a more positive impact on generating resource rent from oil extraction. The findings also align with the study by Chen and Perry (2015) that introducing the RRT increases the competitiveness of the mining sector.

2.5.2 Robustness tests

Table 2.3 presents the estimation results of regressing future RRT (RRT_{it+n}, from n=1 to n=5) on the current oil rents (y_{it}). Except for mining fiscal systems, other variables use their current values (X_{it}), the same as those used in the main model. Significant effects of future RRT on current oil rents would provide an indication that the findings are biased by reverse causality. As shown in columns 1-5, there is no evidence for this potential problem since all the estimated coefficients are statistically insignificant. This means that the adoption of future RRT has no impact on current oil rents. Therefore, it can be argued that the mining fiscal system in this case is exogeneous, and the main estimation result is driven by a causal relationship, rather than random chance.

Table 2. 3 Placebo test using the future resource rent tax

Dependent variable	**Oil rents**				
Models	(1)	(2)	(3)	(4)	(5)
RRT (t+1)	0.990 (0.842)				
RRT (t+2)		0.718 (0.791)			
RRT (t+3)			0.683 (0.793)		
RRT (t+4)				0.604 (0.838)	
RRT (t+5)					0.584 (0.877)
Country FE	Yes				
Year FE	Yes				
Control variables	Yes				
N	2,314	2,242	2,168	2,094	2,019
R-squared	0.197	0.196	0.197	0.199	0.201

Notes:
The dependent variable for all specifications is oil rents. The main variable of interest is future mining fiscal systems (RRT_{it+n}, from n=1 to n=5). Control variables: per capita GDP, GDP growth, trade openness, non-oil rents, inflation, population, oil reserves and democracy index. The number of observations changes because some variables are dropped when applying different periods of future rent tax. Standard errors are clustered by country.

Table 2.4 shows the results of using the variations of lag RRT, from two to seven years (columns 1-6). As displayed in the table, there are no immediate effects of adopting the RRT, as in columns 1-2, but it has a positive and statistically significant impact on generating rents after four years of its adoption (columns 3-6). The results reveal the fact that oil companies need some years for exploration activities before starting to produce and generate rents.

Table 2. 4 Lag variations of RRT

Dependent variable	**Oil rents**					
Models	(1)	(2)	(3)	(4)	(5)	(6)
L2.RRT	0.852 (0.694)					
L3.RRT		0.936 (0.653)				
L4.RRT			1.203* (0.625)			
L5.RRT				1.460** (0.637)		
L6.RRT					1.534** (0.654)	
L7.RRT						1.214** (0.576)
Country FE	Yes					
Year FE	Yes					
Control variables	Yes					
N	2,322	2,282	2,242	2,202	2,160	2,117
R-squared	0.210	0.212	0.219	0.220	0.223	0.222

Notes:
The dependent variable for all specifications is oil rents. The main variable of interest is mining fiscal systems, RRT_{it-n} (n = 2 to 7 years). Control variables: per capita GDP, GDP growth, trade openness, non-oil rents, inflation, population, oil reserves and democracy index. The number of observations changes because some variables are dropped when applying different lags of RRT. Standard errors are clustered by country.
**, * indicate significance at 5 per cent and 10 per cent, respectively.

A range of other tests are also performed to check the robustness of the results, and these are reported in Appendix, Table A2.3. A brief summary of the results is as follows. First, the results are robust when some new control variables are added into the main estimation model. As reported in columns 1-5, the values of coefficient estimates lie between 1.276 and 1.456. They are close to the value of regression coefficient in the main model, 1.460 (Table 2, column 2), and all are significant at 5 per cent level. Second, even though the magnitude of the impact is also slightly smaller, the result in general is stable ($\beta = 1.353$, and also significant at 5 per cent level) when using a one-year lag of economic, geological and institutional variables (column 6). Lastly, the finding is still robust, as reported in column 7, when the 1970s are excluded from the estimation. The value of β is 1.283 and significant at 10 per cent level. This provides evidence that oil prices, and hence, oil rents influenced by either OPEC or developed nations should not be a concern in this estimation. In general, the results indicate that there is no need to worry about the potential problems due to omitting variable bias and reverse causation between both the control variables and the outcome variable, and the variable of interest (RRT) and the rents.

2.5.3 Heterogeneity analysis

Table 2.5 provides the estimation results using sub-samples of data: OECD and non-OECD countries; democratic and non-democratic countries; and countries with higher and lower levels of freedom. All variables are the same as those used in the main model.

Table 2. 5 Income, democratic and freedom levels

Dependent variable	**Oil rents**					
Models	(1) OECD	(2) Non-OECD	(3) Democratic countries	(4) Non-democratic countries	(5) Countries with greater levels of freedom	(6) Countries with lower levels of freedom
L5.RRT	0.090 (0.349)	2.048** (0.829)	1.211** (0.513)	1.721 (1.642)	1.374** (0.536)	0.499 (2.129)
Country FE	Yes					
Year FE	Yes					
Control variables	Yes					
N	768	1,434	1,466	725	1,696	506
R-squared	0.325	0.294	0.182	0.432	0.202	0.488

Notes:
The dependent variable for all specifications is oil rents. The main variable of interest is a five-year lag of mining fiscal systems. Control variables in columns 1,2, 3 and 4: per capita GDP, GDP growth, trade openness, non-oil rents, inflation, population, oil reserves and democracy index. In columns 5 and 6, democracy index is replaced by freedom index: political rights index and civil liberties index. Standard errors are clustered by country.
** indicates significance at 5 per cent

Columns 1 and 2 show the estimation results for OECD countries and non-OECD countries, respectively. It is found that the RRT system has a significantly positive impact on oil rents only in non-OECD countries, while in OECD countries there is no significant difference in impact between RRT and GRT.[17] The impact of adopting the RRT system on generating oil rents in developing countries is quite strong, around two times higher than using

[17] The estimations for columns 1-4 use the democracy index. The results are still similar when using the freedom index ($\beta = 2.055$, significant at 5 per cent level in non-OECD countries, and not significant in OECD countries).

the GRT system (β =2.048, significant at 5 per cent level). The findings seem to suggest that the dissimilar conditions between developed and developing countries may result in different designs of RRT features, and hence lead to their distinct impacts on generating rents. Most of the RRT systems applied in developed nations are in the form of concession agreements, while those applied in developing nations are largely in the form of contractual agreements. In addition, the adoption of the RRT in developed nations may distort the sectoral allocation of capital, since the investments in most natural resource projects in these countries are mainly from domestic sources (Garnaut and Clunies-Ross, 1979). Developing countries, in contrast, mostly rely on foreign investment (Nakhle, 2004) and have a strong desire to attract foreign investors (Otto et al, 2006).

The results also show that the adoption of the RRT system has a significantly positive impact ($\beta = 1.211$, significant at 5 per cent level) on oil rents in democratic countries (column 3), while in non-democratic countries its effect disappears (column 4). The results are still similar by using the freedom index instead of the democracy index. The value of β is 1.374 and also significant at 5 per cent level in countries with a higher freedom index (column 5), but there is no significant impact in countries with a lower index (column 6). These results provide evidence that good political institutions, in this case, democracy and freedom are necessary for optimizing RRT systems in generating resource rents. It seems logical because governments in democratic countries and those with greater levels of freedom are generally more capable of overcoming potential problems associated with the regulatory constraints of the RRT application—asymmetric information, transactional cost, and administrative and political constraints (Laffont and Tirole, 1993). Moreover, some drawbacks of using RRT, such as transfer pricing and gold plating due to asymmetric information and other moral hazards, are less likely to happen in these countries compare to non-democratic countries and those with a lower freedom index.

Another evidence of the importance of democracy and freedom for the adoption of RRT in developing countries is shown in Table 2.6. The impacts of RRT on generating oil rents in democratic countries and those with higher freedom levels are positive and significant (columns: 1 and 3), while in non-democratic countries and those with a lower level of freedom, their effects are insignificant (columns 2 and 4).

Table 2. 6 Democratic and freedom levels in non-OECD countries

Dependent variable	**Oil rents**			
Models	(1) Non-OECD - Democratic countries	(2) Non-OECD, Non-democratic countries	(3) Non-OECD with greater levels of freedom	(4) Non-OECD with lower levels of freedom
L5.RRT	2.199*** (0.722)	1.727 (1.646)	1.989** (0.812)	0.499 (2.129)
Country FE	Yes			
Year FE	Yes			
Control variables	Yes			
N	713	721	928	506
R-squared	0.304	0.433	0.298	0.488

Notes:
The dependent variable for all specifications is oil rents. The main variable of interest is a five-year lag of mining fiscal systems. Control variables in columns 1 and 2: per capita GDP, GDP growth, trade openness, non-oil rents, inflation, population, oil reserves and democracy index. In columns 3-4, democracy index is replaced by freedom index: political rights index and civil liberties index. Standard errors are clustered by country.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

2.5.4 Channel tests

Table 2.7 shows the estimation results of regressions for testing possible channels through which mining fiscal systems affect rents. In column 1, the number of oil exploration wells is used to represent the effort of companies. The result reveals that adopting the RRT system has a significantly positive effect (at 1 per cent level) on drilling oil exploration wells. It increases the number of oil wells drilled, approximately seven wildcat wells higher than applying the GRT system. The reimbursement of costs in the RRT system, whether in PSCs or other leasing arrangements, could be one of the key factors encouraging oil companies to take greater risks in exploring and finding new oil reserves. Under the RRT system, as shown in column 2, oil companies also produce more output than under the GRT system ($\beta =$

10.905 million tonnes of oil equivalent, significant at 5 per cent level). Additional test for the potential channels, as shown in Appendix, Table A2.4, reveals that the estimated coefficient decreases (column 2) or becomes less significant (columns 3 and 4) after including channel variables in the regression. This provides further evidence that oil drilling and production serve as the mediator between applying the RRT system and generating oil rent. These findings suggest that the RRT system is better than the GRT, as it encourages companies to drill more exploration wells and leads to increased oil production. This then helps explain why adopting RRT generates higher rents than using GRT. It sounds reasonable because more exploration wells will increase the possibility of finding new oil reserves. Subsequently, with more reserves, production levels could be increased, and hence, more rents could be generated.

Table 2. 7 Channel tests

Dependent variable	Wildcat wells	Oil production
	(1)	(2)
RRT	7.246*** (2.660)	
L5.RRT		10.905** (5.373)
Year FE	Yes	
Country FE	Yes	
Control variables	Yes	
N	2,611	2,106
Period	1970-2015	1973-2015
R-squared	0.113	0.323

Notes:
The dependent variables are the number oil exploration wells (Wildcat wells) in column 1 and oil production in column 2. The main variable of interest is mining fiscal systems. Control variables: per capita GDP, GDP growth, trade openness, non-oil rents, inflation, population, oil reserves and democracy index. Standard errors are clustered by country.
***, **-indicate significance at 1 per cent and 5 per cent, respectively.

2.6 Conclusion

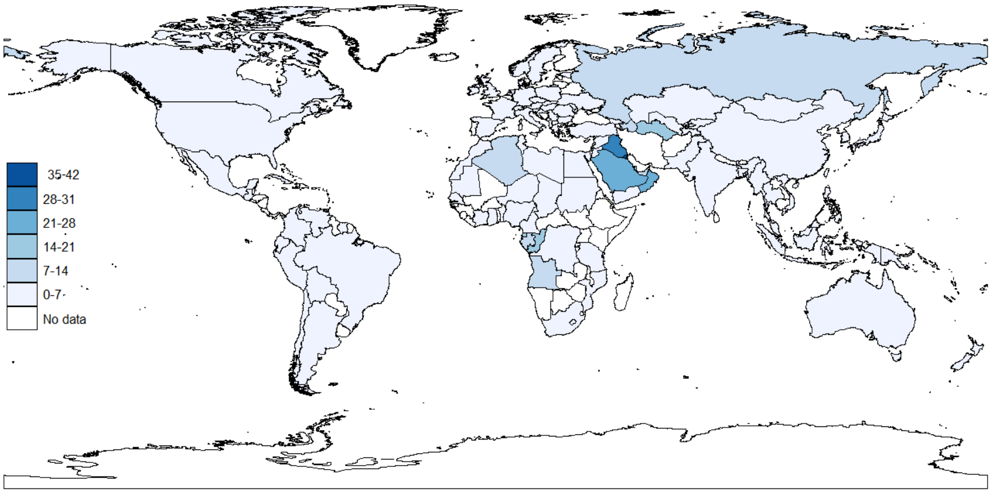
The causal impacts of applying widely used mining fiscal systems in oil extraction (GRT and RRT) on resource rents has been tested in this empirical study using the fixed effects estimation model. This study examined 82 oil-producing countries and carefully observed their mining fiscal systems applied between 1970 and 2015. The results show that, in general, the RRT system has a better impact than the GRT system on generating oil rents. These findings offer new empirical evidence that the RRT, as a profit-based tax system, is a good and reliable fiscal system for improving economic performance of oil extraction. However, changing the fiscal system from GRT to RRT has no significant effect on oil rents since the old fiscal system, in most cases, continued to be applied until the end of their contracts.

The study also finds that the significantly positive impacts of applying RRT on oil rents only occur in developing countries, particularly democratic countries or countries with higher levels of freedom. Conversely, the effects are statistically insignificant in developed nations, non-democratic countries and countries with lower degrees of freedom. These findings suggest that the RRT system is capable of raising oil rents in developing countries with better quality of democracy and freedom. These countries are more likely to have better governance and strong checks and balances, supporting a favourable business environment in the oil sector. Therefore, the RRT system can be applied more effectively and its potential drawbacks, such as moral hazard and other agency problems due the presence of asymmetric information, can be reduced. It also seems to indicate that the effects of the RRT systems are influenced by their designs and payment structures (i.e., the RRT systems are mainly applied in a concession system in developed countries and in a contractual agreement in developing countries). This may also indicate that their distinct impacts are influenced by different foreign capital dependency in oil extraction in these two groups of countries. Compared to developing countries, developed countries are less dependent on foreign investment.

In general, according to these findings, the same fiscal system applied in different countries may generate different impacts due to the differences in their economic development status and institutional capacities, specifically democracy and freedom levels. Another important piece of evidence is that the number of oil wells and oil production are crucial channels in the relationship between fiscal systems and resource rents. It is found that the RRT system provides more rents than the GRT system through its positive effect on the efforts of oil companies in drilling more oil exploration wells, resulting in increased production.

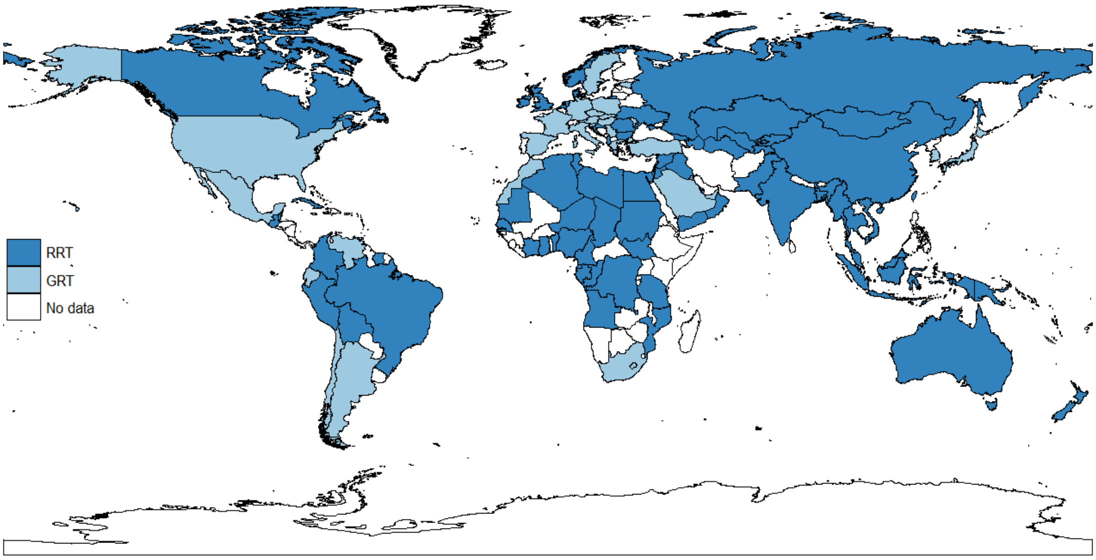
This study focuses on the impacts of mining fiscal systems on the generation of oil rents as an indicator of sector performance and it does not address the distribution of the rents between government and oil companies. However, it can be assumed that the more oil rents generated from the sector under the RRT system, with its equity principle—those with more profit should pay more and those with less should pay less—the higher the possibility of governments to obtain more revenues. Therefore, the findings support a significant public policy suggestion: with higher levels of democracy and freedom, governments in developing countries should consider applying the RRT system to enhance the economic rent from oil extraction.

Appendices



Source: Author's calculation, based on World Bank Data (2018)

Figure A2. 1 The distribution of oil rents (% GDP) in 2015



Source: Author's analysis, based on various sources.

Figure A2. 2 Distribution of GRT and RRT 2015

Table A2. 1 Mining fiscal system classifications in the oil sector (1970-2015)

Mining Fiscal Systems									
Adopting GRT		**Adopting RRT or hybrid**		**Changing from GRT to RRT or hybrid**					
No	**Country**	**No**	**Country**	**No**	**Country**	**Year Change**	**No**	**Country**	**Year Change**
1	United Arab Emirates	1	Azerbaijan	**1**	Angola	1979	25	Malaysia	1976
2	Argentina	2	Bulgaria	**2**	Australia	1984	26	Niger	2008
3	Austria	3	Georgia	**3**	Benin	2006	27	Nigeria	1973
4	Switzerland	4	Indonesia	**4**	Bahrain	2009	28	New Zealand	1995
5	Czech Republic	5	Kazakhstan	**5**	Canada	1985	29	Norway	1975
6	Germany	6	Mongolia	**6**	Cote d'Ivoire	1992	30	Oman	1974
7	Spain	7	Mozambique	**7**	Cameroon	1999	31	Pakistan	1997
8	Estonia	8	Netherlands	**8**	Congo, Dem. Rep.	1981	32	Papua New Guinea	1977
9	France	9	Senegal	**9**	Congo, Rep.	1994	33	Peru	2003
10	Italy	10	South Sudan	**10**	Colombia	1975	34	Philippines	1973
11	Japan	11	Turkmenistan	**11**	Denmark	1982	35	Qatar	1976
12	Korea, Rep.	12	Tanzania	**12**	Egypt, Arab Rep.	1976	36	Russian Federation	1994
13	Morocco			**13**	Gabon	1982	37	Sudan	1975
14	Moldova			**14**	Greece	1976	38	Suriname	1980
15	Poland			**15**	United Kingdom	1975	39	Chad	2007
16	Saudi Arabia			**16**	Ghana	1984	40	Thailand	1986
17	Serbia			**17**	Equatorial Guinea	2006	41	Tajikistan	2007
18	Slovak Republic			**18**	India	1980	42	Trinidad and Tobago	1995
19	Slovenia			**19**	Ireland	2007	43	Tunisia	1985
20	Sweden			**20**	Israel	2011	44	Ukraine	2007
21	Turkey			**21**	Jordan	1986	45	Uzbekistan	2001
22	United States			**22**	Kyrgyz Republic	2004	46	Vietnam	1988
23	South Africa			**23**	Libya	1974	47	Yemen	1981
				24	Mauritania	2010			

Notes:

The Mining fiscal systems applied in each country are carefully examined from various sources, as explained in Section 2.3 and Appendix Table A2.2. These fiscal systems are then categorised into two groups: Gross Royalty Tax (GRT) and Resource Rent Tax (RRT, including hybrid systems). GRT is based on gross production or revenue, whereas RRT is a profit-based tax, including hybrids where both GRT and RRT are applied. Several mining fiscal systems fall under the GRT category: First, concession regimes with royalty payments based on gross production or gross value of production. Second, concession regimes with royalty payments based on R-factor, which is calculated using gross production or gross value of production. Third, contractual regimes with production sharing based on gross production or gross value of production. Other fiscal systems are categorised as RRT fiscal system: First, concession regimes that include a special tax based on profit. Second, concession regimes that feature a hybrid royalty system with an element of royalty payments based on profit. Third, concession regimes with royalty payments calculated using R-factor, which is based on the cumulative value of production divided by cumulative costs. Fourth, contractual regimes based on profit sharing. Lastly, hybrid fiscal regimes that apply both concession and contractual regimes, featuring profit-based tax in one or both systems.

