International Institute of Social Studies

Revisit the "Resource Curse" in Vietnam

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***Declaration*:**

This Research Paper represents part of the author's study programme at the International Institute of Social Studies. The Research Paper is the author's own original work. All ideas, arguments, analyses, interpretations, and conclusions presented in this paper are entirely those of the author.

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ABSTRACT

This study examines the causal impact of mineral deposit discoveries on local economic development in Vietnam during the period 1992-2000. Using district-level nighttime light data as a proxy for economic activity, the study applies a multi-period difference-in-differences framework following Callaway and Sant'Anna (2021) to identify the causal effect of mineral discoveries on local economies. This approach allows for heterogeneous treatment effects across cohorts and over time, while mitigating bias arising from invalid comparisons inherent in conventional two-way fixed effects models. The results show that districts with mineral discoveries differ substantially in geographic and natural conditions from those without discoveries. When these factors are not controlled for, naïve estimates suggest the presence of a local "resource curse". However, after conditioning on covariates and allowing treatment effects to vary over time, the analysis finds no evidence of a uniform average effect of mineral discoveries on short-run local economic growth. Instead, the estimated effects are heterogeneous. Positive impacts are observed mainly in districts that experienced early discoveries, whereas districts with later discoveries show no statistically significant effects. Overall, the study provides empirical evidence that natural resource discoveries do not inevitably lead to either a resource curse or an economic boom at the local level. The findings underscore the central role of spatial heterogeneity and geographic context in assessing the economic consequences of natural resource discoveries.

Keywords: resources curse, nighttime light, subnation, Vietnam, stagged DID

1. INTRODUCTION

In March 2025, Vietnam explored 110 mineral deposits in the Northwest, coinciding with a broader wave of structural reforms, including provincial mergers and reorganization of ministerial functions. The discovery of a large number of mineral deposits may lead to economic stagnation or even crisis (Sachs and Warner, 1995). This phenomenon was first formalized by Corden and Neary (1982) as Dutch Disease[1]. They explained that windfall income from the discovery of mineral resources can stimulate consumption and reallocate labour away from tradable sectors, under a particular circumstances particularly weak and unstable institutional (Auty, 2001) this process result in long-term deindustrialization.

This context motivated me to study the relationship of natural resources, particularly mining resources, in Vietnam, with the goal of providing policy recommendations that might help the country avoid repeating the mistakes experienced by the Netherlands. Surprisingly, despite the extensive international literature on the resources curse, research findings for Vietnam remain inconsistent. Some studies argue that Vietnam is negatively affected by the rich of resource (Rahim *et al.*, 2021; Breul and Nguyen, 2022; Ngo, 2024), while others find no clear relationship between natural resources and economic growth (Xiao *et al.*, 2025). Moreover, to my knowledge, no study has examined this issue at the district level, likely because both data on district gross domestic product (GDP) and mineral sectors was unavailable prior to 2010.

Although a number of studies have been conducted to explore the concept of the resource curse, ranging from the national to the subnational level (Badeeb, Lean and Clark, 2017; Papyrakis, 2017), the empirical results remain far from robust. For example, Indonesia has been identified as suffering from a resources curse in some studies (Rahim *et al.*, 2021) while other research

[1] Dutch Disease was first introduced by The Economist magazine in the 1970s, when the Dutch economy experienced economic stagnant following a sharp appreciation of the currency triggered by the discovery of large oil reserves (Matt Whittaker, no date).

characterizes natural resources as a blessing (Haseeb *et al.*, 2021). Recently, Brintanti et al., (2025) show an inverted N-shape relationships between resources and poverty in Indonesia. This inconsistency highlights a fundamental challenge of studying the resource curse at the national level. Because we simply can not observe and control for all factors that simultaneously affect economic development and resource revenues (if resource revenues was used as explain variable) (van de Ploeg, 2011). Additionally, there is a reversed causal effect between economic development and extraction productivity, while natural resources contribute to national GDP, through investment in extraction technology that income can in turn feed back into higher productivity of mineral resource extraction (Brunnschweiler and Bulte, 2008). Economists studying this topic seem to have acknowledged that resources curse is not an obvious fact, not a certain future for resource-rich countries, but only a conditional phenomenon, a non-linear effect of natural resources on economic growth. Therefore, this study does not aim to confirm or reject the existence of natural resources curse, but focuses on examining the forms of impact of mineral deposit discovery on economic growth in Vietnam at district level.