Table A2. 2 Variables and data sources

Variables	Sources
Oil rents GDP per Capita GDP growth Trade openness Inflation rate Population Population density Gross capital formation	World Development Indicator (WDI)
Oil exploration wells	US Geological Survey (USGS)
Mining Fiscal Systems (RRT and GRT)	Various sources, include: Ernst & Young, PricewaterhouseCoopers, Deloitte, and oil laws and regulation in each country.
Oil reserve	US Energy Information Agency (IEA) and British Petroleum (BP p.l.c.)
Democracy index	Polity IV dataset
War	Uppsala Conflict Data Program, the Department of Peace and Conflict Research (UCDP/PRIO dataset)
Political rights Civil liberties	Freedom House dataset

Table A2. 3 Further robustness tests

Dependent variable	**Oil rents**						
Models	(1) Adding population density	(2) Adding investment	(3) Adding war	(4) Adding political rights	(5) Adding civil liberties	(6) Lag 1 year of control variables	(7) Exclude period 1970s
L5.RRT	1.456** (0.638)	1.276** (0.590)	1.303** (0.594)	1.399** (0.629)	1.381** (0.641)	1.353** (0.576)	1.283* (0.679)
Year FE	Yes						
Country FE	Yes						
Control variables	Yes						
N	2,202	2,176	2,176	2,176	2,176	2,188	2,051
R-squared	0.220	0.225	0.225	0.226	0.226	0.233	0.224

Notes:
The dependent variable for all specifications is oil rents. The main variable of interest is a five-year lag of mining fiscal systems. Control variables in the main model: per capita GDP, GDP growth, trade openness, non-oil rents, inflation, population, oil reserves and democracy index. All control variables in column 6, except population, use a one-year lag. Standard errors are clustered by country.
**, * indicate significance at 5 per cent and 10 per cent, respectively

Table A2. 4 Additional tests for potential channels

Dependent variable	**Oil rents**			
	(1) Main model	(2)	(3)	(4)
L5.RRT	1.460** (0.637)	1.317** (0.634)	1.267* (0.669)	1.232* (0.627)
Include channel variable: Wildcat wells	No	Yes	No	
Include channel variable: Oil production	No		Yes	No
Include both channel variables	No			Yes
Country FE	Yes			
Year FE	Yes			
Control variables	Yes			
N	2,202	2,104	2,072	1,990
R-squared	0.164	0.169	0.160	0.214

Notes:
The dependent variable for all specifications is oil rents. The main variable of interest is a five-year lag of mining fiscal systems. Control variables: per capita GDP, GDP growth, trade openness, non-oil rents, inflation, population, oil reserves and democracy index. Standard errors are clustered by country.
**, * indicate significance at 5 per cent and 10 per cent, respectively.

Chapter 3

Is there any natural resource curse at local levels? evidence from oil village economies in Indonesia

3.1 Introduction

The causal relationship between natural resources and economic growth is complex and remains unclear until now. Assessing the role of natural resources in economies has been one of the central issues in economic development, both in theory and practice. This topic has been extensively discussed and investigated since the 1990s. It is evident from the literature that natural resources could be a curse or a blessing for economic development. The seminal empirical study on the natural resource-economic growth nexus, conducted by Sachs and Warner (1995), finds a negative relationship between natural resources and the economy.[18] This inverse association phenomenon was first coined as the natural resource curse by Auty (1993).

The term natural resource curse also refers to the 'paradox of plenty' (Karl, 1997), suggesting that countries rich in natural resource endowments tend to have lower economic performances than those with fewer natural resources. The subsequent investigations, however, revealed mixed results. Some studies, such as those by Gylfason et al (1999), Leite and Weidmann (1999) and Brückner (2010), among many others, support the natural resource curse hypothesis. Conversely, other studies, including those by Sala-i-Martin and Subramanian (2003), Mehlum et al (2006) and, more recently, Gerelmaa and Kotani (2016) and Komarek (2016), among many others, come out with different outcomes. In general, using a different

[18] Sachs and Warner (1995) show that economies with a high ratio of natural resource exports to GDP in 1971 tended to have low growth rates during the subsequent period 1971-1989.

proxy of natural resources, estimation methods and different sets of control variables can lead to different results.[19]

Similar studies in the context of oil have been provided by numerous researchers since the 2000s, yielding mixed results. On one hand, oil can be considered as part of natural capital and can be extracted and utilised to support the economic development process. It serves as a potential revenue source generated from oil rent or as an energy source and raw input for other industries. On the other hand, this resource may slow down the economy due to its negative effects through various potential channels, such as Dutch disease, rent-seeking behaviour, corruption, conflict, and weak institutions.[20] Therefore, whether oil resources are beneficial or detrimental to the economy still puzzles many development economists. The intense debate over this issue continues and is moving from the cross-country and country-level analyses to the sub-national and local-scale investigations.

This study tries to provide another empirical evidence on whether oil extraction could boost or hamper local economic activities, by investigating the impacts of oil extraction on the economy at the village level in Indonesia. Most previous studies, in the case of Indonesia, used qualitative analyses of aggregate country-level data, as seen in works by Arndt (1983), Gelb (1988), Usui (1996) and Seda (2014). All argue that oil extraction in Indonesia was a blessing rather than a curse that helped the nation's economic development. Summarising these findings, it is asserted that the Indonesian government implemented effective policies in dealing with oil windfalls and utilising its oil revenues, particularly during the oil booms in the 1970s and 1980s. Oil revenue was used for financing various development strategic programs in several sectors, such as infrastructure, education, agriculture, capital-intensive industries and transmigration

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[19] The detailed review of the relationship between natural resources and economic growth and development was provided by some researchers, such as Frankel (2010), van der Ploeg (2011), Gilberthorpe and Papyrakis (2015), and more recently by Badeeb et al (2017) and Vahabi (2018).
[20] Channels in the natural resources and economic development nexus are also explained in more detail in studies mentioned in footnote 19.

programs. Only a few empirical studies within Indonesia, using sub-national data, have been provided, including those by Cust and Rusli (2014) and Cust et al (2019). They also find positive impacts of oil endowment on economic activities at the district level.

In the case of Indonesia, to the best of my knowledge, no empirical study had been conducted at the village level, primarily due to the difficulty in accessing oil data. It is worth emphasizing that the Indonesian government used to treat individual oil well data as confidential and only provided the aggregate data that it reported annually. However, this practice changed in 2019 when the government introduced a new policy that these data can be access by the public. I then seized this policy change to collect information on oil drilling activities and analyse their impacts on the local economic activities.

This study makes significant contributions to the ongoing debate on natural resource curse, particularly by examining the local impacts of oil extraction in the context of a developing country. It offers at least three main contributions. First, it analyses individual oil well drilling activities at the most disaggregated village level, which were previously difficult to access. Second, it provides the causal relationship between oil extraction and local economy by exploiting the random outcome of oil drilling; that is, comparing oil-producing villages and non-oil-producing villages conditional on oil drilling. Lastly, the study provides possible channels through which oil extraction affects the local economy.

The results may indicate the presence of natural resource curse at the village level across Indonesia. Oil extraction has significantly negative effects on both the number of small-scale enterprises and the number of workers in them. These findings contradict the conclusion from previous studies, both country-level analysis and district-level investigation, which suggested that oil was a blessing for the overall Indonesian economy and local economies at the district level, respectively. Therefore, despite the revenue from oil extraction, particularly during the peak production and high oil price in the 1970s that helped the nation in financing many strategic development programs, its impacts on the local economies are negative.

As can be noted from the channel test, local governments in oil-producing villages, compared to those in non-oil-producing villages, are less likely to provide appropriate programs to support local industries. The influence of these local institutions may explain why the inverse relationship between oil extraction and local economy only happen in either major oil-producing regions or outer islands, and not in minor oil-producing regions. It should be emphasised that villages in both rich-oil regions and outer islands are less developed, compared to those in scarce-oil areas that are predominantly located in Java.

The rest of this study is organised into several sections, as follows. The next section provides a historical background that briefly describes the institutional setting of oil extraction activities in Indonesia and empirical analysis of economic consequences of oil extraction. Section 3.3 describes data that explains variables and data sources and the reason why they are required for the analysis. Section 3.4 explains the identification strategy of this study. This includes explanation of the randomness of oil discovery and production, and estimation methods. Section 3.5 presents the estimation results and discussion of the findings, followed by the last section which includes the conclusion and policy suggestion related to the findings.

3.2 Historical background

3.2.1 Institutional setting of oil extraction in Indonesia

Oil exploration in Indonesia, formerly known as the Dutch East Indies, was started under the Dutch colonial rule in the 19th century. The earliest attempt was made in 1871 in Cirebon, West Java, approximately a decade after the first successful oil drilling in the United State in 1859. The first commercial oil production in Indonesia took place in 1885 in Langkat, North Sumatera. Then, oil exploration expanded to Kalimantan and Java regions. Initially, oil permits were granted by the Sultan (or the King), but later on this control was taken over by the Dutch government.

Indonesia was one of the significant oil producers in the world, contributing around 13 million barrels or 3.4 per cent of total world oil production in 1911 (Bee, 1982). By the early 20th century, oil exploration had also expanded to Papua region, formerly known as Dutch New Guinea. During this period, over 100 oil concessions had been granted. Major international oil companies (IOCs) participated in this oil extraction activity, such as Royal Dutch, Shell Transport and Trading Company, California Texas Oil Company, known as Caltex and the Standard-Vacuum Company, widely known as Stanvac (Carlson, 1977; Bee, 1982).

After declaring its independence in 1945, Indonesia established its National Oil Companies (NOCs)—Permina, Pertamin and Permigan— while IOCs were still allowed to continue their operations. The previous colonial oil concession system was abolished, and a new system known as Work Contracts (Kontrak Karya) was introduced in 1960 with the enactment of Law No. 44/1960. Under this law, oil was recognised as a national asset controlled by the state, and its extraction could only be carried out by NOCs. In this revised arrangement, IOCs participated as contractors to the NOCs.

In 1966, the Indonesian government introduced a new permit system, known as Production Sharing Contracts (PSCs), followed by the establishment of Pertamina as a new national oil company in 1968. Under this system, the state or Pertamina, as the owner of the oil resource, retained control over the management of oil operations. Private companies, including both IOCs and local oil companies, as the contractors, were required to submit the annual work programs and budgets for their operations. This system underwent further changes with the introduction of the latest oil law (Law No. 22/2001), transferring the supervision of oil extraction activities from Pertamina to the government. This marked the end of Pertamina's monopoly in oil extraction, allowing private oil companies to operate independently without its oversight.

In terms of oil rent distribution in Indonesia, government revenue is derived from various means. During the colonial oil concession system, government income primarily came from royalty payments, while in the work system and PSC arrangement, the revenue was from its oil share that is stipulated in the contracts. In addition to these non-tax revenues, government also collects payments from the taxes. Since 2004, under Regional Administration Law (Law No. 32/2004) and the Financial Equilibrium between the Central and Regional Governments Law (Law No. 33/2004), oil revenue is required to be shared with oil-producing provinces and districts. This sharing is based on the value of oil extracted from their areas. It should be emphasised that during this study period, and even up to the present, there is no direct payment for local governments at the village levels from oil revenue.

3.2.2 Oil extraction process

In the early period, oil could be easily collected from seepage or tar ponds and its use was still limited. Since the 19th century, the utilization of oil as an energy source increased, leading to a surge in oil demand and exploration activities, including in the Dutch East Indies/Indonesia. Since then, oil extraction has become more complex and requiring a long process because most oil reserves are located deep below the earth's surface. The first step of the oil extraction process is oil exploration, by conducting a survey to detect a potential oil reservoir – rock formation associated with oil deposit. In Indonesia, this task is undertaken by either government agencies or national oil companies. Private oil companies may also conduct oil exploration under the PSC, with exploration costs being recovered by the government, only if oil is found and produced commercially.

The main objective of exploration activities is to collect data related to geological and geophysical features. Exploration data provides information on whether there is any potential oil resource or not. At this stage, a potential oil resource is known only within a spectrum of uncertainty and should be expressed in terms of probability ranges: possible reserves (likelihood of commercial extraction ≤ 50 per cent) or probable reserves (likelihood of commercial extraction > 50 per cent but < 90 per cent); and proved reserves (likelihood of commercial production ≥ 90 per cent). The area with a potential oil resource will be designated as an oil basin. Within this oil basin, government will decide to allocate oil blocks that could be developed for oil production. Several oil blocks could be prepared from one oil basin, depending on its size.

The subsequent step involves inviting oil companies to develop the designated oil block. After obtaining government permits through various arrangements, such as Oil Concession (until 1960), Work Contracts (1960-1966), and the PSCs (since 1966), the oil company proceeds to drill an oil well. The first is an exploratory well, also known as wildcat, aimed at identifying the presence of oil reserves in the area. This drilling is the final stage of exploration activities. The possible outcomes of this drilling are either discovery or failure. The exploration stage, from geological survey to the first exploratory drilling, could take two to seven years on average. The discovery well is followed by an appraisal well to calculate the amount of oil or the span of oil reservoir, and the outcome of this drilling could determine the size of proved oil reserves. If the quantity of oil is sufficient to be produced commercially, an oil company will continue to the next step by drilling an oil development well for the extraction process.

3.2.3 Review of economic consequences of oil extraction

Oil has been frequently used in the natural resource curse literature. It is regarded as an important asset and the main source of wealth in many countries. By extracting this non-renewable resource, governments can generate considerable income that can be used to finance their development programs. Despite these potential benefits, evidence indicates that oil extraction does not always yield positive impacts on the economy. Instead, it may lead to a slowdown of economic growth, as reviewed in several studies, including those provided by Frankel (2010), Gilberthorpe and Papyrakis (2015), and more recently by Vahabi (2018). The negative relationship between oil extraction and economic development can be seen as natural resource curse. This inverse association has also been called oil curse and has been extensively examined in the literature.

As mentioned in the introduction, spurred by the work of Sachs and Warner (1995), numerous researchers have tried to further investigate natural resource curse by using oil as the proxy of natural resources. So far, the results in this more specific sector are also mixed, mirroring the broader studies on natural resources in general. Some empirical cross-country studies, such as those provided by Eregha and Mesagan (2016) and Antonakakis et al (2017), and country-level studies like the one by Satti et al (2014), among others, provide evidence supporting the existence of natural resource curse. Contrastingly, other cross-country investigations, such as those provided by Alexeev and Conrad (2009), Cavalcanti et al (2011), and more recently Arezki et al (2017) and Cassidy (2019), reveal a positive relationship. Apergis and Payne (2014) further complicate the narrative by suggesting that the relationship between oil resource and economic growth is time-varying, and it could change from a curse into a blessing, depending on the improvement of the institutional qualities. These studies represent examples of conflicting results of the relationship between oil and the economy in the literature, particularly in the context of cross-country and country-level studies.

Similar to the cross-country and country-level investigations, within-country setting using oil as the proxy for natural resource have also yielded mixed results. The evidence of natural resource curse in this setting were provided by some researchers, such as: Caselli and Michaels (2013) in Brazil; Haggerty et al (2014) and Jacobsen and Parker (2016) in the US; and Xue et al (2020) in China, among many others. Other local studies, however, show that oil is a blessing rather than a curse. Examples of empirical studies for this case include: Michaels

(2011), Weber (2012), and more recently, Agerton et al (2017) and Allcott and Keniston (2018) in the US; Marchand (2012) in Canada; Cust and Rusli (2014) in Indonesia; Fleming and Measham (2015) in Australia; and Cavalcanti et al (2019) and Gradstein and Klemp (2020) in Brazil.

Another important aspect to consider in the discussion of the oil–local economic development relationship is potential channels. Factors that influence how oil extraction affects local economy have been widely discussed, as highlighted by Aragon et al (2015) and Fleming et al (2015). First, similar to what happened in cross-country and country-level studies, the Dutch disease phenomenon could also occur in the local setting. Oil production may lead to specialisation in primary sectors, and subsequently negatively affect non-primary sectors. Second, oil windfall that could affect local economy positively or negatively depends on how the oil revenue is spent. The quality of local institutions plays a crucial role in determining the impacts. Lastly, oil production activities may generate local demand shocks, influenced by the strength of the linkages between oil exploitation businesses and local inputs.

3.3 Data and sample description

This study focuses on the impacts of oil extraction on the local economy in Indonesia. I use the most disaggregated level at which data are observed, considering that some villages were split during the study period. The analysis encompasses approximately 7,600 onshore oil drilling activities in 1,205 villages across the country, spanning the period from 1900 to 2012.[21] The oil data is obtained from Ministry of Energy and Mineral Resources Republic of Indonesia. This dataset includes individual oil well information such as well name, location with latitude and longitude, status (production, discovery, no discovery—water, dry hole and abandoned), drilling date, well depth and the associated oil company.[22] By employing the coordinates of

[21] See Appendix, Figure A3.1 for geographical distribution of oil drilling in Indonesia.
[22] See Appendix, Table A3.1 for more detail on individual oil-well information.

individual oil wells, I merge the well locations into village level data and classify these villages into two categories: with oil production; and with no oil production. In the analysis, villages with oil production are treated as the treatment group, while villages without oil production serve as the control group.

Data regarding local economic activities are obtained from the 2016 Indonesian Economic Census (Sensus Ekonomi 2016), Statistics Indonesia (locally known as BPS). This dataset includes information on the number of enterprises and the number of workers. These two variables serve as proxies for the local economy as they lead to local socio-economic development (Memili et al, 2015), including their roles in fostering innovation and job creation (Chege and Wang, 2020), as well as in reducing poverty (Duncombe, 2006; Mbuyisa and Leonard, 2017). Moreover, they contribute to sustainable development, as highlighted by Jones and de Zubielqui (2017) and Sohal and De Vass (2020). The classification of firms is based on size, distinguished between micro (1-4 workers) and small (5-19 workers). Geographical features of villages, such as topography, river and coastal indicators are extracted from the 2014 Village Potential Survey (Potensi Desa Survey – PODES). Economic and infrastructure variables, such as local fund, main income sources of households, irrigation, and types of roads, are also obtained from this data source. Using village coordinates, I calculate the distance of each village to the capital of the Dutch East Indies/Indonesia (Batavia/Jakarta) and to the capital of nearest districts. Population data is derived from the 2010 Population Census (Sensus penduduk), Statistics Indonesia, while data of village size is obtained from each sub-district statistics, Kecamatan Dalam Angka 2016, an annual publication by Statistics Indonesia. All variables and their data sources are shown in Appendix, Table A3.2. A detailed explanation of each variable used in the estimation is also provided in Appendix, Table A3.3, while the summary statistics are presented in Table 3.1 below.

Table 3. 1 Summary statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Dependent variables					
No. of small enterprises	1,205	17.237	38.163	0	529
No. workers in small enterprises	1,205	144.867	331.386	0	4,737
Small enterprise per capita	1,180	0.004	0.005	0	0.104
Worker per capita in small enterprises	1,180	0.038	0.052	0	1.242
Small enterprise density	1,205	2.224	8.906	0	149.465
Worker density in small enterprises	1,205	18.175	71.764	0	1,107.512
No. of small enterprises–manufacturing	1,205	2.152	13.751	0	379
No. of small enterprises–services	1,205	12.604	27.468	0	407
No. of small enterprises–education	1,205	4.324	4.968	0	40
No. of workers in small enterprises–manufacturing	1,205	18.761	155.933	0	4,530
No. of workers in small enterprises–services	1,205	108.098	227.855	0	3,240
No. of workers in small enterprises–education	1,205	43.686	51.071	0	344
No. of micro enterprises	1,205	286.561	445.519	0	5,880
No. workers in micro enterprises	1,205	413.288	652.328	0	9,000
Local government fund for local industries	1,186	0.664	0.472	0	1
Local government training program for local industries	1,188	0.058	0.233	0	1
Variable of interest					
Oil production	1,205	0.087	0.283	0	1
No. of oil production wells	1,205	0.410	5.072	0	163
No. of oil production wells per total oil wells	1,205	2.817	12.490	0	100
Main Control variables					
Distance1 (to Batavia/Jakarta)	1,205	1,054.892	661.164	14.134	3,744.563
Topography	1,188	2.915	0.388	1	3
Coastal	1,188	0.877	0.327	0	1
Rivers	1,188	0.204	0.403	0	1
Additional control variables					
Distance2 (to closest district's capital)	1,205	27.734	17.147	0.765	159.826
Population	1,180	3,506.478	4,418.118	53	42,778
Household main income sources	1,188	1.289	1.055	1	7
Irrigation	1,188	0.839	0.367	0	1
Road types	1,160	1.538	0.732	1	4
Instrumental variable					
Oil discovery	1,205	0.523	0.499	0	1

Table 3.2 presents the results of balance tests for covariates used in the estimation model. Notably, most of the village characteristics in the treatment group (column 1) and control group (column 2) are similar, except for two variables: coastal indicators and rivers. Overall, the results suggest that unobserved factors influencing economic outcomes are likely to be

similar between two groups. These findings serve as supporting evidence for the identification strategy by using these non-oil-producing villages as the comparison group for the oil-producing villages.

Table 3. 2 Balancing checks on the covariates

Variables	1 Treatment group		2 Control group		3 Coef.
	Obs.	Mean	Obs.	Mean	
Main control variables					
Distance1 (to Batavia/Jakarta)	106	1082.575 (583.479)	1,099	1052.222 (668.357)	-0.504
Topography	106	2.943 (0.333)	1,082	2.913 (0.394)	-0.877
Coastal	106	0.792 (0.407)	1,082	0.886 (0.317)	2.304**
Rivers	106	0.339 (0.475)	1,082	0.191 (0.393)	-3.106***
Additional control variables					
Distance2 (to the closest district)	106	25.675 (13.685)	1,099	27.932 (17.437)	1.579
Population	97	4282.67 (6132.12)	1,083	3436.958 (4227.829)	-1.330
Household income sources	106	1.264 (0.865)	1,082	1.292 (1.072)	0.309
Irrigation	106	0.830 (0.377)	1,082	0.840 (0.366)	0.259
Road types	104	1.451 (0.605)	1,056	1.547 (0.743)	1.4997

Notes:
Columns 1 and 2 report number of observations, mean and standard deviations for the treatment group and the control group, respectively. Column 3 presents the t-value and P-value. Standard deviations are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

3.4 Identification strategy

This study investigates whether oil extraction activities yield positive or negative impacts on the local economy at the village level in Indonesia. In contrast to cross-country and country-level analyses, this local setting offers more robust results because, as explained by van der Ploeg (2011), this design can exploit more on variation within the country and diminishes potential confounding factors between natural resources and macroeconomic variables. Therefore, using this localised approach aids in reducing unobserved heterogeneity caused by various factors, such as institutional, cultural and historical backgrounds, as commonly encountered in cross-country studies (James and Aadland, 2011; Fleming et al, 2015).

The approach taken in this study is relatively close in spirit to the work of Cavalcanti et al (2019) where the causal effects of a natural resource on local economy are analysed by exploiting the random outcomes of oil drilling. However, a key distinction lies in the choice of the main variable of interest. While they focus on oil discovery as the main variable of interest, this study centres around oil production. The rationale behind this decision is grounded in the belief that the potential direct impact of oil on a local economy is most likely through extraction rather than discovery. In this setting, villages with at least one oil production well are designated as the treatment group, while those with one or more oil wells that failed to produce oil are categorised as the control group. Therefore, it should be emphasised that oil wells had been drilled in all villages in the samples, encompassing both the treatment and control groups.

3.4.1 The randomness of oil discovery and production

Taking into account the process of oil extraction outlined in the preceding section, it is essential to note that all villages in the sample are situated in the oil basin or oil block area. Therefore, it can be contended that these villages have similar characteristics in terms of geological features and possess an equal likelihood of discovering and producing oil. However, in practice, oil was only found and commercially produced in certain villages, while other villages experienced unsuccessful outcomes. I then argue that oil discovery and production are random events conditional on exploratory oil drilling and treated as a quasi-experiment. Leveraging this characteristic, I exploit the randomness in oil extraction to analyse the causal relationship between oil extraction and the local economy.

Despite advancements in drilling technology, finding new oil reserves remains highly uncertain. This uncertainty is evident in the fact that the success ratio of oil discovery in Indonesia has not undergone significant changes over the last several decades–1970s:30.3 per cent; 1980s: 47.9 per cent; 1990s: 54.2 per cent; and 2000s: 45.4.[23] This implies that during the study period, there is no guarantee that drilling oil wells will consistently lead to the successful discovery of new oil reserves. Furthermore, oil discovery does not always translate into oil production due to some reasons, such as small reserves, technical difficulties, and high costs. In addition, there is inherent trade-off between the development of science and technology in finding and extracting oil and the scarcity of this resources; that is, the availability of oil resources remaining underground.

Table 3.3 provides an overview of oil drilling activities across Indonesia from 1900 to 2012. Among the 1,205 villages where oil wells were drilled, oil production only occurred in 106 villages, while in 1099 villages, oil production failed. Oil was not produced either because of no oil discovery or there was an oil discovery, but it was not profitable to be developed. From the total sample, oil was discovered in 631 villages, with 106 being oil-producing villages and 525 being non-oil-producing villages. Conversely, oil was not discovered in 574 villages.[24]

Table 3. 3 Treatment and control groups

Village categories	Number of villages	Definition
Full sample	1,205	Villages with oil wells
Treatment group	106	Oil-producing villages
Control group	1,099	Non-oil-producing villages

[23] The value of the success ratio of finding new oil reserves is calculated using oil drilling data from US Embassy (1994, 2000, 2008), and BPMigas (2011).
[24] See Appendix: The geographical distribution of oil drilling activities in Indonesia (1900-2012).

3.4.2 Estimation model

I first use an Ordinary Least-Squares (OLS) model (1) to estimate the relationship between oil extraction and economic activities at the village level:

$$y_i = \beta OP_i + \gamma X_i + \lambda_t + \alpha_i + \varepsilon_i \quad (1)$$

where y_i represents economic activities – number of small enterprises and number of workers in small enterprises in village i (year: 2016) as the main outcome variables. In additional tests, it also used to proxy other local economic variables: small enterprise per capita; labourer per capita in small enterprises; small enterprise density; labourer density in small enterprises; number of small enterprises and labourers in sub-sectors (manufacturing, services and education) and sub-regions (major oil-producing regions, minor oil-producing regions, and outer islands); number of micro enterprises; labourers in micro enterprises; and local government support for small enterprises. OP_i is variable of interest. It is a dummy variable, coded 1 if oil was produced in village i (during the study period, from 1900 to 2012), otherwise 0. X_i is a group of control variables which includes the geographical features of the village *i*: distance to the capital of the Dutch East Indies/Indonesia (Batavia/Jakarta); topography; coastal indicator; and the presence of river. The value of these variables stays the same during the study period. λ_t is year of oil drilling dummy, considering oil exploration wells had been drilled by the oil companies in every year during the study period, while α_i is sub-district dummy, capturing possible influences of unobservable time-invariant sub-district characteristics. It should be noted that policies at the village level are generally coordinated in the sub-district government. εi is the random error term, capturing all other omitted factors. The parameter of interest, β, captures the average effects of oil production.

Using OLS model (1) may lead to potential biased in the β coefficient because of potential correlation between OP_i and ε_i, given that oil production may not be random. It could be the case that oil production activities may be endogenous, which were influenced by local economic activities. To address this potential problem, I then apply a two-stage least squares – 2SLS (IV) model as the main model, as follow:

$$y_i = \beta OP_i + \gamma X_i + \lambda_t + \alpha_i + \varepsilon_i \qquad (2)$$

$$OP_i = \eta OD_i + \varphi X_i + \tau_t + \delta_i + \nu_i \qquad (2a)$$

In this IV model, the endogenous variable OP_i (oil production) is instrumented using OD_i (oil discovery), as expressed in equation 2a. There are at least three reasons why oil discovery can be used as a valid instrument in this setting. First, it is common sense to argue that oil discovery has a correlation with oil extraction since it is impossible to produce oil without oil reserves. This can be seen as the first condition for a valid instrument, known as 'instrument relevance' (Stock and Watson, 2003). Evidence of this is provided in the first-stage estimation of the IV regression. Second, oil discovery is considered exogenous because it represents the presence of the oil deposit, which is located in the sub-surface geologic formation underneath the village and is unlikely to be influenced by local economic activities. It is challenging to predict the discovery of oil, particularly by either local government or small industries. Therefore, as explained by Cust et al (2019), because of its high uncertainty, oil discovery can be considered as unanticipated shock. Lastly, it is less likely that an oil deposit could influence a local economy directly, except through production. It may be possible that discovery, prior to production, influences either local industries in making business decisions or local governments in planning their programs, considering the expectation of the future benefit from extracting the resource. However, as shown in Appendix, Table A3.4, oil discovery at least has no significant correlation with both number of small industries and number of labourers in small companies which are used in this study as the proxy of local economic activities.

I also test the exogeneity of the instrument (oil discovery) and variable of interest (oil production) by regressing them on geographic and geological variables: distance to Batavia/Jakarta, topography, coastal indicator, and river. I use these variables as they remain unchanged during the study period. As shown in Appendix, Table A3.5, oil discovery is not influenced by all these variables, while oil production is only affected by the presence of a river. This provides supporting evidence that oil discovery is exogenous. This means that the second assumption in the IV setting, the 'instrument exogeneity' (Stock and Watson, 2003), is satisfied, and, therefore, I have a valid reason to use oil discovery as an instrument for oil production.

To assess potential omitted variable bias, I apply tests developed by Altonji et al (2005) and Oster (2019). First, gradually using additional control variables: geographical variable (distance to capital of closest district); socioeconomic variables (population and main income sources); and infrastructure (irrigation and road types). These variables can capture potential influence of population, economic structure and level of development. Second, analysing the selection of unobservable variables relative to the selection of observable variables. I also provide further robustness tests to check the stability of the estimation results: (i) excluding villages within and near Jakarta, the capital of Indonesia, considering the differences in economic structures of these areas and the rest;[25] (ii) addressing potential influence of outliers by excluding villages with extremely high oil endowment (both number of oil production wells and discovery wells); (iii) using number of small enterprises per capita and number of labourer per capita, and also small enterprise density and labourer density as the outcome variables, instead of number of small firms and labourers, to consider the potential impact of population size and village size, respectively; and (iv) applying number of oil production wells and ratio of them and total oil wells as variable of interests, instead of dummy variable to capture the effect of oil production intensity.

In addition to the main analysis, other tests are conducted for extended analyses. First, heterogeneity analyses by: (i) categorising small enterprises and labourers in small enterprises into sub-sectors: manufacturing, services and education; and (ii) dividing regions into: major

[25] Excluding villages in Jakarta, Banten and West Java provinces.

oil-producing regions; minor oil-producing regions; and outer islands. These tests aim to provide additional insight for analysing the effects of oil extraction in more specific sectors and regions. Lastly, channel test for investigating through which way oil extraction affects local economic activities. In this test, local fund assistance (microcredits: Kredit Usaha Rakyat - KUR and Kredit Usaha Kecil - KUK) and training programs (sales and production) at the village level are used as potential channel variables. As analysed in several studies, including those by Cho and Honorati (2014), Cravo and Piza (2016) and Nakasone et al (2024) funding and training assistances significantly influence the performance of small and medium enterprises and their employments in low- and middle-income countries.

3.5 Estimation results

3.5.1 Main results

The main estimation results are shown in Table 3.4. Columns 1-2 and 5-6 depict the outcomes obtained using the OLS model, while columns 3-4 and 7-8 display the results of applying the IV model. Control variables are applied only in columns 2-4 and 6-8, while other columns are without any control variable. As shown in the table below, oil extraction has significantly negative impacts on both the number of small enterprises and the number of labourers in small enterprises. The impacts remain relatively consistent regardless of the inclusion or exclusion of control variables. Notably, the effects of oil extraction on both the number of small enterprises and the number of labourers, are more pronounced in the IV model compared to the OLS model. When control variables are applied in the estimation (section I), the coefficient β is −2.682, significant at 5 per cent level in the IV estimation, while in the OLS model, β is −0.725, significant only at 10 per cent level. The pattern of the estimation results is similar to those without using any control variable, as shown in column 3 ($\beta = -2.918$, significant at 5 per cent level) in the IV model and in column 1 ($\beta = -0.760$, significant at 10 per cent level) in OLS regression. Similar trends emerge for the number of labourers (section II). The impacts in the IV model are more substantial, approximately four times higher than those in the OLS model for both without control variables (-4.119 vs. -1.084), as shown in columns 7 and 5, respectively, or with control variables (-3.776 vs. -1.042), as shown in columns 8 and 6, respectively. The results presented in columns 4 and 8 are used as the primary findings of this study.

Table 3. 4 Main estimation results: Number of small enterprises and labourers

Dependent variable	**I. Number of small enterprises**				**II. Number of labourers in small enterprises**			
	OLS		IV-second stage		OLS		IV-second stage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Oil production	-0.760* (0.387)	-0.725* (0.390)	-2.918** (1.342)	-2.682** (1.289)	-1.084** (0.505)	-1.042** (0.509)	-4.119** (1.758)	-3.776** (1.689)
Year of oil drilling dummy	Yes							
Sub-district dummy	Yes							
Control variables	No	Yes	No	Yes	No	Yes	No	Yes
R-squared	0.6052	0.6093	0.5836	0.5915	0.5864	0.5896	0.5600	0.5681
N	1,205	1,188	1,205	1,188	1,205	1,188	1,205	1,188
Dependent variable			Oil production IV-first stage				Oil production IV first stage	
Oil discovery			0.143*** (0.029)	0.149*** (0.029)			0.143*** (0.029)	0.149*** (0.029)
First-stage F-statistics			24.25	25.50			24.25	25.50

Notes:
The dependent variables are number of small enterprises (columns: 1-4) and number of labourers in small enterprises (columns: 5-8). The main variable of interest is oil production. Columns 1, 3, 5 and 7 are estimated without any control variable. Columns 2, 4, 6 and 8 are estimated with control variables: distance to Batavia, topography, coastal indicator, and river. All columns are estimated by controlling for year of oil drilling and sub-district dummy. The instrument for oil production in the IV model (columns: 3, 4, 7 and 8) is oil discovery. Standard errors are in parentheses.
***, **, * indicate significance at 1 per cent, 5 per cent and 10 per cent, respectively.

The larger coefficients observed in the IV model compared to the OLS model are expected and commonly found in cross-sectional analysis. This is because the dummy variable for oil production (if oil produced=1, and without production=0) in the OLS model is replaced by the probability of oil being produced, which is less than 1 in the IV model. Consequently, the variances in the IV model are smaller and subsequently increase the magnitude of the estimated coefficients. While the OLS model provides the average treatment effect, the IV model yields the local average treatment effect (LATE). The results from the IV approach suggest that OLS estimation results are downward biased.

As indicated in the first-stage regression, oil discovery has a significantly positive effect on oil production, both in the absence of control variables (columns 3 and 7) and when control variables are incorporated (columns 4 and 8). All findings are significant at 1 per cent level. This provides additional evidence that oil discovery is a suitable instrument for oil production. It is also noted from the estimation results (columns 4 and 8) that the values of F-statistics in the first-stage regressions are 25.50 for the estimation with full control variables. This high F-statistic suggest the strength of the instrument for oil production, conditional on covariates.

The results reveal the negative relationship between oil extraction and local economic activities, specifically the number of small enterprises and the workforce within those enterprises, at the village level in Indonesia. By using the results of IV estimation with full control variables as the main estimation, villages with oil production during the period 1900-2012 have smaller numbers of small firms (i.e., 93 per cent lower) and a reduced number of labourers (i.e., 98 per cent lower) compared to those without oil production. These results may be regarded as evidence of natural resource curse in the context of oil extraction at the local level. This means that this finding contradicts the results of previous studies, as explained in the introduction section, and provides new evidence of the natural resource hypothesis in the local context. Despite the positive effects of oil extraction on the economy observed in country- and district-level analyses, as found in some previous studies, at the village level, its impacts are negative, particularly concerning the number of small-scale firms and the number of labourers working in these enterprises.