Studying the impact of natural resources at the subnational level can reduce the influence of external shocks, or confounding from unobserved variables (van de Ploeg, 2011), but it cannot solve the reversed causal effect. Brunnschweiler & Bulte (2008) show that the main reason for this problem lies in the choice of explanatory variables, studies using resource exports as a measure of the plenty of natural resources tend to suffer from this bias. They suggest that replacing the measurement of the explanatory variable with non-monetary indicators such as the share of labour in mineral sectors, or the total quantity of extracted resources, can help avoid this problem. Another way used by Xie et al. (2021) to deal with this endogenous problem is to use mineral reserves as an instrumental variable. They argue that reserves are an exogenous variable and directly determines the amount of resources that can be extracted but has no relationship with economic development. Similarly, since this study examines the impact of mineral deposit discovery, the location of mineral discoveries is clearly a semi-random variable. This is because whether a region exists or is rich in natural resources is random, but discovering it is partly determined by investigations and surveys conducted by authorities.

One of the most common approaches in identification strategy is different-in-different (DID) approach, because it can capture the causal effect of event studies. However, a standard DID model with only two time points, before and after being treated, will be hard to capture something like the discovery of mineral deposits, which varies overtime. Besides that, the essential assumption of DID is parallel trends, and random sampling in DID is unlikely to hold in this concept. To overcome this limitation, Callaway & Sant'Anna (2021) introduce an approach that can adopt the issue of treatment varying by time by estimating ATT for each cohort, so-called staggered DID. Furthermore, their framework also addresses different parallel trends across districts by allowing for non-zero pre-trends under covariate control.

This study does two things. First, it takes the approach of identifying the simple relationship between mineral deposit discovery and economic development, in which treatment will be proxied as whether one district first discovered at least one ore deposit in the period 1992 to 2000, and the outcome variable is the light intensity in the period 1992-2000. Using DID with the multiple-time framework proposed by Callaway and Sant'Anna (2021), this research aims to figure out the dynamic treatment effect on the treated. Beside that, the study further addresses the remaining endogeneity concerns that cannot be fully resolved by the DID design alone. Although staggered DID helps correct for forbidden comparisons (Goodman-Bacon, 2021) and heterogeneous treatment timing, it still relies on the assumption that, conditional on observed covariates, the timing of mineral discovery is as good as random. In practice, however, the discovery of mineral deposits may still be correlated with unobserved factors such as historical exploration intensity, geological knowledge accumulation, or strategic priorities of the state, which could simultaneously affect local economic trajectories.

To mitigate this concern, this study second work is incorporates an instrumental variable (IV) strategy that exploits exogenous geological characteristics, which is, magnetic anomaly. This index is widely used in geological exploration to identify subsurface mineralization potential, particularly for metallic ores, and is determined by ancient geological formations rather than contemporary economic conditions (Hinze, 1960; Babu, 2003; Tao, Wang and Zhang, 2019). As such, it affects the probability of discovering a mineral deposit but plausibly has no direct impact on local economic growth, except through mineral discovery itself. By combining the staggered DID framework and an IV approach, this study strengthens causal interpretation and provides an additional robustness check against reverse causality and omitted variable bias.

Overall, this empirical strategy allows the paper to move beyond the binary question of whether Vietnam suffers from a resource curse. Instead, it provides a more essential analysis of how, when, and under what conditions mineral discoveries affect local economic outcomes. By focusing on the discovery stage rather than extraction revenues, by exploiting subnational variation, and by allowing for heterogeneous and dynamic treatment effects, the study contributes to the literature on natural resources and development in three ways.

First, it provides district-level evidence from Vietnam, a context that has been largely absent from subnational resource curse studies. While most existing studies examine post-2000 outcomes or rely on national aggregates, this paper exploits newly assembled district-level data to analyse the early phase of mineral discovery during the 1990s, when most deposits were first found. More importantly, rather than focusing on extraction revenues or production intensity, this study emphasizes the discovery stage of mineral resources. This distinction is crucial, as discovery represents an informational and expectation shock rather than a production shock. Second, from a methodological perspective, the paper combines a staggered DID framework with an instrumental variables strategy based on geological characteristics. By consider Callaway and Sant'Anna (2021) approach to allows treatment effects to vary across cohorts and over time, while conditioning on rich geographical covariates and Baum, Schaffer and Stillman (2007) guideline of using IV-GMM estimation to further addresses remaining endogeneity concerns by exploiting plausibly exogenous variation in mineral discovery driven by magnetic anomalies. It demonstrates the importance of accounting for treatment timing and pre-existing heterogeneity when evaluating the shocks in mineral sectors. Moreover, it introduces geological magnetic anomaly as a novel instrument in the empirical resource curse literature, opening new avenues for future research on the causal impacts of natural resource discoveries.