3.5.2 Robustness tests

3.5.2.1 Omitted variable bias tests

I first explore the possibility of omitted variable bias through tests based on Altonji et al (2005) and Oster (2019). These tests utilise the selection on observable variables as a guide to assess potential biased caused by unobserved variables. The initial test involves systematically introducing additional control variables and observing the corresponding changes in coefficients and R-squared. The significant change in either coefficient or R-squared will be an indication of potential omitted variable bias. Additionally, I employ another test devised by Oster (2019), which measures the selection of unobservable variables relative to the selection on observable variables. This measure is denoted by δ and obtained from regressing an uncontrolled and a controlled regression on the outcome variables. The larger measure of δ (>1) indicates a lower likelihood of omitted variable bias.

Tables 3.5 and 3.6 report the outcomes of the first robustness tests by adding more control variables − geographical variable (column 2), socioeconomic variables (columns 3–4) and infrastructure status (columns 5–6) − for the number of small enterprises and number of labourers in them, respectively. Variable distance to the closest district's capital is used to proxy village development status. Generally, villages in proximity to a city are presumed to be more developed. The population variable is employed to account for the economic sizes, where larger populations are indicative of larger economic sizes. The main sources of household income represent the economic structure of each village, while irrigation and road type serve as proxies for infrastructure development at the village level, which may influence local economic activities.

Table 3. 5 Robustness test: gradually adding more control variables (small enterprises)

Dependent variable	**Number of small enterprises**					
	Second-stage					
	(1)	(2)	(3)	(4)	(5)	(6)
Oil production	-2.682** (1.289)	-2.705** (1.288)	-2.661** (1.173)	-2.588** (1.176)	-2.544** (1.167)	-2.392** (1.183)
Year of oil drilling dummy	Yes					
Sub-district dummy	Yes					
Control variables	Yes	Adding dist. to the closed district	Adding population	Adding main incomes sources	Adding irrigation	Adding road types
R-squared	0.5915	0.5920	0.6590	0.6606	0.6619	0.6787
N	1,188	1,188	1,163	1163	1163	1136
Dependent variable	Oil production					
	First-stage					
Oil discovery	0.149*** (0.029)	0.149*** (0.029)	0.152*** (0.029)	0.151*** (0.029)	0.152*** (0.029)	0.147*** (0.029)
First-stage F-statistics	25.50	25.49	26.59	26.28	26.58	24.85

Notes:
The dependent variable for all specifications is number of small enterprises. The main variable of interest is oil production. Control variables in the main model (column 1): distance to Batavia, topography, coastal indicator and river. The instrument for oil production l (all columns) is oil discovery. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

As depicted in Table 3.5, the results remain robust when adding each of the additional control variables. The values of β range from -2.392 (column 6) to -2.705 (column 2), showing relatively minor deviations from the main estimation model (column 1). Notably, the R-squared values exhibit minimal change with the introduction of additional control variables. The adverse effects of oil production persist and remain statistically significant at 5 per cent level for all variations (columns 2-6). Similarly, the impacts of oil production on the number of labourers in small enterprises, as reported in Table 3.6, demonstrate stability when additional control variables are considered. The magnitude of β varies from -3.581 (column 6) to -3.841 (column 5), with no substantial difference from its value in the main estimation model (column 1). Furthermore, the impacts remain consistent and statistically significant at 5 per cent level, for each additional control variable (columns 2-8).

Table 3. 6 Robustness test: gradually adding more control variables (labourers)

Dependent variable	**Number of labourers in small enterprises**					
	Second-stage					
	(1)	(2)	(3)	(4)	(5)	(6)
Oil production	-3.776** (1.689)	-3.805** (1.687)	-3.807** (1.555)	-3.761** (1.562)	-3.841** (1.557)	-3.581** (1.574)
Year of oil drilling dummy	Yes					
Sub-district dummy	Yes					
Control variables	Yes	Adding dist. to the closed district	Adding pop	Adding main incomes	Adding irrigation	Adding road types
R-squared	0.5681	0.5687	0.6304	0.6311	0.6324	0.6506
N	1,188	1,188	1,163	1163	1163	1136
Dependent variable	Oil production					
	First-stage					
Oil discovery	0.149*** (0.029)	0.149*** (0.029)	0.152*** (0.029)	0.151*** (0.029)	0.151*** (0.029)	0.147*** (0.029)
First-stage F-statistics	25.50	25.49	26.59	26.28	26.34	24.71

Notes:
The dependent variable for all specifications is number of labourers in small enterprises. The main variable of interest is oil production. Control variables in the main model (column 1): distance to Batavia, topography, coastal indicator, and river. The instrument for oil production (all columns) is oil discovery. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

Table 3.7 reports the results of Oster (2019) test, utilising the first stage of the IV estimation model. As shown in the table the values of δ are all positive (>1), ranging from approximately 1.1 to 2.4 (column 1). The results indicate that the main estimation results are robust to omitted variable bias. Following Oster (2019) by choosing R_{max}=1.3R (columns 2), I can conclude that the selection of unobserved variables has to be 1.1 times (column 1) as important as selection on the included control variables to fully explain the estimated effects for oil production.

Table 3. 7 Robustness test: using the selection of observable and unobservable variables

Dependent variable	**Oil production**	
	(1)	(2)
	δ	R_{max}
Oil discovery	2.426	$1.1R$
	1.497	$1.2R$
	1.083	$1.3R$
Year of oil drilling dummy	Yes	
Sub-district dummy	Yes	
Control variables	Yes	
N	1,188	

Notes:
The dependent variable is oil production. The main variable of interest is oil discovery. Control variables are the same as those used in the main model: distance to Batavia, topography, coastal indicator, and river.

3.5.2.2 Further robustness tests

Additional robustness checks, as detailed in the Appendix, have been conducted to affirm the stability of the estimation results. Table A3.6 shows the results of estimations by excluding villages in Jakarta, the capital of Indonesia, and in its neighbouring areas; that is, villages in Banten province and West Java province (columns 2 and 4). The exclusion of these villages does not significantly alter the results for both the impacts on number of small enterprises and the effects on number of labourers in small enterprises, respectively. Table A3.7 reports the results by excluding potential outliers; that is, villages with more than 100 oil wells (both production and discovery wells). The results demonstrate that the effects of oil production on the local economies remain relatively consistent.

Further robustness tests using number of small enterprise per capita and labourer per capita, and small enterprise density and labourer density in small enterprises, as shown in Table A3.8, reveal similar impacts. Although the magnitudes are smaller, the direction of the effects remain unchanged. The impacts are still relatively consistent when changing variable oil production from dummy variable to continuous variable; that is, number of oil production wells and ratio of oil production wells and total oil wells, as reported in Table A3.9. Moreover, the negative impact of oil production on both number of small enterprises and number of labourers remains unchanged when clustering standard errors at the village level (Table A3.10). The findings across diverse robustness checks strengthen the credibility and stability of the estimated impacts of oil production on local economic activity.

3.5.3 Extended analysis.

Table 3.8 presents the estimation results of the impacts of oil production on both number of small enterprises and number of labourers in sub-sectors of small enterprises.

Table 3. 8 Heterogeneity tests for small enterprises and labourers in sub-sectors

Dependent variable:	**Number of small enterprises**			**Number of labourers in small enterprises**		
	Manufacturing	**Services**	**Education**	**Manufacturing**	**Services**	**Education**
	Second-stage					
	(1)	(2)	(3)	(4)	(5)	(6)
Oil production	-0.219 (0.991)	-2.986** (1.340)	-3.482** (1.392)	-0.313 (1.322)	-4.087** (1.771)	-4.951** (1.914)
Year dummy	Yes					
Sub-district dummy	Yes					
Control variables	Yes					
R-squared	0.7245	0.5753	0.5268	0.7182	0.5564	0.5150
N	1,188	1,188	1,188	1,188	1,188	1,188
Dependent variable:	Oil production					
	First-stage					
Oil discovery	0.149*** (0.029)	0.149*** (0.029)	0.149*** (0.029)	0.149*** (0.029)	0.149*** (0.029)	0.149*** (0.029)
First-stage F-statistic	25.50	25.50	25.50	25.50	25.50	25.50

Notes:
The dependent variables are number of small enterprises − manufacturing sector (column 1), service sector (column 2) and education sector (columns 3) − and number of labourers in small enterprises: manufacturing sector (4), service sector (column 5) and education sector (column 6). The variable of interest is oil production. Control variables are the same as those used in the main model: distance to Batavia, topography, coastal indicator, and river. The instrument for oil production (all columns) is oil discovery. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

As shown in Table 3.8, oil production has significantly negative effects on number of small enterprises in both services (column 2) and education (column 3). However, there is no significant impact on the manufacturing sector (column 1). The impacts are also relatively similar for number of labourers in each sector, as reported in columns 4-6. The results provide evidence that oil production has heterogeneous effects. While oil production reduces the number of small enterprises and labourers in both services and education sectors, it does not significantly impact the manufacturing sector. Although the manufacturing sector is not significantly affected, the negative spillover impacts of oil production on the services and education sectors may indicate potential Dutch disease at the local level. Booming in the oil sector adversely affects other economic sectors, particularly in non-oil-related industries (Corden and Neary, 1982; Warr (1984); Krugman (1987). It is possible that entrepreneurs and workers are more inclined to participate in oil-related industries rather than in other fields, including services and education. The findings align with previous studies, such as those by, among others, Komarek (2016) on manufacturing sector, Edwards (2016) on services and Oyarzo and Paredes (2021) on education.

Table 3.9 shows the estimation results based on oil-producing region classifications: Major oil producing regions (Sumatera Island); Minor oil-producing regions (non-Sumatera Islands); and Outer Islands (all islands outside Java). Approximately 80 per cent and 95 per cent of oil-producing villages were located in Major oil-producing regions and Outer Islands, respectively. The results reveal that the significantly negative effects of oil production persist in the Major oil-producing regions (columns 1 and 3) and Outer Islands (columns 3 and 6). However, as shown in columns 2 and 5, the impacts disappear in the Minor oil-producing regions. Since most oil drilling activities in the Minor oil-producing regions were located in Java, it may be possible that the different results are driven by the influence of different institutional qualities between Java (more developed) and non-Java (less developed). These findings seem to support arguments presented in some previous studies, such as by Sala-i-Martin and Subramanian (2003) and Mehlum et al (2006), suggesting that institutions play a pivotal role in determining whether natural resource is a curse or a blessing. Local governments in the Major oil-producing regions and Outer islands may be less inclined to provide appropriate supportive policies for local economy compared to those in the Minor oil-producing regions.

Table 3. 9 Heterogeneity analysis by oil-producing regions

Dependent variable:	Number of small enterprises			Number of labourers in small enterprises		
	Major oil-producing regions	Minor oil-producing regions	Outer Islands (non-Java)	Major oil-producing regions	Minor oil-producing regions	Outer Islands (non-Java)
	Second stage					
	(1)	(2)	(3)	(4)	(5)	(6)
Oil production	-3.124** (1.470)	2.773 (2.163)	-2.810** (1.323)	-4.212** (1.919)	3.524 (2.792)	-3.971** (1.737)
Year of oil drilling dummy	Yes					
Sub-district dummy	Yes					
Control variables	Yes					
R-squared	0.5036	0.8400	0.5637	0.4894	0.8304	0.5418
N	790	398	1,052	790	232	1,052
Dependent variable	Oil production					
	First-stage					
Oil discovery	0.162*** (0.035)	0.145* (0.073)	0.155*** (0.030)	0.162*** (0.035)	0.145* (0.073)	0.155*** (.030)
First-stage F-statistic	21.64	3.92	25.62	21.64	3.92	25.62

Notes:
The dependent variables are number of small enterprises (columns: 1-3) and number of labourers in small enterprises (columns: 4-6). The main variable of interest is oil production. Control variables are the same as those used in the main model: distance to Batavia, topography, coastal indicator, and river. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

3.5.4 The impact of oil production on micro enterprises

Table 3.10 reveals the estimation results regarding the impacts of oil production on micro enterprises, specifically the number of micro enterprises and the number of labourers in them. According to the findings presented in the table (section I), there is no significant impact of oil production on the number of micro enterprises. This result remains unchanged regardless of the inclusion or exclusion of control variables. Similarly, the impacts of oil production on number of labourers engaged in micro enterprises are also statistically insignificant, as reported in section II of the table.

Table 3. 10 The impacts of oil production on micro enterprises

Dependent variable:	I. Number of micro enterprises				II. Number of labourers in micro enterprises			
	OLS		IV Second-stage		OLS		IV Second-stage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Oil production	0.173 (0.186)	0.232 (0.188)	0.427 (0.629)	0.402 (0.608)	0.134 (0.192)	0.186 (0.194)	0.543 (0.651)	0.514 (0.629)
Year of oil drilling dummy	Yes							
Sub-district dummy	Yes							
Control variables	No	Yes	No	Yes	No	Yes	No	Yes
R-squared	0.4072	0.4128	0.7214	0.7275	0.3764	0.3813	0.7055	0.7118
N	1,205	1,188	1,205	1,188	1,205	1,188	1,205	1,188
Dependent variable:			Oil production First-stage				Oil production First-stage	
Oil discovery			0.143*** (0.029)	0.149*** (0.029)			0.143*** (0.029)	0.149*** (0.029)
First-stage F-statistic			24.25	25.50			24.25	25.50

Notes:
The dependent variables are number of micro enterprises (columns: 1-4) and number of labourers in micro enterprises (columns: 5-8). The main variable of interest is oil production. Columns 1, 3, 5 and 7 are estimated without any control variable. Columns 2, 4, 6 and 8 are estimated with control variables: distance to Batavia, topography, coastal indicator, and river. The instrument for oil production used in IV model (columns: 3, 4, 7 and 8) is oil discovery. Standard errors are in parentheses.
*** indicates significance at 1 per cent.

3.5.5 Potential channels

Table 3.11 presents the estimation results exploring possible channels through which oil extraction negatively affects local economic activities, by using the same model used in the main estimation. It is assumed that local government in village with oil production will have more revenue from the oil sector and used it to support economic development, including small enterprises. However, the finding in column 3 suggests that local governments in villages with oil production are less inclined to provide support programs for local industries; that is, sales training program compared to those in villages with no oil production. Even though not statistically significant, oil production has also negative association with microcredit programs—KUR (column 1) and KUK (column 2)—and production training program (column

4). These results offer a potential explanation for why oil production has negative impacts on the local economic activities. They provide additional evidence that oil extraction may have an adverse effect on local institutions, subsequently leading to a deterioration of the local economy, as widely observed in previous studies (Aragon et al, 2015; Fleming et al, 2015). The results seem to suggest that the local governments in oil-producing villages may be less innovative in implementing appropriate supportive policies for local small industries and the labour force working in these industries.

Table 3. 11 Potential channels

Dependent variable	(1) Microcredit (KUR)	(2) Microcredit (KUK)	(3) Training (sales)	(4) Training (production)
Oil production	-0.219 (0.166)	-0.021 (0.146)	-0.178* (0.093)	-0.148 (0.130)
Year dummy	Yes			
Sub-district dummy	Yes			
Control variables	Yes			
Adj R-squared	0.6986	0.6952	0.6691	0.7230
N	1,186	1,186	1188	1188
Dependent variable	Oil production			
	First-stage			
Oil discovery	0.147*** (0.027)	0.151*** (0.029)	0.149*** (0.029)	0.149*** (0.029)
First-stage F-statistic	29.68	25.94	25.50	25.50

Notes:
The dependent variables are local government fund: KUR program (column 1) and KUK (column 2); training program: Sales (column 3) and production (column 4). Variable of interests are oil production. Control variables in all columns are the same as those used in the main model: distance to Batavia, topography, coastal indicator, and river. Standard errors are in parentheses.
***, * indicate significance at 1 per cent and 10 per cent, respectively.

3.6 Conclusion

This study has investigated the causal relationship between oil extraction and local economic activities at the village level in Indonesia, encompassing 1,205 villages across the nation. The data for the analysis covered oil drilling activities from 1900 to 2012, while local economic activities were measured for 2016. To discern the effects of oil extraction on local economies, I compare the effects of oil extraction on the local economies in the treatment group (villages with oil production) and the control group (villages with no oil production), conditional on oil well drilling. For the analysis, an IV estimation model is used, followed by applying various robustness tests to check the stability of the estimation results.

The primary findings of this study show that oil extraction exerts significantly negative impacts on local economic activities; that is, both number of small enterprises and number of labourers working in those small enterprises. This implies that villages with oil production exhibit a lower number of small enterprises and reduced workforce in small enterprises, compared to those with oil drilling but no oil production. Consequently, the results may indicate the presence of natural resource curse at the village level in Indonesia. This observation may also shed light on the nature of the oil extraction business itself. It should be emphasised that policies related to the oil extraction activities in Indonesia are predominantly formulated by the central government. Furthermore, there is no direct payment for the locals at the village level from oil rent. The findings also seem to indicate the lack of positive economic multiplier effects on the local industries, contradicting the results in a previous district-level empirical study by Cust and Rusli (2014). Moreover, the inverse relationship between oil production and the economy also happens in more specific industries − services and education sectors − while in the manufacturing sector there is no significant effect. The study also found that the negative effect of natural resource extraction is recorded in oil-rich regions, but there is no significant effect in oil-poor regions.

Another important revelation from the channel test is that local government capacity may affect the relationship between oil extraction and local economy. It influences the effects of oil extraction on the local economy. It seems that local governments in oil-producing villages are unable to provide strategic policies supporting local small businesses, compared to their counterparts in villages without oil production. This finding aligns with existing evidence suggesting that natural resource extraction may undermine local institutions' qualities, a phenomenon observed in cross-country and country-level studies. The influence of local institutions also provides an explanation for the divergent impacts of oil extraction in major oil-producing regions (negative) and in minor oil-producing regions (no effect). Therefore, a policy suggestion from the findings of this study is to improve both the quality of local government and the oil rent-sharing mechanism to support local citizens, including local business communities. This could involve modifying the rent-share mechanism generated from oil extraction that can contribute directly to the communities in oil-producing villages. Such a strategy is justifiable, as potential negative effects of oil extraction activities are more likely to affect local communities near the oil production site. This could be an alternative means to transform the impact of oil extraction on the local economy, turning it from a curse into a blessing.

Appendices

Table A3. 1 Examples of individual oil well information

WELL DETAIL - Well Name: ABAB-119 (production well)

Working Area	: EXT. AREAS, S. SUMATRA (OLD)	Status	: OIL PRODUCING
Type	: Not Set	Position	: ONSHORE
Field	: ABAB	SPUD Date	: 06/08/1981
Old Right Holder	: PT. STANVAC INDONESIA	Completion Date	: 19/08/1981
Elevation		Depth	
Derrick Floor	: 48 feet	Total Depth Driller	: 6114 feet
Ground Level Elevation	: 35 feet	Water Depth	: - feet
RKB Elevation	: 49 feet	Prognosed Depth	: - feet
Actual Depth	: 6114 feet	True Vertical Depth	: - feet
		Total Depth Logger	: 6111 feet
Location		Objective	
Latitude	: 3,10,34.46,S	Primary	: TALANG AKAR SANDS
Longitude	: 104,7,33.02,E	Secondary	: -

WELL DETAIL - Well Name: AIR SERDANG JOB-044 (discovery well)

Working Area	: OGAN KOMERING	Status	: Oil Abandoned
Type	: -	Position	: Onshore
Field	: AIR SERDANG JOB	SPUD Date	: 19/05/1998
Old Right Holder	: JOB PERTAMINA-TALISMAN (OGAN KOMERING)	Completion Date	: 01/06/1998
Elevation		Depth	
Derrick Floor	: - meter	Total Depth Driller	: 1577 meter
Ground Level Elevation	: 43.56 meter	Water Depth	: - meter
RKB Elevation	: 48.57 meter	Prognosed Depth	: - meter
Actual Depth	: 1577 meter	True Vertical Depth	: - meter
		Total Depth Logger	: - meter
Location		Objective	
Latitude	: 3,45,37.52,S	Primary	: -
Longitude	: 104,10,57.37,E	Secondary	: -

WELL DETAIL - Well Name: AIR SERDANG JOB-020 (non-production well)

Working Area	: OGAN KOMERING	Status	: Dry Hole
Type	: -	Position	: Onshore
Field	: AIR SERDANG JOB	SPUD Date	: 28/01/1996
Old Right Holder	: JOB PERTAMINA-TALISMAN (OGAN KOMERING)	Completion Date	: 28/02/1996
Elevation		Depth	
Derrick Floor	: - meter	Total Depth Driller	: 1658 meter
Ground Level Elevation	: 48.44 meter	Water Depth	: - meter
RKB Elevation	: 53.17 meter	Prognosed Depth	: 1678 meter
Actual Depth	: 1658 meter	True Vertical Depth	: - meter
		Total Depth Logger	: - meter
Location		Objective	
Latitude	: 3,50,55.1,S	Primary	: TALANG AKAR SAND
Longitude	: 104,19,57.3,E	Secondary	: -

Source: Author's calculation based on data from ministry of Energy, Indonesia.

Figure A3. 1 Geographical distribution of oil drilling activities in Indonesia (1900-2012)

Table A3. 2 Variables and data sources

Variables	Sources
Oil drilling activities (±7,600 onshore oil wells, from 1900 to 2012).	Ministry of Energy and Mineral Resources Republic of Indonesia.
Data of enterprises: Number of enterprises and the number of workers	The 2016 Indonesian Economic Census (Sensus Ekonomi 2016), Statistics Indonesia.
Geographic data: Topography River Coastal	The 2014 Village Potential Survey (Potensi Desa Survey – PODES)
Population	The 2010 Population Census (Sensus penduduk), Statistics Indonesia
Village size	Sub-district statistics (Kecamatan Dalam Angka 2016), Statistics Indonesia

Table A3. 3 Details of variables

Variables	Variable forms in the regression	Unit
Outcome variables		
No. of small enterprises	Log (0.01 + number of small enterprises)	Number of firms
No. labourers in small enterprises	Log (0.01 + number labourers in small enterprises)	Number of labourers
Small enterprise per capita	Log (0.01 + small firm per capita)	Number of firms/populations
Labourer per capita in small enterprises	Log (0.01 + labourer per capita in small firm)	Number of labourers/ populations
Small enterprise density	Log (0.01 + small firm density)	Number of firms/village's size
Labourer density in small enterprises	Log (0.01 + labourer density in small firm)	Number of labourers/village's size
No. of small enterprises–manufacturing.	Log (0.01 + small firm in manufacturing sector)	Number of firms
No. of small enterprises–services.	Log (0.01 + small firm in service sector)	Number of firms
No. of small enterprises–education	Log (0.01 + small firm in education sector)	Number of firms
No. of labourers in small enterprises–manufacturing	Log (0.01 + labourers in small firms (manufacturing)	Number of labourers
No. of labourers in small enterprises–services.	Log (0.01 + labourers in small firms (services)	Number of labourers
No. of labourers in small enterprises–education	Log (0.01 + labourers in small firms (education)	Number of labourers
No. of micro enterprises	Log (0.01 + micro firm)	Number of firms
No. labourers in micro enterprises	Log (0.01 + labourers in micro firm)	Number of labourers
Local fund for local industries	Whether there is a local fund or not	0,1
Sales skill training for local industries	Whether there is a sales skill training or not	0.1
Variable of interest		
Oil production	The presence of oil production well	0,1
Oil production well	Log (0.01 + number of oil production wells)	Number of oil wells
Oil production well ratio	Log (0.01 + (number of oil production wells per total oil wells * 100))	Percentage (%)
Main Control variables		
Distance1	Log (1/distance from village to Batavia/Jakarta, the capital of the Dutch East Indies/Indonesia)	km
Topography	Village topography	1-3
Coastal indicator	Whether the village is located on the seashore or not	0,1
River	Whether there is a river in the village or not	0,1
Additional control variables		
Distance2	Log (1/distance from village to the capital of closest district)	km
Population	Log population	Number of populations
Household income sources	Main income sources	1-7
Irrigation	Whether there is an irrigation in the village or not	0,1
Road	Road types in each village	1-4
Instrumental variables		
Oil discovery	The presence of oil discovery well	0,1

Notes:
Village topography: Hill=1; valley=2; flat=3. Main income sources of the most households in the village: Agricultures=1; Mining=2, Manufacturing=3, Trade and restaurant=4; Transport, logistics and communication=5; services=6; and others=7. Types of roads: asphalts roads=1; gravel roads=2; earthen roads=3; and others=4. Adding 0.01 to some variables helps avoid losing significant number of observations, as the values of some of these variables are zero.

Table A3. 4 Association between oil discovery and local economic activities

Dependent variable	**(1)** **Number of small enterprises**	**(2)** **Number of labourers in small enterprises**
Oil discovery	-0.013 (0.167)	-0.056 (0.213)
N	1,205	1,205
R-squared	0.0000	0.0001

Notes:
The dependent variables are number of small enterprises (column 1) and number of labourers in small enterprises (column 2). The variable of interest is oil discovery. Standard errors are in parentheses.

Table A3. 5 Exogeneity test of oil drilling, discovery, and production

Dependent variable	**(1)** **Oil drilling**	**(2)** **Oil discovery**	**(3)** **Oil production**
Ln_distance1	60.765 (80.565)	55.727 (56.375)	7.309 (22.500)
Topography	-0.960 (3.289)	0.251 (2.302)	0.083 (0.918)
Coastal	-5.547 (4.998)	-5.295 (3.497)	-.441 (1.395)
River	3.287 (2.583)	1.737 (1.807)	1.406* (0.721)
Year of oil drilling dummy		Yes	
Sub-district dummy		Yes	
Adj R-squared	0.4664	0.5158	0.2968
N	1,188	1,188	1,205

Notes:
The dependent variables are number of oil drilling (column 1), number of oil discovery wells (column2) and number of oil production wells (column 3). Variable of interests are distance to Batavia/Jakarta, topography, coastal indicator, and river. Standard errors are in parentheses.
* indicates significance at 10 per cent.

Table A3. 6 Robustness tests by excluding National Capital and its neighbours

Dependent variable:	No. of small enterprises		No. of Labourers in small enterprises	
	Second-stage			
	(1) (main model)	(2)	(3) (main model)	(4)
Oil production	-2.682** (1.289)	-2.612** (1.312)	-3.776** (1.689)	-3.736** (1.722)
Year dummy	Yes			
Sub-district dummy	Yes			
Control variables	Yes			
R-squared	0.5915	0.5868	0.5681	0.5639
N	1,188	1,135	1,188	1,135
Dependent variable	Oil production			
	First-stage			
Oil discovery	0.149*** (0.029)	0.150*** (0.030)	0.149*** (0.029)	0.150*** (0.030)
First-stage F-statistics	25.50	24.82	25.50	24.82

Notes:
The dependent variables are number of small enterprises (columns: 1-2) and number of labourers in small enterprises (columns: 3-4). Columns 2 and 4 exclude villages in the Capital of Indonesia and its neighbours. The main variable of interest is oil production. Control variables are the same as those used in the main model: distance to Batavia, topography, coastal indicator, and river. Instrument for oil production (all columns) is oil discovery. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

Table A3. 7 Further robustness tests by excluding outliers

Dependent variable:	Number of small enterprises		Number of labourers in small enterprises	
	Second-stage			
	(1) (main model)	(2)	(3) (main model)	(4)
Oil production	-2.682** (1.289)	-2.661** (1.285)	-3.776** (1.689)	-3.754** (1.684)
Year dummy	Yes			
Sub-district dummy	Yes			
Control variables	Yes			
R-squared	0.5915	0.5917	0.5681	0.5682
N	1,188	1,185	1,188	1,185
Dependent variable	Oil production: First-stage			
Oil discovery	0.149*** (0.029)	0.150*** (0.029)	0.149*** (0.029)	0.150*** (0.029)
First-stage F-statistics	25.50	25.70	25.50	25.70

Notes:
The dependent variables are number of enterprises (columns: 1-2) and number of labourers in small enterprises (columns: 3-4). Columns 2 and 4 exclude villages with more than 100 oil production wells or with more 100 oil discovery wells. The main variable of interest is oil production. Control variables are the same as those used in the main model: distance to the Batavia/Jakarta, topography, coastal indicator, and river. Instrument for oil production (all columns) is oil discovery. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

Table A3. 8 Further robustness tests using small enterprise and labourer per capita, and small enterprise and labourer density

Dependent variable:	Small enterprise per capita	Labourer per capita in small enterprises	Small enterprise density	Labourer density in small enterprises
	Second-stage			
	(1)	(2)	(3)	(4)
Oil production	-0.237** (0.117)	-1.007** (0.376)	-1.979** (0.814)	-3.025*** (1.159)
Year dummy	Yes			
Sub-district dummy	Yes			
Control variables	Yes			
R-squared	0.6230	0.5533	0.7145	0.6561
N	1,163	1,163	1,188	1,188
	Oil production			
Dependent variable	First-stage			
Oil discovery	0.152*** (0.029)	0.152*** (0.029)	0.149*** (0.029)	0.149*** (0.029)
First-stage F-statistics	26.63	26.63	25.50	25.50

Notes:
The dependent variables are small enterprise per capita (column 1), labourer per capita in small enterprises (column 2), small enterprise density (column 3) and labourer density in small enterprises (column 4). The main variable of interest is oil production. Control variables in all columns are the same as those used in the main model: distance to the Batavia/Jakarta, topography, coastal indicator, and river. Instrument for oil production in all columns is oil discovery. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

Table A3. 9 Further robustness tests using oil production intensity

Dependent variable:	No. small enterprises	No. of labourers in small enterprises	No. small enterprises	No. of labourers in small enterprises
	Second-stage			
	(1)	(2)	(3)	(4)
Ln_number of oil production wells	-0.519** (0.250)	-0.731** (0.328)		
Ln-oil production well per total oil wells			-0.334** (0.160)	-0.470** (0.209)
Year dummy	Yes			
Sub-district dummy	Yes			
Control variables	Yes			
R-squared	0.5886	0.5647	0.5934	0.5702
N	1,188	1,188	1188	1188
Dependent variable	Ln_number of oil production wells		Ln-oil production well per total oil wells	
	First-stage			
Oil discovery	0.773*** (0.157)	0.773*** (0.157)	1.203*** (0.226)	1.203*** (0.226)
First-stage F-statistics	24.07	24.07	28.17	28.17

Notes:
The dependent variables are number of small enterprises (columns 1 and 3) and number of labourers in small enterprises (columns 2 and 4). The main variable of interests are log number of oil production wells (columns 1 and 2) and log ratio of oil production wells and total oil wells (columns 3 and 4). Control variables in all columns are the same as those used in the main model: distance to the Batavia/Jakarta, topography, coastal indicator, and river. Instrument for oil production used in both columns is oil discovery. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

Table A3. 10 Further robustness tests by clustering standard errors at village level

Dependent variable:	**Number of small enterprises**		**Number of labourers in small enterprises**	
	Second-stage			
	(1) Main model	(2)	(3) Main model	(4)
Oil production	-2.682** (1.289)	-2.682* (1.416)	-3.776** (1.689)	-3.776** (1.859)
Year of oil drilling dummy	Yes			
Sub-district dummy	Yes			
Control variables	Yes			
Village cluster	No	Yes	No	Yes
R-squared	0.5915	0.5915	0.5681	0.5681
N	1,188	1,188	1,188	1,188
Dependent variable	Oil production			
	First-stage			
Oil discovery	0.149*** (0.029)	0.149*** (0.030)	0.149*** (0.029)	0.149*** (0.029)
First-stage F-statistic	25.50	24.10	25.50	24.10

Notes:
The dependent variables are number of small enterprises (columns: 1-2) and number of labourers in small enterprises (columns: 3-4). The main variable of interest is oil production. Control variables are the same as those used in the main model: distance to the Batavia/Jakarta, topography, coastal indicator, and river. Instrument for oil production used in all columns is oil discovery.
***, **, * indicate significance at 1 per cent, 5 per cent and 10 per cent, respectively.

Chapter 4

Is it a curse or blessing to have a resource-rich neighbour? the case of gas extraction in Indonesia

4.1 Introduction

Recent developments in empirical studies have shed light on the causal relationship between natural resources and economic development. First, the investigations of economic impacts of natural resource extraction have been carried out in more specific areas, and shifted from macro-level analysis, such as cross-country models pioneered by Sach and Warner (1995), to a micro-level approach. This local setting explores within country setting, reflecting a growing interest in assessing the local economic impacts of natural resource extraction. Second, researchers are increasingly utilising more disaggregated data to estimate the impacts of a specific type of natural resource, including mineral and energy resources. Black et al (2005) could be considered among the earliest studies in this setting, by using coal as a proxy of natural resources. Lastly, there is a growing emphasis on analysing spillover effects, also known as the indirect effects of natural resource extraction, encompassing both industrial and geographic spillovers.[26]

Previous empirical studies examining the economic spillover effects of natural resource extraction within a country have yielded mixed results. On one hand, there are studies indicating positive spillover effects, as demonstrated by Black et al (2005), Marchand (2012), Aragon and Rud (2013), Brown (2014), Fleming and Measham (2014) and Alcott and Keniston (2018). In

[26] Theoretical analysis of economic spillover of natural resource extraction was first provided by Corden and Neary (1982).

contrast, other studies, such as those by Cosgrove et al (2015), Fleming et al (2015), Muehlenbachs et al (2015) and Aragon and Rud (2016), document negative spillover effects. Meanwhile, certain studies, including those by Michaels (2011), Caselli and Michaels (2013) and Munasib and Rickman (2015), have found no spillover impacts.

In the context of Indonesia, only a limited number of empirical studies have investigated the causal effects of natural resources, particularly mineral and energy resources, on local economic development. Notably, within-country studies examining the causal impacts of these resources on the local economy have been conducted by Cust and Rusli (2014) and Hilmawan and Clark (2019). Both studies reveal positive impacts of natural resource extraction on district GDP per capita. Similar studies have also been conducted by Edwards (2016), Rusli and Vermeulen (2019) and Pelzl and Poelhekke (2021) particularly on the spillover effects of natural resource booms. Edwards (2016) finds negative spillover effects of coal boom on services and agricultural sectors, while Rusli and Vermeulen (2019) identify positive impacts of oil extraction on local revenue and public sector spending. Additionally, Pelzl and Poelhekke (2021) indicate significantly positive impacts of mining booms on earning per worker in the manufacturing sector, but only in areas where mineral extraction is labour-intensive. In contrast, in regions where mineral extraction is capital-intensive, the effects are not statistically significant. Additionally, they highlight that fiscal revenue sharing among local governments does not lead to economic spillover.

This study aims to provide additional empirical evidence regarding the causal relationship between a specific natural resource and the local economy, utilising disaggregated data. The focus is on examining the local impacts of the gas boom on district economies in Indonesia. Distinguishing itself from most prior studies in this field, this study specifically concentrates on the effects of gas boom on neighbouring economies. This setting capitalises on government intervention in re-distributing gas rent generated from gas extraction to sub-national levels of governments; that is, province and district-level governments. Through this resource revenue-sharing policy, all districts, including those that do not produce gas, that are located in the gas-producing provinces, receive a share of revenue from gas production.[27]

The distinctive feature of this study lies in the introduction of 'unnatural spillover effects' resulting from natural resource extraction. This type of spillover is instigated by institutional intervention, specifically through government policy on resource revenue sharing. It is different from natural spillover, which typically occurs through economic linkages influenced by local market supply and demand, as discussed in previous studies, such as those explored by Marchand (2012), Aragon and Rud (2013), Gradstein and Klemp (2020), Mejía (2020) and Pelzl and Poelhekke (2021). Instead, unnatural spillover in this case is measured by whether a non-gas-producing district receives a significant amount of gas windfall or not. The sites of gas extraction may be in their neighbouring districts or several districts within the same province, including offshore areas.

This study offers three key contributions. First, it provides additional evidence on the effects of a particular natural resource extraction – namely, gas – on the local economy. Notably, in the case of Indonesia, to the best of my knowledge, this is the first attempt to unveil economic effects of gas windfall at the district level. Second, this study uncovers the spillover effects of gas windfall on the neighbouring economies. This is achieved by comparing non-gas-producing districts that are located in rich-gas provinces and those that are situated in scarce-gas provinces. In this framework, non-gas-producing districts in rich-gas provinces receive a considerable amount of gas revenue, whereas those in poor-gas provinces collect a comparatively smaller share of this revenue. Lastly, the study provides further evidence of the spillover impacts of gas windfall on other socioeconomic indicators; that is, poverty rate,

[27] Detailed explanation of gas revenue sharing is in section 4.2.2.

number of people living below poverty line and household expenditure. These variables are widely recognised as indicators of local economic development.

The results reveal significantly negative effects of gas windfall on the economies of neighbouring districts. Non-gas-producing districts in rich-gas provinces which receive higher gas revenue have lower GDP per capita compared to those in poor-gas provinces with less gas revenue. This suggests that gas windfall facilitated through resource revenue-sharing possess a curse rather than a blessing for non-gas-producing districts around gas extraction sites. The evidence presented in this study contradicts or, at the very least, complements the findings of previous within-country studies in Indonesia, such as those performed by Cust and Rusli (2014), Edwards (2016), Hilmawan and Clark (2019), Rusli and Vermeulen (2019) and Pelzl and Poelhekke (2021). It is worth noting that these studies employed different proxies of natural resources, along with distinct setting and period of analysis, as explained earlier.

This study additionally contributes crucial evidence highlighting the heterogeneous effects of gas windfall across regions and periods. It has only significantly affected local economy in non-gas producing districts in Java, with no significant effects observed in non-Java areas. Furthermore, the study reveals that the immediate effect of this gas windfall on the local economy is not significant, but its negative influence becomes more pronounced in the long run. It is also found that gas windfall has negative effects on both poverty rate and number of people living below the poverty line in neighbouring districts.