2. BACKGROUND

This part reviews the main theoretical perspectives explaining the mechanisms through which natural resources affect economic development. In the first section, I briefly go through the literature of this topic. Sub-section 1 focus on the studies of early 19 centuries, when the Dutch disease phenomenon first appeared in the Netherlands. Attracting scholarly attention to a paradoxical phenomenon, namely, that a natural resource windfall could lead to lower-than-expected economic performance. The extension of this discussion in Sub-section 2 broader relationship between natural resource abundance and national economic development, which is often found to be negative and is referred to as the resources curse. Paradoxically, empirical evidence does not always clearly confirm this relationship, particularly when additional control variables or instrumental variables are included. Sub-section 3 presents the modern strand of research on this topic, focusing on studies conducted at more localized levels. It highlights the remaining limitations of national-level analyses and the ongoing evolution of research on this topic. Section 2 specifically focuses on the Vietnamese context, where the resource curse may manifest in different forms. This section also introduces the main research question together with the corresponding hypotheses.

2.1. Literature

2.1.1. The Model of Dutch Disease

"The term Dutch Disease refers to the adverse effects on Dutch manufacturing of the natural gas discoveries of the nineteen sixties" (Corden, 1984, p. 1)

The term Dutch disease originates from an economic phenomenon observed in the Netherlands during the 1960s, when the Dutch economy performed below expectations following the discovery of a large natural gas field. Corden & Neary (1982) were the first to formally explain this phenomenon through an economic model, which later became widely used to interpret similar phenomena in other countries with different types of natural resources. This framework is referred to as the Dutch disease model or the "core model" according to Corden and Neary. The authors further developed this model in their 1984 study, where they explained the paradoxical phenomenon of an economy experiencing a natural resource boom as a potential cause of deindustrialization (see Appendix).

In the basic Dutch disease Core Model, Corden and Neary showed that a boom or abundance of non-renewable natural resources in an open economy can lead to deindustrialization through two key mechanisms: the spending effect and the resource movement effect. The model assumes that only one sector is mobile, where the booming sector represents the tradable sector and the lagging sector represents manufacturing. The model demonstrates that deindustrialization is an inevitable outcome in economies experiencing a resource boom, in which the spending effect serves as an indirect source of deindustrialization, while the resource movement effect is a direct one. Together, these two effects ultimately contribute to an overall economic curse.

In a more comprehensive version of the model, Corden (1984) allowed multiple factors to be mobile across sectors, providing a more realistic representation of the economy. Furthermore, he expanded the analysis to incorporate additional elements such as international capital mobility, immigration, and endogenous terms-of-trade effects. These contributions laid the foundation for a broader body of research on the effects of natural resources on economic growth, what R. Auty & Warhurst (1993) later termed the "natural resources curse".

2.1.2. Natural resource curse and/or blessing

Although the idea of a curse of natural resources already existed, the term resources curse initially served merely as another way to describe the Dutch disease phenomenon. It was not until Auty introduced the term in his thesis that it came to represent a broader set of indirect mechanisms affecting the long-term economic performance of resource-rich countries. While the Dutch disease describes a direct economic impact, typically leading to deindustrialization, empirical studies on Dutch disease often rely on simple one-stage regression models.

In his thesis, R. M. Auty (1994) conceptualize the resources curse to refer the negative overall effects of natural resource abundance through indirect transmission channels such as political dynamics, environmental degradation, and conflict. He provided a broader case study to deeply focus on 6 large newly industrializing countries (included Korean, Taiwan, India, Chia, Mexico, and Brazil). This is where the term "resources curse" taken not only the oil-producing boom (as Dutch disease did) but also others mineral-goods-producing boom into account. The

Auty thesis of resources curse stress the important of quality of institution, especially industrial policy, on the process of stabilize domestic industrial production of these countries.

In recent years, a large body of scholarly work has shifted its focus toward exploring the specific channels through which the natural resources curse can emerge and harm economic performance, with the goal of identifying strategies to prevent or mitigate its effects. The collected evidences of the "curse of the resources" (Sachs and Warner, 1995, 1997, 1999, 2001) indicates that there is "almost without exception, the resource-abundant countries have stagnated in economic growth (J. D. Sachs & Warner, 2001, p. 837)". Notable contributions include the efforts of Gylfason, who explored the role of education (Gylfason, Herbertsson and Zoega, 1999; Gylfason, 2001), investment (Gylfason and Zoega, 2006), governance (Gylfason, 2011). Moreover, recent studies have expanded the literature by incorporating additional factors such as geopolitical risks (Jensen and Johnston, 2011), green finance (Wang and Li, 2025), and green growth (Cheng, Li and Wang, 2021).

In addition, comprehensive reviews of Ross, 2004, 2015; Ploeg, 2011; Havranek, Horvath and Zeynalov, 2016; Badeeb, Lean and Clark, 2017; Papyrakis, 2017; Mien and Goujon, 2022 have synthesized decades of research in an effort to answer long-standing questions and construct a general analytical framework for studying the natural resources curse. They, in a whole show that the central question, which is how natural resources can effect the economy in long-run seem hard to answer completely due to the problem of endogeneity and the identification of "resources curse".