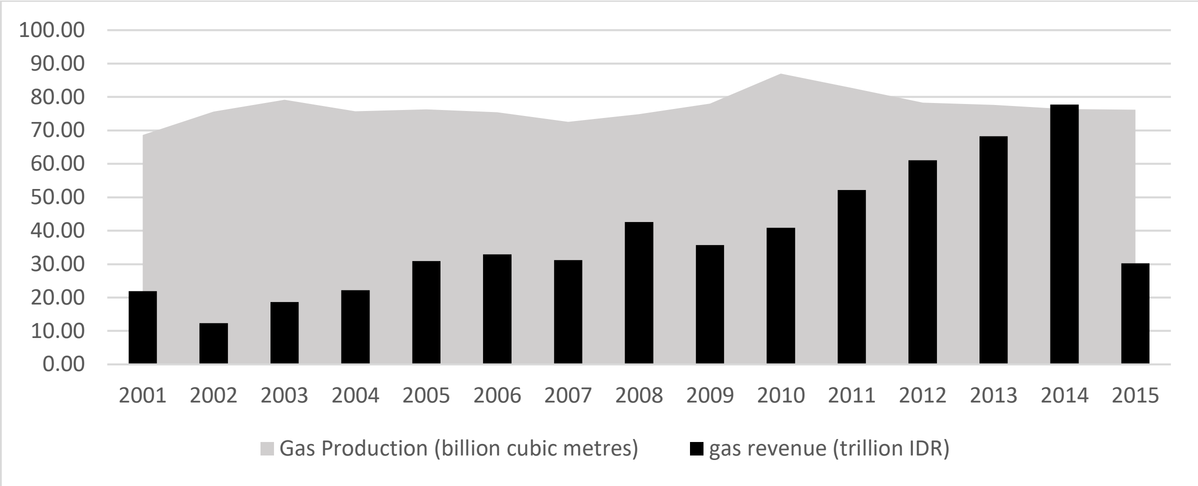
The rest of the study is organised into five sections, additional to the introduction. Section 4.2 describes a historical background of gas production in Indonesia, gas revenue-sharing policy, and literature review of the local economic spillover impacts of gas booms. Section 4.3 describes data and data sources, including variables used in the analysis. Section 4.4 explains the identification strategy of this study, such as its validity, parallel trend analysis and the estimation method. Section 4.5 explains the estimation results and discuss the findings, which include the results from main estimation, followed by robustness checks, heterogeneity analysis and additional tests using other outcome variables. The last section of this study is the conclusion, which presents a summary of the study.

4.2 Historical background

4.2.1 Gas extraction in Indonesia

Indonesia possesses a significant amount of gas resources, with proven reserves of 96.06 trillion cubic feet (TCF) in 2018, according to Ministry of Energy and Mineral Resources (2019). In addition, the country holds unconventional gas reserves in the forms of both coal bed methane (CBM), also known as coal seam gas (CSG), and shale gas. Indonesia ranks as the 6th largest CBM holder globally, with total resource endowments of approximately 453 TCF, while its shale gas resources were predicted to be even larger than CBM resources, at approximately 574 TCF (PwC, 2019). With these substantial gas resources, the country has a promising opportunity to continuously develop this sector and provide significant revenue source for the government in the future.

Gas extraction for commercial purposes in Indonesia commenced in the early 1970s, spurred by the discovery of large gas reserves in two key locations. The first discovery was the Arun Gas Field in North Aceh by Mobile Oil Indonesia in late 1971. The second significant discovery was the Badak Gas Field in East Kalimantan in early 1972 by Huffco Inc. Both companies operated under PSC with Pertamina, the Indonesian state oil company. Bolstered by these discoveries, Indonesia established two liquefied natural gas (LNG) plants in these locations and started exporting LNG in 1977. Subsequently, some other gas fields have also been discovered across the country, solidifying Indonesia's position as one of the leading global producers of gas and exporters of LNG. During the 1990s, the country supplied more than one-third of global LNG exports and had been the largest LNG exporter in the world before being overtaken by Qatar in 2006. Nevertheless, Indonesia has sustained its status as a major producer of both gas and LNG worldwide, ranking 12th and 7th, respectively in 2018 (BP Statistical Review of World Energy, 2022).



Source: Author's calculation based on the data of natural gas production from BP Statistical Review of World Energy 2022, and data of state revenue from Indonesia Government State Budget, Ministry of Finance, various years.

Figure 4. 1 Gas production and government revenue from gas, 2001-2015

The revenue from gas in Indonesia is derived from both export earnings and domestic sales, and it is strongly influenced by gas production level and its price. As illustrated in Figure 4.1, spanning the period from 2002 to 2015, the gas production level remained stable at approximately 77 billion cubic metres. However, gas revenue exhibited fluctuations primarily driven by changes in gas prices. During this period, gas contributed approximately 579 trillion Indonesian Rupiah (IDR) to the state revenue as non-tax revenue.[28] It should be noted that gas production in Indonesia has surpassed oil production since 2002. By 2018, gas production constituted 60 per cent of total oil and gas production with a projection indicating that it will reach nearly 90 per cent by 2050 (PwC, 2019). This trend reflects the growing significance of gas in Indonesia's energy landscape and its substantial contribution to the national economy.

[28] IDR: Indonesian Rupiah.

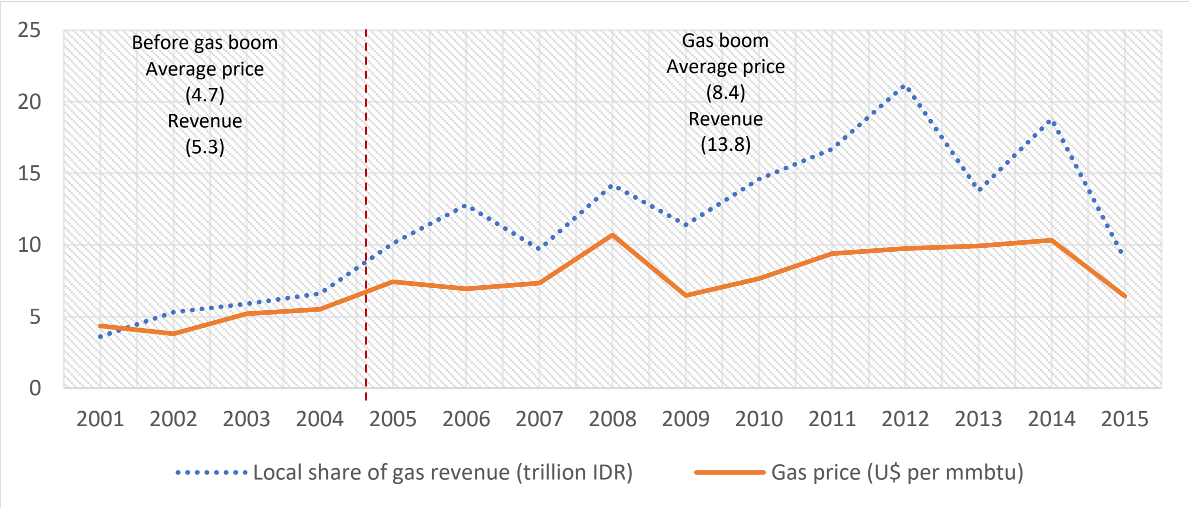
4.2.2 The Natural Resource Revenue Sharing Scheme (NRRSS) and local gas boom in Indonesia

Similar to oil, gas serves as a pivotal driver of economic development in Indonesia. Gas plays a crucial role as an energy source across various sectors, such as electricity, transportation, and households. Moreover, it is also used as feedstock for other industries, such as fertilizer and petrochemical industries. Additionally, gas functions as a substantial revenue source for the government, contributing significantly to both central government and local economies through the NRRSS. The revenue generated from gas contributed more than 10 per cent of total local government revenue in more than 20 districts during the period 2005-2015.[29]

The sharing of gas revenue between the central and sub-national governments (i.e., province and district governments) has been an integral part of the NRRSS implemented since 2001. This scheme is based on the Law Number 33/2004 on Financial Balance between the central government and regional governments, which superseded Law Number 25/1999. The NRRSS has been a fundamental component of political and economic reform since the Asian Financial Crisis in the late 1990s. In accordance with Article 14 of Law Number 33/2004, as shown in the Appendix, Table A4.1, the net revenue from gas extraction is distributed between the central government and local governments, with shares of 69.5 per cent and 30.5 per cent, respectively. It is noteworthy that there is another gas-revenue-sharing arrangement for special autonomy regions; that is, Aceh and West Papua. Under this arrangement, the central government receives 30 per cent of gas revenue, while the local governments' share is 70 per cent. This local share is divided among the province (46%), gas-producing districts/municipalities within the producing province (12%), and all non-producing districts/municipalities within the producing province (12%).

[29] Source: Author's calculation based on Ministry of Finance data.

As shown in Figure 4.2, local governments receive considerable amounts of gas revenue following the implementation of the NRRSS. The local share of gas revenue greatly increased, particularly during the local gas boom from 2005 to 2015. Before the boom period, during 2001-2004, the average gas revenue share for local governments was only around 5.3 trillion IDR per year. However, during the boom period, this figure significantly escalated to approximately 13.8 trillion IDR per year. The surge in local gas revenue was primarily driven by international gas prices, given that the gas production level remained stable throughout the study period, as displayed in Figure 4.1.



Source: Author's calculation based on the data of natural gas prices (i.e., the average gas price of Japan (CIF)) from BP Statistical Review of World Energy 2022, and data of district revenues from Indonesia Government State Budget, Ministry of Finance, various years.

Figure 4. 2 Gas prices and local gas boom in Indonesia

As implemented for other natural resources such as oil, general mining, forestry, fisheries and geothermal, gas sharing is integrated into intergovernmental transfer, offering additional funds for local governments. This financial mechanism aims to address fiscal imbalance either between the central government and local governments or among local governments themselves. It is particularly crucial for managing disparities between resource-rich and resource-poor regions. Local governments are granted the authority to administer these funds, utilising them to finance various programs and meet their local development objectives. These goals may include mitigating the negative impacts of natural resource extraction, improving standards of living, and fostering local economic development.

4.2.3 Review of local economic and spillover effects of gas boom

Gas, extracted from both conventional and unconventional gas reservoirs such as CBM or CSG, shale gas and tight gas, stands as a crucial economic asset in numerous countries. It is also regarded as a major revenue source for governments in many gas-producing nations. In comparison to other fossil fuels, especially coal and oil, gas is relatively cleaner and more environmentally friendly. This characteristic has led many countries to decide to prioritise the maximisation of gas utilisation as a key component of their transition strategies towards a low-carbon economy.

In line with the increasing use of gas, the study of its local impacts on socioeconomic development has witnessed notable growth. The findings of previous studies, however, have been mixed. The positive impacts of gas extraction can be found in some studies, such as its influence on regional income (Fleming et al, 2014; Mei et al, 2022), employment (Weber, 2012; Paredes et al, 2015; Mei et al, 2022), wages (Weber, 2012) and property prices (Boslett et al, 2016). On the contrary, other studies present contradictory evidence, suggesting that this resource extraction can have negative effects, including impacts on housing prices (Gopalakrishnan and Klaiber, 2014; Muehlenbachs et al, 2015; Balthrop and Hawley, 2017), or no significant impacts on various outcomes such as employment (Cosgrove et al, 2015; Paredes et al, 2015), wages (Cosgrove et al, 2015), income (Paredes et al, 2015), and housing prices (Mei et al, 2022). The complexity of these findings underscores the need for nuanced assessments that consider the specific context and variables at play in each study area.

It is important to note that research on the economic spillover effects of gas extraction remains limited, both in terms of economic sectors and geographical locations. For instance, Cosgrove et al (2015) discovers that shale gas extraction did not have statistically significant local effects on total employment and wages. However, it did have a significantly positive impact on employment and wages in the natural resource, mining, and construction sectors, while showing a negative effect on the manufacturing sector. Similarly, Komarek (2016) demonstrates that shale gas production had positive impacts on employment and wages in related sectors such as construction, transportation, trade and accommodation, without evidence of crowding out employment and increasing wages in the manufacturing sector. The investigations of economic spillover based on geographical distance are provided in some studies, such as those by Muehlenbachs et al (2015), Gopalakrishnan and Klaiber (2014) and Balthrop and Hawley (2017). These studies find a significantly negative spillover effect of gas extraction, particularly on housing prices in areas close to the gas well. However, the effects tended to fade in locations at a greater distance from the extraction site.

4.3 Data and sample description

This study is a within-country analysis that explores the impacts of gas windfall on the local economy near natural gas extraction sites at the district level in Indonesia. This study focuses on the district status in 2001 and encompasses 97 non-gas producing districts located in gas-producing provinces during the period 2002-2015. Throughout this study period, some of these districts were split and created new districts. In the analysis, these new districts were subsequently merged back into their original districts.

Data of oil and gas production were obtained from Ministry of Energy and Mineral Resources of Republic of Indonesia and the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas), while data of their prices are acquired from BP Statistical Review of World Energy. The data for the main outcome variables, district GDP, is sourced from Statistics Indonesia. I construct real district GDP per capita by dividing district GDP with population and use 2002 as the base year. Data of both foreign and domestic investments are from Ministry of Investment (The Investment Coordinating Board/BKPM). Socioeconomic and geographic data used in the estimation are obtained from either Statistics Indonesia or Indonesia Database for Policy and Economic Research (INDO-DAPOER), World Bank, and include: population; labour force; years of schooling; poverty rate; number of people below poverty rate; household expenditure; personnel expenditure (salaries and allowances), non-personnel expenditure (mostly on materials and capital), and latitude and longitude. Data of natural disasters are obtained from the National Agency for Disaster Countermeasure (BNPB). There are nine types of natural disasters reported by BNPB: floods, landslides, abrasion, extreme weather, droughts, forest fires, earthquakes and eruptions. Data of the general allocation fund is collected from Ministry of Finance. Distance from each district to Jakarta, the Capital of Indonesia, are calculated using their geographic coordinates. Missing data in some variables used in some additional tests are filled by applying extrapolation. The summary statistics of these variables are presented in Table 4.1, while the data sources and detail of each variable applied in the estimation is explained in Appendix, Table A4.2 and Table A4.3, respectively.

Table 4. 1 Summary statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Outcome variables					
District GDP per capita (billions IDR)	1,694	13.45	19.37	1.95	272.27
Poverty rate (0-100)	1,694	14.13	6.83	1.41	34.43
Number of people living below poverty line (number of people, in thousands)	1,694	114.68	109.06	5.63	627
Household per capita expenditure (thousands IDR)	1,694	2,839.02	3,692.52	307.45	25,023.4
Personnel expenditure (billions IDR)	1,624	463.717	374.15	14.88	3,044.72
Non-personnel expenditure (Billions IDR)	1,623	449.227	437.267	-350.751	5,780.437
Variable of interest					
Gas windfall (0,1)	1,694	0.16	0.37	0	1
Control variables					
Labour force (number of people, in thousands)	1,694	398.33	352.06	17.78	2,315.17
Years of schooling~~,~~ (number of years)	1,694	7.98	1.48	4.8	11.34
Foreign investment (million US$)	1,694	55.00	312.06	0	6,700
Domestic investment (billion IDR	1,694	191.92	757.38	0	9,800
Natural disaster (number of events)	1,694	4.44	8.42	0	118
Additional control variables					
Distance to Jakarta (km)	1,694	740.56	565.49	3.53	1,887.29
District split indicator (0,1)	1,694	0.22	0.41	0	1
Coastal indicator (0,1)	1,694	0.57	0.49	0	1
Oil production (million barrels oil)	1,694	5.25	9.89	0	74.02
General allocation fund (billions IDR)	1,625	522.05	367.71	76.99	2,987.56

Notes:
District GDP per capita is used in the main estimation, while other outcome variables are applied in the additional tests. The variable of interest is gas windfall: coded 1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise.

4.4 Identification strategy

4.4.1 Validity of the identification strategy

This study analyses the local economic spillover effects of natural resource extraction by exploiting within-country quasi-natural experimental conditions generated by gas endowments at the district level in Indonesia. The idea of this empirical strategy is close to those applied by Caselli and Michaels (2013) and Gradstein and Klemp (2020), both of which were applied at the municipality level in Brazil. The former study used oil and gas as the proxy of natural resources and the causal effect of their discovery is determined by the randomness of the outcome of oil and gas drilling. The latter study applied oil as the proxy of natural resources and the causal impacts of oil revenue dependent on the exogeneity of oil price in the international market.

Different from the two papers mentioned above, this study focuses on the impacts of gas production on the economies in neighbouring districts, specifically non-gas-producing districts located in gas-producing provinces. Although there is no gas production in their districts, they still get a share of gas windfall because their neighbours in the same province are engaged in gas production, as stipulated in the NRRSS, outlined in section 4.2.2 of this chapter. The causal effect of gas windfall in this study setting relies on the exogeneity of gas price as an external shock. These non-gas-producing districts cannot influence gas price since it is determined in the international market.

In this experimental design, non-gas-producing districts located in rich-gas provinces with high gas production levels in 2001 (above median) are classified as the treatment group, while those in poor-gas provinces with low gas production (below median) are categorised as the control group.[30] During the gas boom period, districts in the provinces with larger gas production received more revenue compared to those with lower production levels. This classification provides a quasi-experimental scenario for impact evaluation, and is widely applied in previous studies, including those conducted by Black et al (2005), Marchant (2012) and, more recently, by Gradstein and Klemp (2020).

It should be noted that all districts in both the treatment and control groups receive gas windfall since they are located in provinces that have gas production. These districts are located in major gas-producing provinces or, at least, in provinces that have larger gas production than oil production. All districts located in oil-rich provinces and oil-producing districts in gas-producing provinces are excluded from the estimation. In the main estimation, the sample

[30] The median of gas production in 2001 was 6.216 million barrels of oil equivalent (BOE).

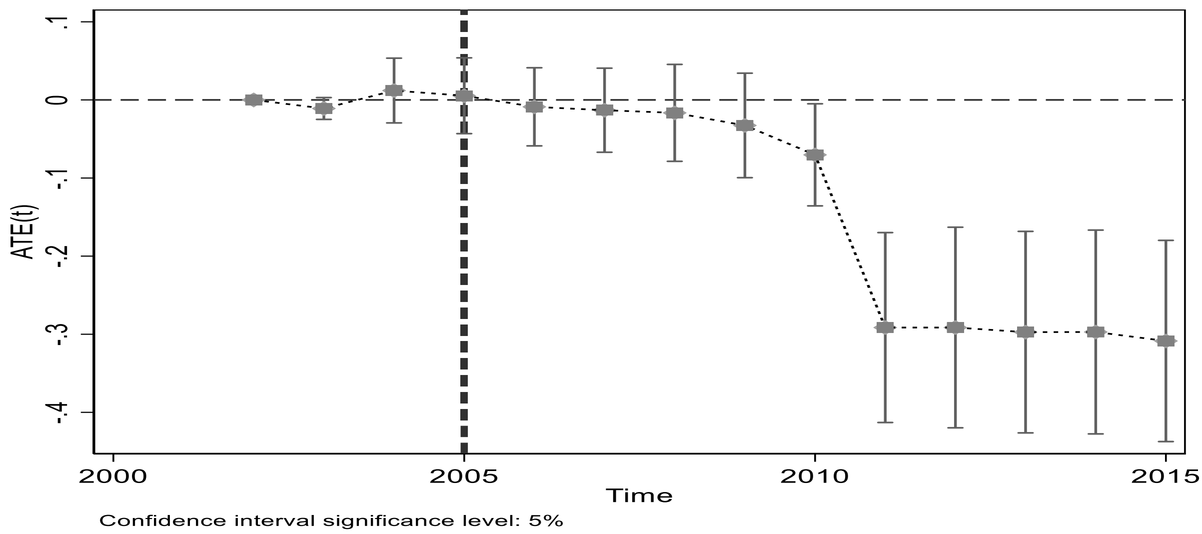
consists of 97 districts: 26 districts in the treatment group; and 71 districts in the comparison group.[31]

The validity of the identification strategy applied in this study relies on several key underlying assumptions. First, the exogeneity of gas prices, which influence the gas boom, is crucial. Gas prices are determined by the international market, making them exogeneous to the districts under study. Consequently, these districts cannot dictate the amount of gas windfall they will receive, as it depends on the gas revenue influences by gas prices. In addition, it is noteworthy that gas production sites are located outside their administrative areas. Second, for the identification strategy to be valid, districts in both the treatment and control groups should have experienced similar economic performances in the absence of the gas boom. The presence of pre-intervention trends could indicate a serious problem in the estimation, as it could be a sign of endogeneity.

4.4.2 Parallel trend assumption analysis

Figure 4.3 shows the average treatment effects before and during gas boom periods for the main estimation without applying any control variables. This parallel trend test is crucial for checking the validity of the estimation results using the difference-in-difference (DID) approach. It is evident that there is a significant change in the outcomes after treatment for the treated group in this setting. In addition to the parallel assumption test, it is proved that there is no anticipation effect. A similar pattern occurs when all control variables are included in the estimation, as displayed in the Appendix, Figure A4.3. The result, therefore, provides supporting evidence of causal impact of gas windfall on local economy in the districts near gas extraction sites.

[31] The classification of rich-gas producing provinces and scarce-gas producing provinces and the distribution of treatment and control groups are shown in Appendix, Figure A4.1.



Notes:
The result of parallel-trend test of the main estimation using estat ptrends in Stata: F (1, 120) = 0.03, and Prob > F = 0.8627; and the result of anticipation-effect test using estat granger: F (2, 120) = 2.08, and Prob > F = 0.1289.

Figure 4. 3 The average treatment effect before and during gas boom

4.4.3 Estimation model

I first apply a standard panel DID approach (1) to empirically assess the relationship between gas windfall and neighbours' economy. This estimation model is similar to the two-way fixed-effects method. Since there is a potential biased using this method due to dynamic and heterogeneous treatment effects, I then use the DID model proposed by de Chaisemartin and D'Haultfoeuille (2022), as shown in equation 2*,* to address those potential problems:

$$y_{it} = \beta Treat_{it} + \gamma X_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \qquad (1)$$

$$y_{it} = \alpha_i + \lambda_t + \sum_{e=-K}^{-2} \beta_1 Treat_{it} + \sum_{e=0}^{L} \beta_2 Treat_{it} + \gamma X_{it} + \varepsilon_{it} \qquad (2)$$

where y_{it} is the outcome variables representing local economy using GDP per capita of individual district *i* at year *t* (t=2002-2015). In the additional analyses, it is also applied for other socioeconomic variables that are generally used as the proxy of local economic development, such as poverty rate, number of people living below poverty line and household expenditure. $Treat_{it}$ is the variable of interest, representing the interaction between the postgas boom (equal to one [zero] for periods: 2005-2015 [2002-2004]) and district location dummy (equal to one [zero] if a district is located in rich-gas-producing provinces [in scarce-gas provinces]). K and L are positive constants representing periods before and after treatments, respectively. e=0 represents the first year of treatment, while e=-1 corresponds to the base year. X_{it} is a group of control variables: labour force, years of schooling, foreign investment, domestic investment and natural disaster. αi and λt are individual district fixed effects to absorb time-invariant district characteristics, and time fixed effects to absorb time-invariant heterogeneity across years, respectively, while εit is the random error term. The parameter of interest, β, captures the average effects of gas production on the district GDP per capita. In the regression, standard errors are clustered at the district level, considering the fact that the variation of gas windfall is at the district level.

A range of robustness tests are provided to address further potential threats to the validity of the estimation. First, by applying event study design to analyse the heterogeneous trend of gas windfall impacts in each year during the study period. Second, by using Sun and Abraham (2021) model to test whether the results are still robust to heterogeneous treatment effects or not with this approach. Lastly, by employing various additional tests to address other possible threats. One potential threat may arise from time-varying unobserved heterogeneity common to both treatment and control groups, which could impact the estimation results. To mitigate this, I control for time trend which could capture the volatility of gas windfall caused by the fluctuation of either gas production or its price. In addition, I apply the interaction of time trend and the distance of each district to Indonesia's capital (Jakarta), district split and coastal indicators. These interaction variables can capture various important factors that may influence the estimation results, such as geographic and socioeconomic conditions.

Further robustness tests are applied: (i) examining potential influence of oil windfall on the findings by controlling for oil production. Even though, all districts in rich-oil provinces and oil-producing districts are already excluded in the estimation, I still check their influences on their neighbours; (ii) assessing potential effects of other types of funds from the central government, specifically general allocation fund (DAU–Dana Alokasi Umum). To address this possible threat, I control for this fund, as it represents approximately 69 per cent of the total balance fund during this study period, as shown in Appendix, Figure A4.3. This fund can also capture potential influences of other natural resource revenues because districts with high revenue from natural resources will receive smaller DAU, compared to those with lower revenue from natural resources; (iii) checking potential effect of transforming covariates into log-form by applying non-log forms of control variables. In the main estimation, all covariates are transformed into log-forms to normalise their skewed distributions; and (iv) testing potential influence of non-revenue spillover effects. For this threat, I dropped all adjacent districts, those that share the same border with gas-producing districts. The reason for this is that, as explained in the previous section, the economic spillover effects generally fade with distance.

For an extended analysis, some additional tests are provided in this chapter. First, heterogeneity tests by dividing the dataset into: (i) regions, specifically Java and Outer Islands); and (ii) study periods, distinguished between short-term (2002-2009) and long-term (2002-2015), which corresponds to the main estimation. Second, additional tests by using other outcome variables; that is, poverty rate, number of people living below poverty line and household expenditure. These variables are widely used in the analysis of socioeconomic impacts of resource extraction on local economy.

4.5 Estimation results

4.5.1 Main results

Table 4.2 presents the results of the estimation using the standard panel DID method. The estimation results without any control variables are shown in column 1, with full control variables displayed in columns 2 and 3. The last column (3) shows the estimation results of clustering standard errors at the district level.

Table 4. 2 Early estimation: the impacts of gas windfall on district GDP per capita

Dependent variable	**Log District GDP per Capita**		
Model	(1)	(2)	(3)
Gas windfall	-0.139*** (0.020)	-0.129*** (0.019)	-0.129*** (0.035)
Year FE	Yes		
District FE	Yes		
Control variables	No	Yes	
Standard errors are clustered at the district level	No		Yes
R-squared: overall	0.2655	0.4510	0.4510
No. of observations	1,694	1,694	1,694
No. of districts	121		
Period	2002-2015		

Notes:
The dependent variable is log-district GDP per capita. The variable of interest is gas windfall: coded 1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise. Control variables are log-labour force, log-years of schooling, log-foreign investment, log-domestic investment, and log-number of natural disasters. Standard errors are in parentheses.
*** indicates significance at 1 per cent.

All estimations as presented in Table 4.2 yield similar results. Gas windfall has a significantly negative effect on district GDP per capita, and as displayed in all columns (1-3), these effects are statistically significant at 1 per cent level. The impact without any control variables (column 1: $\beta=-0.139$) is slightly higher than that for full control variables (column 2: $\beta=-0.129$). Importantly, the effect of gas windfall remains statistically significant at 1 per cent level when standard errors are clustered at the district level (column 3). A potential problem that may arise from using this regression method is that the results might not be robust to heterogeneous treatment effect (de Chaisemartin and D’Haultfoeuille, 2022). This threat can determine the validity of the estimation results. To address this concern, I then apply the DID model proposed by de Chaisemartin and D’Haultfoeuille (2022) for the main estimation, and the results are presented in Table 4.3.

Table 4. 3 Main estimation: the impacts of gas windfall on district GDP per capita

Dependent variable	**Log District GDP per Capita**	
Gas windfall	Point estimate	Standard errors (SE)
Model		
Placebo_Year-2	-0.002	0.020
Placebo_Year-1	-0.017	0.020
Effect_Year-0	-0.006	0.012
Effect_Year+1	-0.018	0.014
Effect_Year+2	-0.028	0.017
Effect_Year+3	-0.032	0.022
Effect_Year+4	-0.048	0.025
Effect_Year+5	-0.068**	0.029
Effect_Year+6	-0.273***	0.059
Effect_Year+7	-0.271***	0.062
Effect_Year+8	-0.276***	0.062
Effect_Year+9	-0.281***	0.063
Effect_Year+10	-0.292***	0.061
Average effect	-0.145***	0.034
Control variables	Yes	
Standard errors are clustered at the district level	Yes	
No. of observations	1694	
No. of districts	121	

Notes:
The dependent variable is log-district GDP per capita. The variable of interest is gas windfall: coded 1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise. Control variables are log-labour force, log-years of schooling, log-foreign investment, log-domestic investment, and log-number of natural disasters. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

It is noteworthy that gas windfall shows no significant effects on district GDP per capita before and in the early years of the gas boom. However, it begins to exhibit significantly negative impacts around five years after the gas boom started. The average effect of this windfall is –0.145, which is higher than that in the two-way fixed effects and is considered the main finding of this study. Unlike the two-way fixed effects, the results from this estimation method are robust to heterogeneous treatment effect.[32] As for the two-way fixed effects, the parallel trend assumption in this setting is also satisfied since all pre-trends are jointly insignificant. Therefore, it can be concluded that gas production reduces district GDP per capita

[32] Further test using twowayfeweight (de Chaisemartin et al, 2019) proved that no-sign reversal property is satisfied since all β coefficients receive positive weights.

in the neighbours of gas-producing districts. District GDP per capita in non-gas-producing districts located in rich-gas provinces is lower compared to those in poor-gas provinces (i.e., 13.5 per cent lower).

This finding provides evidence of the presence of resource curse at the local context, particularly at the district level in Indonesia. It reveals that natural resource extraction has heterogeneity effects on the local economy, particularly in the case of Indonesia. As explained in the previous section, natural resources have a positive impact on the local economy where the resources are extracted, as found in previous studies, such as those presented by Cust and Rusli (2014), Edwards (2016) and Hilmawan and Clark (2019). However, the effect on the neighbouring economies, as found in this study, is negative. The finding also contradicts the result of a previous study conducted by Pelzl and Poelhekke (2021) that suggested there is no spillover effect of natural resource revenue sharing. The heterogeneity effects of natural resource extraction are not unique to Indonesia but are also observed in other countries, as discussed in section 4.2.3 of this chapter. The findings also reveal that natural resource extraction can have negative spillover effects, not only through natural spillover transmitted via local supply and demand mechanisms, as analysed in previous studies, including those by Fleming et al (2015), Muehlenbachs et al (2015) and Aragon and Rud (2016), but also through 'unnatural spillover' resulting from institutional interventions.

4.5.2 Robustness tests

4.5.2.1 Applying different estimation methods

The negative effects of gas windfall on the local economy are further tested by using event study design as illustrated in Table 4.4 (column 1). A similar result (column 2) is obtained by applying the model proposed by Sun and Abraham (2021). This provides evidence that the estimation results in the main estimation are robust to heterogeneous treatment effect using different methods. The average effect of gas windfall on the local economy obtained from these two models is relatively smaller compared to that in the main estimation, but larger than the coefficient from the two-way fixed effects. However, all are statistically significant at 1 per cent level. It is also proved that the causal relationship is supported by the fact that all pre-trends in both models are jointly insignificant. As shown in the table, gas windfall has heterogeneous effects across periods. There are no significant impacts in the early periods of the gas boom, but significant effects start after four years (column 1) or five years (column 2), and the effect becomes stronger in the later periods (statistically significant at 1 per cent level).

Table 4. 4 Robustness test: applying event study and Sun and Abraham (2021) Model

Dependent variable	**Log District GDP per Capita**			
Model	(1) Event study design		(2) Sun and Abraham (2021) Model	
Gas windfall	Point estimate	Robust SE	Point estimate	Robust SE
Year-3	-0.005	0.021	-0.002	0.026
Year-2	-0.015	0.022	-0.013	0.025
Year 0	0.002	0.012	0	
Year+1	-0.007	0.014	-0.004	0.008
Year+2	-0.022	0.018	-0.019	0.011
Year+3	-0.025	0.021	-0.022	0.014
Year+4	-0.041	0.024	-0.038**	0.017
Year+5	-0.061**	0.030	-0.058**	0.025
Year+6	-0.273***	0.056	-0.270***	0.052
Year+7	-0.260***	0.060	-0.257***	0.055
Year+8	-0.270***	0.060	-0.267***	0.055
Year+9	-0.270***	0.060	-0.267***	0.055
Year+10	-0.279***	0.059	-0.276***	0.054
Average effect	-0.137***	0.033	-0.139***	0.020
Year FE	Yes			
District FE	Yes			
Control variables	Yes			
Standard errors are clustered at the district level	Yes			
No. of observations	1694			
No. of clusters	121			

Notes:
The dependent variable is log-district GDP per capita. The main variable of interest is gas windfall: coded 1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise. Control variables are log-labour force, log-years of schooling, log-foreign investment, log-domestic investment, and log-natural disaster.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

4.5.2.2 Further robustness tests

Table 4.5 presents the results of additional robustness checks (columns 1-7): controlling for time trend (column 1); controlling for time trend and its interaction with the distance to Jakarta (column 2); controlling for interaction of time trend and coastal indicator (column 3); controlling for interaction of time trend and district split indicator (column 4); controlling for oil production (column 5); applying non-log form of all covariates (column 6); and controlling for general allocation fund (column 7).

Table 4. 5 Further robustness tests

Dependent variable	**Log District GDP per Capita**						
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Gas windfall (Average effects)	-0.145*** (.034)	-0.145*** (.034)	-0.145*** (0.34)	-0.145*** (0.34)	-0.135*** (0.34)	-0.144*** (0.34)	-0.138*** (0.35)
Year FE	Yes						
District FE	Yes						
Control variables	Yes						
Standard errors are clustered at the district level	Yes						
No. of observations	1694						1625
No. of cluster	121						117
Period	2002-2015						

Notes:
The dependent variable is log-district GDP per capita. The main variable of interest is gas windfall: coded 1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise. Control variables are log-labour force, log-years of schooling, log-foreign investment, log-domestic investment, and log-natural disaster. Standard errors are in parentheses.
*** indicates significance at 1 per cent.

The results from the tests in columns 1-7 are compared to the main estimation result, as displayed in Table 4.3, to assess whether there is a significant change. Notably, the results remain relatively stable, and the magnitudes of the β coefficients (-0.135 to -0.145) are close to the value in the main estimation (β=-0.145). Furthermore, the effects are statistically significant at 1 per cent level for all estimations. These findings provide strong support for the negative impact of natural resource extraction on neighbouring economies, as identified in the main estimation.

4.5.3 Extended analysis

4.5.3.1 Heterogeneity tests

Table 4.6 presents the results of the heterogeneity tests conducted using sub-samples of data. First, by regions: Java Island (column 2) and non-Java Islands, also known as the Outer Islands (column 3). Second, by periods: short term, 2002-2009 (column 4); and long term, 2002-2015 (column 1).

Table 4. 6 Heterogeneity tests by location and period

Dependent variable	**Log District GDP per Capita**			
Model	(1) Main estimation	(2) Java	(3) Non-Java	(4) Short term effect
Gas windfall (Average effect)	-0.145*** (.034)	-0.202*** (0.035)	-0.065 (0.094)	-0.026 (0.016)
Year FE	Yes			
District FE	Yes			
Control variables	Yes			
Standard errors are clustered at the district level	Yes			
No. of observations	1694	784	910	968
No. of districts	121	56	65	95
Periods	2002-2015			2002-2009

Notes:
The dependent variable is log-district GDP per capita. The main variable of interest is gas windfall: coded 1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise. Control variables are log-labour force, log-years of schooling, log-foreign investment, log-domestic investment, and log-natural disaster. Standard errors are in parentheses.
*** indicates significance at 1 per cent.

As indicated in the table above, gas windfall has significantly negative effects only in Java region (column 2), whereas in non-Java islands (column 3) the effect is not statistically significant. It is noteworthy that districts in Java region are generally more developed and have larger populations compared to those in non-Java regions. Heterogeneity effects of gas windfall are also observed across different periods. The adverse impacts of the gas windfall become evident several years after the onset of the gas boom. Notably, there is no immediate effect, particularly in the first five years of the gas boom (column 4). The negative effect of gas windfall become more pronounced in the long-term, as shown in the main estimation (column 1).

4.5.3.2 Applying other outcome variables

Table 4.7 displays the estimation results of the additional tests, to further analyse the local effects of gas windfall on socioeconomic outcomes in the neighbouring economies. This analysis examines three variables: the poverty rate, the number of people living below poverty line, and household spending.[33] The inclusion of the number of people living below poverty line is also important. It may be the case that the changes in the poverty rate are influenced by population dynamics rather than the actual number of individuals living below poverty line.

Table 4. 7 The effects of gas windfall on household spending and social outcomes

Dependent variable	**(1) Poverty Rate**	**(2) Number of people below poverty line**	**(3) Household expenditure**
Gas windfall	0.158** (0.064)	0.232*** (0.065)	-0.017 (0.040)
Year FE	Yes		
District FE	Yes		
Control variables	Yes		
Standard errors are clustered at the district level	Yes		
No. of observations	1694	1694	1694
No. of districts	121	121	121
Period		2002-2015	

Notes:
The main variable of interest is gas windfall: coded 1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise. Control variables are the same as those used in the main estimation: log-labour force, log-years of schooling, log-foreign investment, log-domestic investment, and log-natural disaster. Standard errors are in parentheses.
***, ** indicate significance at 1 per cent and 5 per cent, respectively.

As shown in the table above, gas windfall has significantly positive effects on both poverty rate (column 1) and number of people living below poverty line (column 2). The results imply that non-gas producing districts in rich-gas provinces that receive substantial gas windfall

[33] Poverty rate is the ratio of the number of people whose income falls below the poverty line

are associated with higher poverty rates and larger numbers of people living below poverty line compared to those located in scarce-gas provinces with less gas revenue. Additionally, it is observed that an increase in local government revenue due to the gas boom does not influence household spending (column 3). These findings seem to suggest that local governments in non-gas producing districts in rich-gas provinces may not have effectively utilised the additional funds to improve local economic and social conditions.