Although a number of scholars have been conducted to explore the concept of the Resource Curse at national level, these study's result is not robust. Studies have shown that when the measurement of the explanatory variable, namely natural resources, is altered, the results become insignificant (Gylfason, 2011) or even change in direction to become natural resource blessing. For instance, Indonesia is identified as suffering from a resource curse in one study (Rahim *et al.*, 2021) while others identified their natural resources as a blessing (Haseeb *et al.*, 2021). More recently, Brintanti et al. (2025) find that natural resources affects poverty in Indonesia following an inverted N-shaped relationship.

Another issue arises in other transmission channels, such as the relationship between natural resources and institutional quality, where natural resources may negatively affect institutions, and weak, rent-seeking institutions in turn reduce extraction productivity by neglecting technological investment. This can be considering as a reverse causal effect, which lead further bias in any estimation. Hence, a widely accepted conclusion among researchers in this field is that natural resources is not a deterministic outcome for resource-rich countries, rather, it is a conditional phenomenon that depends heavily on a country's specific economic characteristics. Consequently, the manifestation of the resources curse varies substantially across different national contexts.

2.1.3. Main problem in resources curse studies

As long as the endogeneity problem remains unresolved, empirical studies on the resources curse at the national level will continue to face controversy due to inconsistent results. The complexity of endogeneity in this research area has led scholars to acknowledge that the resources curse phenomenon is multi-sectoral and multi-layered; the manifestation of resources curse at the local level may differ significantly from what the same country experiences at the national level. Therefore, shifting the analytical focus to the subnational level provides a more nuanced understanding of its underlying mechanisms and enables the identification of its specific impacts on local economies (Papyrakis, 2017). There are many potential endogeneity problems due to (1) reverse causality and (2) omitted variable (van de Ploeg, 2011). van de Ploeg explained that reverse causality can occurred due to the impact of the new income from booming sectors to the extraction technology.

Reverse causality

Cross-country research seems to struggle in explaining the resources curse (van de Ploeg, 2011). The development of this research field slowed down when the endogeneity problem between natural resources and economic development emerged. The first issue is reverse causality. While natural resources can affects economics development, economics development level can also influence resource productivity. For example, the abundance of natural resources can act either as an independent variable explaining the slowdown of economic growth (Liu *et al.*, 2024) or as a dependent variable influenced by economic growth through investments in exploration technology (Xie *et al.*, 2021).

This issue of reverse causality was explained by Brunnschweiler & Bulte (2008), who argued that when the explanatory variable, natural resource wealth, is measured by the share of natural resource exports in GDP, the resource curse may appear simply because the country is dependent on natural resources, rather than because it is genuinely resource-abundant. They demonstrated that the share of natural resource exports is often influenced by policymakers, which in turn affects institutional quality and economic growth. This problem typically arises when resource wealth is measured using GDP-related indicators, such as the export value or the export-to-GDP ratio. Therefore, they proposed distinguishing between two concepts: resource dependence (proxied by the share of resource exports) and resource abundance (proxied by natural resource reserves). In addition, they suggested using non-monetary proxies, such as the ratio of employment in the mining sector to total employment, to better capture the level of resource endowment.

Omitted unobserved variables

Because the outcome variable of this research is economic development, which is highly sensitive to changes in various macroeconomic variables, it is important to acknowledge potential confounding factors. For instance, i.e. Sala-i-Martin (1997) identified more than 50 factors that can influence economic development. However, it is impossible to include all of the into the model. However, it is impossible to include all of the into the model. Thus, to avoid potential endogeneity problems caused by omitted variables, the study estimates a DID model with geography controls variables to match areas with similar mineral potential. Then we also estimate an IV model to check whether omitted unobserved variables have a significant effect on the estimate power of the framework. Geophysical studies show that gravity and magnetic anomalies are commonly used to preliminarily identify areas with mineral potential (Hinze, 1960; Babu, 2003; Tao, Wang and Zhang, 2019) before conducting detailed geological analysis. Using these indicators is considered a cost-effective way to locate regions with a high likelihood of mineral deposits. In Vietnam, the Geophysical Federation has also successfully discovered mineral deposits during airborne surveys measuring magnetic and gravitational parameters. Hence, this study uses these two indicators to identify the mineral potential of each area and employs them as the exogenous IV control for the discovery of mining site.

2.1.4. Resources curse at subnational level

At the early stage of the subnational research strand, studies began with ideas similar to the mechanisms identified at the national level and found comparable results. Empirical evidence from the United States, China, Tanzania, and Ghana (Papyrakis and Gerlagh, 2007; Fan, Fang and Park, 2012; Moomen and Dewan, 2016; Poncian, 2019) supports the view that natural resources weaken local institutional quality by intensifying rent-seeking behaviour arising from resource windfalls.

Surprisingly, countries that had previously been regarded as examples of a resource blessing at the national level exhibited the opposite pattern at the subnational level. For instance, research in the United States shows that the negative impact of the mineral sector on economic growth is well recognized (James and Aadland, 2011; Michieka and Gearhart, 2018). In addition, Matheis (2016) found that in the early stage, when mineral deposits are first discovered, there tend to be short-term positive effects on local economic performance.

A new mechanism identified by Katovich (2024) in Brazil shows that not only does natural resource extraction undermine institutional quality, but even information about potential resource discoveries can trigger similar effects. Local governments in areas with mineral potential or where resource discovery information is publicly known tend to increase spending and reallocate budget priorities, even before any actual revenue is realized.

These findings have motivated a growing number of scholars to engage in this line of research, leading to an increasing body of empirical evidence from countries such as the United States, China, Ghana, Brazil, Indonesia, Uganda, Kenya, and Russia (Libman, 2011; Van Alstine *et al.*, 2014; Matheis, 2016; Ouedraogo, 2016; Manzano and Gutiérrez, 2019; Ishak and Méon, 2023; Brintanti *et al.*, 2025). Since the analytical framework and transmission mechanisms of natural resources at the subnational level remain insufficiently understood and require further empirical validation, this study contributes to the literature by providing new empirical evidence from Vietnam. In addition, the mechanisms suggested by previous scholars will also be tested within the context of this research.

2.2. Context of Vietnam

The impact of natural resources on Vietnam's economic growth remains ambiguous. While some studies argue that the resources curse exists indirectly based on the observed negative effects on some indicators of economics growth such as green total factors productivity (Ngo, 2024) or market entry (Breul and Nguyen, 2022), others find no significant relationship between natural resource abundance and economic growth in the context of Vietnam (Yu, 2023; Xiao *et al.*, 2025). Importantly, none of these studies consider the early periods, say before 2000, when most of mining site was discovered.

To date, no study in Vietnam has addressed this topic due to the lack of both GDP data at district level before 2010 and the mineral resources data at the early stage. Most of the mining site in Vietnam was intensively found before the year 2000 (Figure 2.a illustrates the number of mining sites discovered by year, compiled by the author based on data from the Vietnam Institute of Geosciences and Mineral Resources report.) due to the colonization of French and U.S. Therefore, to study the impact of mineral deposit discovery on regional economic outcomes, data on socioeconomic indicators and the mining sector are critically important, yet nearly impossible to access. I argue that this is the main reason why research on this topic in Vietnam remains a major challenge for researchers.

After the independence, Vietnamese government start their plan in increasing mineral exploitation to serve the economy increasing demand. In implementing the Eighth Resolution of the Central Committee and Resolution No. 28 of the Politburo[2], the reform named "Doi Moi" shift Vietnam economy from a centrally planned economy to a socialist-oriented market

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[2] Communist Party of Vietnam, *Complete Collection of Party Documents*, vol. 46, p. 236

economy in 1986 contributed to the demand for natural resources. By 1995, the U.S. embargo was lifted, marking a major step forward in Vietnam's international trade relations and potentially affecting the intensity of activities in the extraction sector. These early "Doi Moi" and opening-up policies created stronger incentives for resource exploration and exploitation. One direct outcome was Decision No 07/1999/QĐ-BCN issued by the Ministry of Industry, which set ambitious targets for the exploration and extraction of mineral resources beginning in 1999. For this reason, I focus on the period during which mining sites were intensively discovered prior to 1999, and hypothesize that the discovery of mineral deposits has an impact on local economic development.

H0: The discovery of mineral deposits has no effect on district-level economic activity.

H1: The discovery of mineral deposits affects district-level economic activity.