4.5.3.3 Revenue spillover effects

I conduct a more in-depth investigation to check whether the effect of gas windfall on neighbouring economies is genuinely attributable to economic spillover resulting from government intervention, specifically through the gas revenue-sharing, rather than natural spillover effects dictated by the market. I estimate by excluding all adjacent districts; that is, all districts that share the same border with gas-producing districts. The results are presented in Table 4.8.

Table 4. 8 The effect of gas windfall through revenue spillover effects

Dependent variable	**Log District GDP per Capita**	**Personnel expenditure**	**Non-personnel expenditure**
Model	(1) Non-adjacent districts	(2) All districts	(3) All districts
Gas windfall (Average effects)	-0.157** (0.034)	0.019 (0.031)	-0.329 (0.39)
Year FE	Yes		
District FE	Yes		
Control variables	Yes		
Standard errors are clustered at the district level	Yes		
No. of observations	1246	1694	1694
No. of districts	89	121	121
Period	2002-2015		

Notes:
The main variable of interest is gas windfall: coded 1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise. Control variables are the same as those used in the main estimation: log-labour force, log-years of schooling, log-foreign investment, log-domestic investment, and log-natural disaster. Standard errors are in parentheses.
** indicates significance at 5 per cent.

As shown in Table 4.8 (column 1), the significantly negative effect of gas windfall remains. Even though the estimated coefficient is slightly increase, the result suggests that the spillover effect of gas extraction on neighbouring economies through gas revenue has indeed occurred in this context. It is possible that other factors, such as labour migration, may influence the spillover effects (Beine et al, 2015; Pelzl and Poelhekke, 2021). Due to data limitations, I do not test the potential spillover effects associated with this variable. However, as highlighted by Pelzl and Poelhekke (2021) in their examination of mining extraction in Indonesia, non-revenue spillover from highly specialised and capital-intensive natural resource extraction, such as gas, tends to be minimal. This phenomenon is attributed to the limited potential of labour shifting, as workers in the gas extraction sector are not easily replaceable by those from other sectors. Furthermore, the majority of gas production sites are located offshore, implying a lower level of interconnectedness with other local economic sectors.

I also test the effect of gas windfall on local government spending, specifically focusing on both the share of personnel spending and non-personnel spending. As presented in table above, although the results do not reach statistical significance, there is a positive correlation between gas windfall and personnel spending (column 2), and a negative relationship with non-personnel spending (column 3). The findings seem to suggest that additional funds from the gas windfall are primarily used for paying salaries and allowances, rather than for supporting economic development or addressing social problems, such as poverty rate and number of people living below poverty line. It is important to note that the findings reveal that revenue windfall has a negative association with public spending in the neighbouring districts, which contrast with the impact observed in resource-producing districts, as found in Rusli and Vermeulen (2019). Similar evidence was found in a study by Caselli and Michaels (2013), which examined the case of Brazil and found that revenue from oil-related sources did not lead to improved public service provision and household income. They also highlighted that corruption and embezzlement might contribute to this situation. While further tests are necessary in the case of Indonesia, their findings could help explain why non-gas producing districts in affluent gas provinces have lower economic performance compared to those in poor-gas provinces.

4.6 Conclusion

This study has assessed the economic spillover impacts of natural resource extraction on neighbouring areas. The spillover effects in this setting are caused by government intervention through the Natural Resource Revenue Sharing Scheme. It focused on gas extraction at the district level in Indonesia during the period 2002-2015, covering all non-gas producing districts that are located in gas-producing provinces. Despite the absence of gas production in these districts, they still receive a share of gas revenue due to their locations in a gas-producing province, as stipulated in the government policy. The analysis employs a panel difference-in-differences method, comparing non-gas producing districts located in rich-gas provinces as the treatment group with non-gas producing districts in scares-gas provinces as the control group. This framework leverages the context of a local gas boom, distinguishing between periods before the gas boom (2002-2004) and during the gas boom (2005-2015), influenced by international gas prices.

The findings reveal negative spillover effects of gas extraction on neighbouring economies. Districts located in rich-gas provinces, while benefiting from a substantial amount of revenue from gas windfall, experienced approximately a 12 per cent lower district GDP per capita compared to those in poor-gas provinces with less gas revenue. These findings suggest that having rich-gas neighbours may be more of a curse than a blessing. Furthermore, the study identifies the heterogeneity effect of gas windfall across regions. This only significantly affected the local economy in non-gas producing districts in Java and not in the non-Java region. Moreover, the study also highlights the heterogeneity in the impacts of gas extraction across periods, indicating that local economic effects of gas windfall occur in the long-term rather than the short-term. Other important findings indicate that gas windfall has a significantly positive effect on either poverty rate or number of people living below poverty line, but it does not have a significant effect on household expenditure.

The findings seem to reveal that local governments in non-gas producing districts, despite receiving significant revenue from gas windfall, may struggle to translate this additional income into better socioeconomic conditions. The findings also seem to suggest a need for re-evaluation of the gas revenue-sharing scheme, particularly for non-gas producing districts located in gas-producing provinces. This review could aim to enhance better support for local economies in these specific areas, addressing potential socioeconomic challenges arising from the gas boom.

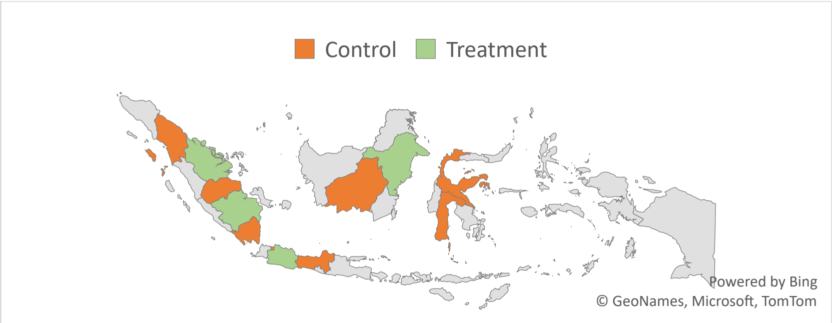
Appendices

Table A4. 1 Natural gas revenue-sharing scheme

Gas production sites	**Gas revenue share**			
	Central Government	Province	Producing district/municipality	Non-producing district/municipality in the same province
District/municipality (Onshore and offshore, distance from the coastline: <4 miles)	69.50%	6.10%	12.20%	12.20%
Province (Offshore, distance from the coastline: 4-12 miles)	69.50%	10.17%	0	20.33%
Central Government (Offshore, distance from the coastline: > 12 miles	100%	0	0	0

Notes:
Aceh and West Papua provinces as the special autonomy regions, have different arrangement of natural resource sharing, including natural gas, and therefore, districts in these provinces are excluded in the estimation.

Source: Article 14 of Law no.33/2004, and articles 23 and 24 of Government Ordinance no. 55/2005



Sample	**Number of districts**	**Definition**
Full sample	121	All non-gas-producing districts in gas-producing provinces
Treatment group (Above median)	26	All non-gas-producing districts in rich-gas-producing provinces (Riau islands, South Sumatera, West Java, and East Kalimantan)
Control group (Below median)	95	All non-gas-producing districts in scarce-gas-producing provinces (North Sumatera, Jambi, Lampung, Central Java, North Kalimantan, central Kalimantan, South Sulawesi and Central Sulawesi)

Notes:
Oil-rich provinces (Riau and East Java), and all oil and gas producing districts in gas-producing provinces are excluded.

Source: Author's calculation based on Ministry of Energy and Mineral Resources of Republic of Indonesia data

Figure A4. 1 Classification of treatment and control groups

Table A4. 2 Variables and data sources

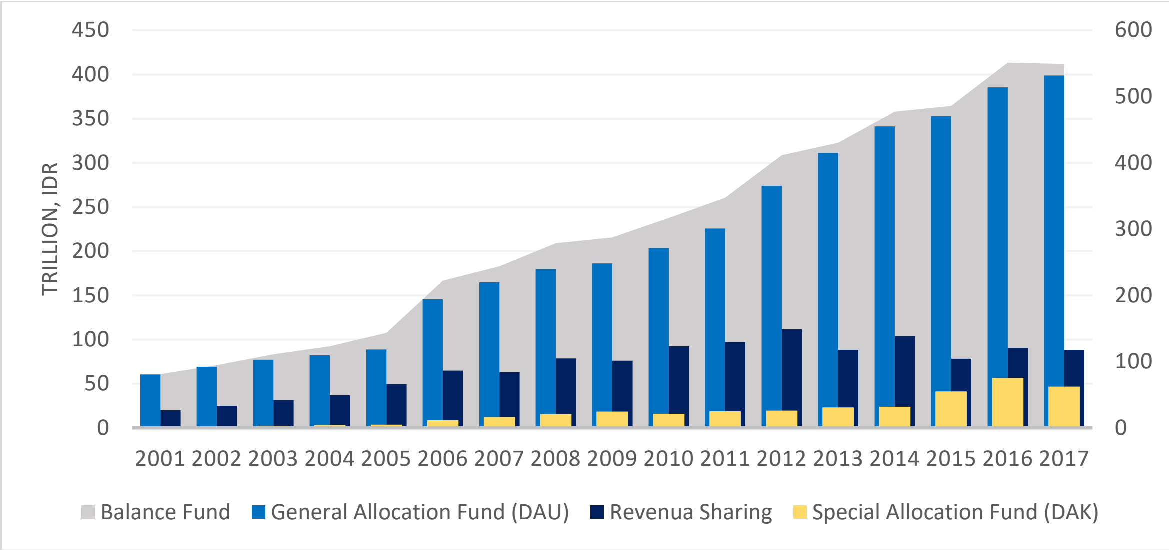
Variables	Data sources
Oil and gas production	Ministry of Energy and Mineral Resources of Republic of Indonesia; and The Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas).
Oil and gas prices	BP Statistical Review of World Energy
District GDP	Statistics Indonesia
Foreign and domestic investments	Ministry of Investment (The Investment Coordinating Board/BKPM)
Socio-economic and geographic data: Population; labour force; years of schooling; poverty rate; number of people below poverty rate; household expenditure; personnel expenditure and non-personnel expenditure; and latitude and longitude.	Statistics Indonesia; and Indonesia Database for Policy and Economic Research (INDO-DAPOER), World Bank
Natural disasters	The National Agency for Disaster Countermeasure (BNPB)
General allocation fund	Ministry of Finance

Table A4. 3 Details of variables

Variables	**Variable forms in the regression**
Dependent variables	
District GDP per capita	Log (District GD per capita)
Poverty rate	Log (poverty rate)
Number of people living below poverty line	Log (Number of people living below poverty line)
Household expenditure	Log (Household expenditure)
Variable of interest	
Gas windfall	1 if a non-gas-producing district is located in a rich-gas province during the local gas boom period, and 0 otherwise
Control variables	
Labour force	Log (Labour force)
Years of schooling	Log (Years of schooling)
Foreign investment	Log (0.001 + Foreign investment)
Domestic investment	Log (0.001 +Domestic investment)
Natural disaster	Log (0.001 + natural disaster)
Additional control variables	
Distance to Jakarta	Log (time trend*(1/distance to Jakarta))
District split indicator	Log (0.001 + (time trend*district split))
Coastal indicators	Log (0,001 + (time trend*coastal split)
General allocation fund	Log (0.001 + general allocation fund)
Oil production	Log (0.001 + oil production)

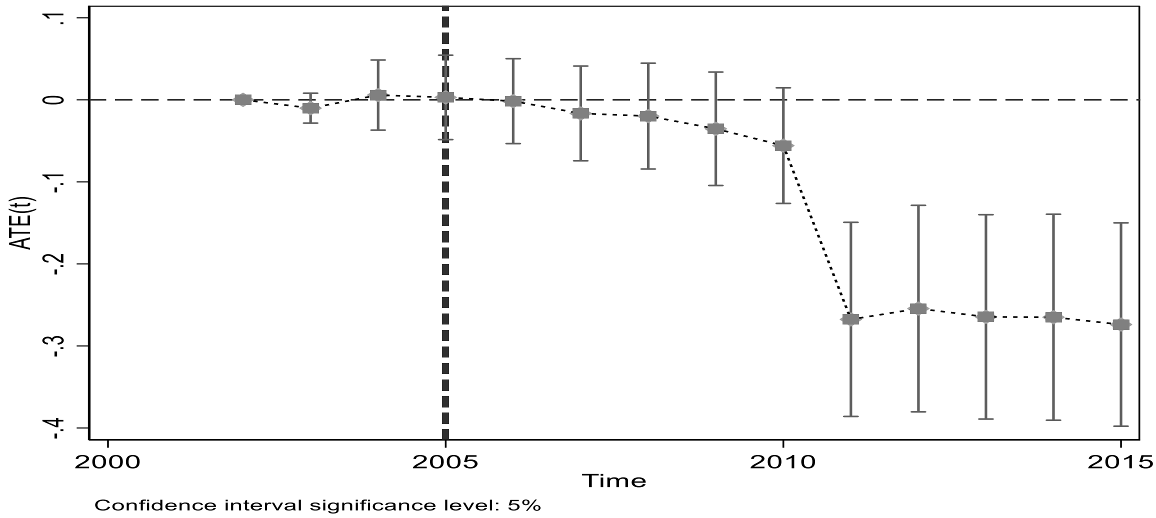
Notes:

The Interaction dummy variables (coastal district and split indicators) and the time trend can capture the potential influence of geographical characteristics throughout the study period. These interaction variables are treated as continuous variables and transformed into logarithmic variables to address their skewed distributions. 0.001 is added to some variables to prevent losing significant number of observations, as the values of these variables are often zero.



Source: Author’s calculation based on Ministry of Finance data.

Figure A4. 2 Intergovernmental transfer (balance fund) 2001-2018



Notes:
The parallel trend assumption in this test is also satisfied since parallel-trend test {estat ptrends (F, 120) = 0.05; Prob > F = 0.8288} and anticipation test {estat granger (F2, 120) = 0.88; Prob > F = 0.4189) are not significant.

Figure A4. 3 The average treatment effect before and during gas boom with full control variables

Chapter 5
Conclusion

This thesis has provided additional empirical evidence on the causal relationship between natural resources and economic development, through three research studies. One study is a cross-country study, while the other two are in a within-country setting. The thesis concentrates on the oil and gas extraction sectors as proxies for natural resources. The analysis in the cross-country setting (Chapter 2) focuses on the impacts of mining fiscal systems, in this case, resource rent tax (RRT) and gross royalty tax (GRT) on generating rents. The within-country studies (chapters 3 and 4) focus on the case of Indonesia. Chapter 3 examines the causal impacts of oil extraction on the village economy, while Chapter 4 analyses the spillover effects of gas extraction on neighbouring economies at the district level. The findings in each empirical study show that natural resources, particularly the oil and gas extraction sectors, have significant impacts on the economy, and therefore have policy implications.

The findings from Chapter 2 prove that a mining fiscal system based on profit (RRT system) is better than that based on production value (GRT system) in generating resource rents. This implies that implementing the RRT system could boost oil performance and subsequently generate more rents. It appears that this mining fiscal system incentivise oil companies to drill more wells and produce more oil. It is also revealed that the impacts of the mining fiscal system on rent generation vary under different circumstances, particularly in relation to democracy and freedom levels. In this case, the RRT system only has a significantly positive effect on generating rent in countries with a higher level of democracy and freedom. The findings suggest that democracy and freedom are the necessary conditions for implementing the RRT system.

Government should have capability to formulate and supervise this fiscal system and engage in negotiation with oil companies.

The policy implication of the findings in this chapter is that one possible way to enhance oil extraction performances is by applying a mining fiscal system based on profit. However, given the complexity of this fiscal system compared to the GRT system, a higher quality of democracy and freedom is needed. It should be emphasised that producing higher oil rents implies an increased possibility for the government to have more revenue from this sector. Nevertheless, to validate this assumption, further research is needed to empirically investigate whether the adoption of the RRT system could escalate not only the rents, but also the government revenue.

It could be observed from the findings in Chapter 3 that the resource curse could occur in a more specific local setting. The study reveals that oil extraction has detrimental impacts on the local economy at the village level, particularly in the case of Indonesia. The extraction of this resource causes a decrease in either number of small enterprises or number of labourers. The results also suggest that oil extraction could spread economic spillover to other economic sectors, also known as industrial spillover effects. The extraction of this resource has positive spillover impacts on services and education sectors, while in the manufacturing industry its impact is not significant. It is also uncovered that, even in the context of this local setting, quality of local government may play an important role in how this resource affects the local economy. Local governments in oil-producing villages seem unable to provide appropriate support for local businesses.

The findings in Chapter 3 propose at least two policy suggestions. First, appropriate policies are required to address the heterogeneity impacts of oil extraction. These, in this case, include how to avoid its negative effects and potentially overturn the resource curse into a blessing, particularly in regions rich in oil. Second, there is a requirement for the improvement of local institutions to better manage natural resource wealth in their areas so that this resource can be utilised to support the local economy. Some lingering questions remain unexplored in this chapter: Why were local governments in oil-producing villages unable to deliver better support for local businesses? Is it related to the fact that there is no oil revenue allocated at the village level since oil revenue-sharing for local governments is only at the province and district levels, or because of other factors? Addressing these questions is important and could be an interesting topic for future research.

Chapter 4 documents evidence on the spillover effects of gas windfall on neighbouring economies at the district level in Indonesia. It is proved that gas windfall has negative economic spillover effects on local economies near gas extraction sites. Non-gas producing districts in provinces with high gas production levels have lower economic performances compared to those in areas with low gas production. In addition, similar pictures emerge when testing the effects of this windfall on other social outcomes. Non-gas producing districts in rich-gas areas also experience higher poverty rates and larger numbers of people living below the poverty line. The results suggest that, in this case, having resource-rich neighbours could be a curse rather than a blessing. Another important finding is that the negative spillover effects of gas windfall only occur in the Java region, while in the non-Java areas the impacts are indifferent.

The findings in this chapter reveal that gas windfall through the Natural Resource Revenue Sharing Scheme fails to contribute to the improvement of economic performance in neighbouring areas. It seems that local governments in rich-gas areas have not been able to use this additional fund to support their economic development. As also indicated by the findings, gas windfall is positively associated with district governments' personnel spending and has a negative relationship with non-personnel spending. Therefore, as a policy suggestion, the government should not only pay attention to how gas windfall is shared, but also in how this additional fund is spent by the local governments. Essential variables that could aid local economic development, such as poverty rate and number of people living below poverty line, or other relevant factors, should be integrated into the scheme. However, for a more comprehensive analysis, further research is necessary. Another potential future study is to investigate why the negative spillover effects of gas windfall only occurred in the Java region, and not in other islands. This aspect has not been fully analysed in this research due to limited data.

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