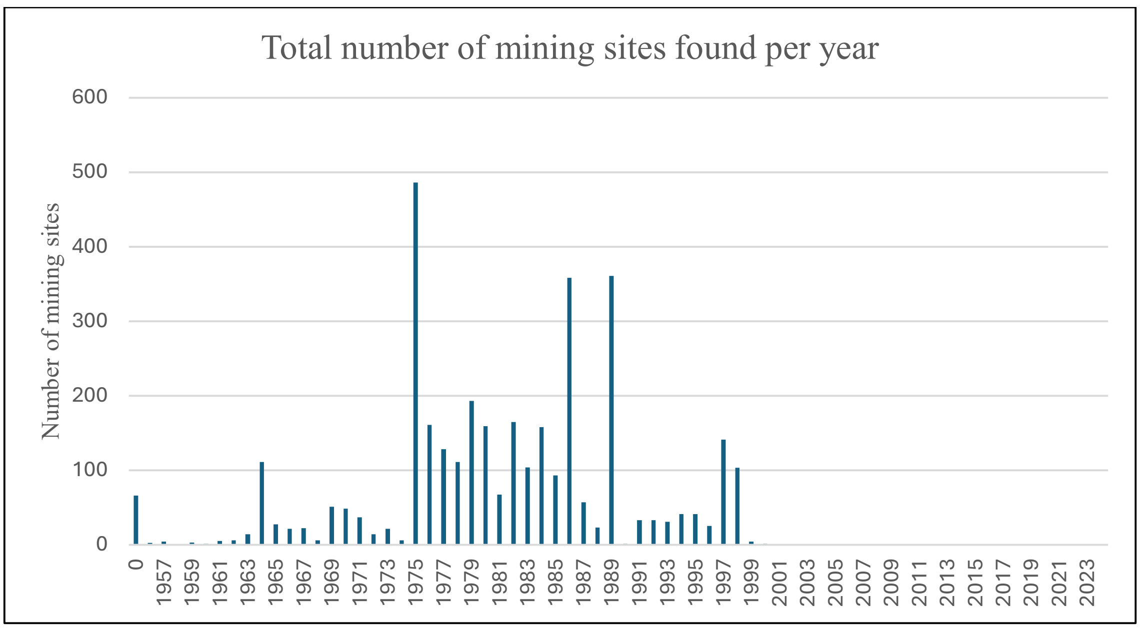

Figure 2.a illustrates the number of mining sites discovered by year, compiled by the author based on data from the Vietnam Institute of Geosciences and Mineral Resources report.

An important point that should be emphasized is that, in the Vietnamese context, the discovery of mineral deposits should not be equated with mineral extraction or mineral revenues, as is commonly done in much of the existing literature. In practice, mineral discovery primarily represents an informational and expectation shock, rather than an immediate production or fiscal shock. The confirmation that a region possesses mineral potential may alter the expectations of local governments, investors, and workers through decisions related to government spending, infrastructure investment, or migration (Katovich, 2024), even when actual extraction has not yet taken place or occurs only with substantial delay. This mechanism may generate short-run economic growth, consistent with the idea proposed by Matheis (2016). Therefore, I introduce an additional subsidiary hypothesis to examine the impact of this information shock on local economic activity.

Ha: The discovery of mineral deposits has a positive effect on district-level economic activity within three years after discovery.

This approach implies that the impact of natural resources is neither linear nor mechanical, and cannot be fully captured by a simple correlational relationship between resources and economic growth. Instead, the effects of mineral discovery are conditional, depending critically on the timing of discovery, the institutional context, and the geographical characteristics of each locality. Accordingly, the central research question is not merely whether mineral discovery generates a "resource curse" but rather when and for how long mineral discovery may influence local economic development trajectories. This perspective is particularly relevant for Vietnam in the 1990s, when the economy was in the early stages of transition toward a market-oriented system, while most mineral deposits had been discovered but not yet exploited at scale. As a result, any short-run economic effects observed during this period, if present, are more likely to reflect responses to information about resource potential rather than direct impacts of extraction activities.

3. RESEARCH DESIGN

Before 2000, most mineral deposits in Vietnam had already been discovered. During this stage, the study focuses on examining whether the discovery of a mineral deposit affects local economic development. One of the most common approaches in identification strategies is difference-in-differences (DID), as it is well suited to capturing causal effects in event-study settings. The particular feature of this study is that mineral discoveries did not occur simultaneously but took place at different points in time. However, a standard DID model with only two time periods, before and after treatment, has difficulty capturing phenomena such as mineral deposit discoveries that vary over time. In addition, the key assumptions of DID, namely parallel trends and random sampling, are unlikely to hold in this context, given that districts differ fundamentally in their underlying economic patterns. To overcome these limitations, I follow the framework proposed by Callaway & Sant'Anna (2021), which accommodates time-varying treatment through the estimation of cohort-specific average treatment effects (ATTs), commonly referred to as staggered DID. Moreover, their framework allows for heterogeneous parallel trends across districts by permitting pre-trends conditional on covariates. The expected outcome of this estimation is to determine whether the discovery of a mineral deposit has a positive, negative, or no effect on local economic performance. The hypothesis is that the discovery of mining sites affects local economic outcomes.

In addition to the main econometric model, this study further tests two important hypotheses from the literature to strengthen theoretical consistency and provide additional empirical support for the identification results. First, following Dou et al. (2022), poor economic performance in resource-rich localities is argued to stem primarily from inherent terrain disadvantages rather than from mineral resources themselves; this hypothesis is examined by tracking how the coefficient on mineral discovery changes as geographic controls are gradually introduced. Second, to address the endogeneity concern stressed by van de Ploeg (2011), the study adopts the instrumental-variable idea of Xie et al. (2021), using magnetic anomaly as an instrument for mineral discovery. Magnetic anomaly is a geophysical indicator widely used in mineral exploration that affects the probability of discovering deposits but has no direct channel influencing economic development. Due to data access restrictions related to national security, gravity anomaly data are unavailable, and therefore this study relies solely on magnetic anomaly as the instrumental variable.

3.1. Data collection

Key variable

Unlike developed countries, developing countries often lack readily available economic data at the district level, and GDP is no exception. As a result, studies conducted at the district level in developing countries commonly use nighttime lights as a proxy for economic development. For example Cruzatti C. et al., (2024) employ nighttime lights as a proxy for local economic conditions in Latin American countries, Dou et al. (2022) use it in the context of China, and Ho (2021, 2025) applies this approach in a study on Vietnam. This approach are also widely used to proxy economics variables such as economics growth (Amavilah, 2018), human development (Bruederle and Hodler, 2018), and population (Sun *et al.*, 2024). Additionally, the legal mining activities in Vietnam are conducted entirely during daylight hours, nighttime lights serve as an appropriate proxy to capture the socioeconomic conditions of an area at the time of observation. Although some may argued that the nighttime lights may correlated with energy accessibility but not economics development, energy accessibility still indicated the development level of one area (Best and Burke, 2018).

For the main explanatory variable which is mining activity, data on the location are collected from Exploration and Discovery Reports by the Vietnam Institute of Geosciences and Mineral Resources. Then, I defined a district is treated as a treatment unit when it experiences the discovery of a mineral deposit. Although there is no reverse treatment, meaning that once a district is treated it cannot become untreated, it is still possible for a district to be treated multiple times due to additional discoveries. Therefore, I use the timing of the first treatment to construct the treatment variable.

Covariant variables

As Vietnam had only recently entered the stage of a socialist-oriented market economy, the influence of global economic fluctuations during the study period appears to have been relatively limited. Consequently, local economic outcomes are largely explained by natural and geographical factors. The set of control variables used in this study is adopted from the work of Ho (2025), whose outcome variable is closely comparable to mine at the district level. The control variables include the following:

Terrain Ruggedness Index: The effect of terrain ruggedness on economic outcomes is documented by Nunn and Puga (2012) in the context of Africa, primarily through transportation costs. They compute the Terrain Ruggedness Index using high-resolution elevation data (30 arc-second grid, approximately 1 km) by taking the root mean square of elevation differences between each grid cell and its surrounding neighbours. I obtained the global ruggedness raster data from their replication package and used QGIS to calculate the average TRI for each district. The dataset also provides slope as an alternative measure related to terrain ruggedness.

Elevation: Elevation data are constructed using the Global 30 Arc-Second Elevation Dataset (GTOPO30), developed by the U.S. Geological Survey (USGS) through the EROS Data Center. GTOPO30 is a global digital elevation model (DEM) with a spatial resolution of 30 arc-seconds, equivalent to approximately 1 km at the equator, designed for regional- and continental-scale analysis. Elevation values are measured in meters above mean sea level and range from –407 meters to 8,752 meters. In the raster data, ocean areas are coded as no data, while low-lying coastal areas have a minimum elevation of 1 meter. Using this dataset, district-level elevation is calculated as the mean elevation of all raster pixels within each district's administrative boundary, computed in QGIS. High-elevation regions, such as mountainous or high plateau areas, often face distinct climatic conditions and accessibility constraints—for instance, cooler temperatures and higher transportation costs. Including average elevation therefore helps control for ecological and accessibility differences. In spatial economic studies, elevation is a commonly used control variable, and in some cases terrain characteristics have also been employed as instrumental variables for cultural and economic outcomes.

Distance to coastline: The distance-to-coastline variable is constructed to capture each district's access to maritime trade routes and international markets, which are important geographical determinants of economic development. This distance is calculated in QGIS as follows. First, a representative point is generated for each district, corresponding to the geometric centroid of its administrative boundary polygon. Next, using a coastline shapefile, QGIS is employed to measure the shortest straight-line distance from each district centroid to the nearest point along the coastline. Distances are measured in kilometers (km).

Caloric suitability: The caloric suitability index is included as a core control variable to capture the natural potential agricultural productivity of each district, which can have deep and persistent effects on long-run economic development. According to Galor and Özak (2016), regions with higher potential crop yields in the pre-industrial era generated higher returns to agricultural investment, thereby fostering selection and learning processes that increased long-term orientation within society. This long-term orientation plays a central role in human capital accumulation, technological investment, and sustained economic growth. This mechanism implies that regions with high caloric suitability not only benefit from agricultural productivity advantages but also develop behavioural and cultural traits conducive to long-run economic development. As a result, caloric suitability may influence contemporary economic outcomes even after controlling for other geographical factors, through persistent historical and cultural channels. Including this variable helps disentangle the effect of mineral discoveries from development advantages or disadvantages rooted in fundamental Agro-ecological conditions, which may simultaneously shape population distribution, economic structure, and growth dynamics at the district level. This study use 'the average potential yields within each cell, attainable given the set of crops that are suitable for cultivation in the post-1500 period' data provided by the authors to control for agricultural productivity.

Climatic zones: The study employs the Köppen-Geiger climate classification to control for systematic differences in climatic conditions, which directly affect biological productivity, agricultural risk, and long-term development trajectories. Climate data are drawn from the high-resolution Köppen-Geiger maps (0.0083°, approximately 1 km) developed by Beck et al. (2023), based on temperature and precipitation datasets that have been explicitly corrected for topographic effects. In this study, climate zones corresponding to the period 1991–2020 are used to identify the representative climate type for each district. Raster climate data are processed in QGIS following several steps. First, indicator variables corresponding to each climate class are created. Next, the number of pixels belonging to each climate class within each district is calculated using zonal statistics. The dominant climate type of a district is then defined as the climate class with the largest number of pixels within that district's administrative boundary.

3.2. Identification strategy (this part is taken from Hung (2025)'s Econometrics assignment)

The objective of this paper is to estimate the impact, or the aggregated causal effect, of mineral discoveries on economic development at the district level during the period 1992–2000. However, it is not straightforward to determine whether observed changes in economic outcomes are truly driven by mineral discoveries, as numerous other factors can simultaneously influence district level development. For this reason, estimation strategies such as OLS or panel two-way fixed effects typically require a large set of covariates for control, which in turn introduces the more complex problem of potential causal relationships between the outcome variable and these covariates. More importantly, these conventional models estimate a weighted average of treatment effects, where some of the weights may be negative, potentially biasing the estimation of the causal effect (Sun and Abraham, 2021).

3.2.1. Method

This study employs the multiple time period Difference-in-Differences method developed by Callaway & Sant'Anna (2021), which relax the non-zero parallel trends assumption and allows for multi-period data. Importantly, this method accommodates treatment effect heterogeneity across groups and time periods. That is, the ATT for districts that first discover mineral deposits in a given year may differ from those treated in other years; likewise, the ATT in the first year after discovery may differ from that in the second year. This flexibility enables the study to test the hypothesis that booming mineral sectors affect economic growth. Furthermore, by incorporating covariates, the analysis also accounts for differences in baseline economic development levels across treated groups, addressing potential selection bias in treatment timing.

In this framework, Callaway & Sant'Anna (2021, p. 203) define group-time average treatment effects, $ATT(g,t)$, as the average effect of the treatment in period t for units that first received the treatment in period g, given by:

$ATT(g,t) = E[Y_t(g) - Y_t(0) \mid G_g = 1],$

Where $Y_t(g)$ is the potential outcome for a unit if first treated in period g, and $Y_t(0)$ is the potential outcome without treatment. G is the time period when a unit treated for the first time, hence G_g is equal to 1 if a unit belongs to the group first treated in period g.

The $ATT(g,t)$ will be estimated using the doubly-robust estimator proposed Callaway & Sant'Anna (2021, p.206), which combines outcome regression and inverse probability weighting. This approach only requires either the propensity score model or the outcome model to be correctly specified for consistency (Sant'Anna and Zhao, 2020), and the doubly-robust estimator relative to the never-treated group is given by:

$$ATT_{dr}^{nev}(g,t) = E\left[\left(\frac{G_g}{E[G_g]} - \frac{\frac{p_g(X)C}{1-p_g(X)}}{E\left[\frac{p_g(X)C}{1-p_g(X)}\right]}\right) \cdot \left(Y_t - Y_{g-1} - m_{g,t}^{nev}(X)\right)\right],$$

Where:

- $ATT_{dr}^{nev}(g,t)$ is doubly-robust estimator of $ATT(g,t)$ comparing to the never-treated group, for units first treated in period g, evaluated at time t
- G_g is equal to 1 if a unit belongs to the group first treated in period g; 0 otherwise
- C is equals 1 if the unit is never treated; 0 otherwise
- $p_g(X)$ is generalized propensity score: the probability that a unit belongs to group g, conditional on covariates X
- Y_t is observed outcome at time t
- Y_{g-1} is the outcome variable one period before treatment
- $m_{g,t}^{nev}(X)$: $E[Y_t - Y_{g-1} \mid X, C = 1]$ is the predicted change in outcomes for never-treated units conditional on X.

3.2.2. Assumptions

I assess six key assumptions of the method and explain how it can be hold in relation to the current research design:

Assumption 1. Irreversibility of Treatment

Once a unit receives the treatment, it remains treated in all subsequent periods. Accordingly, once a district discovers a mineral deposit, it continues to be affected by that treatment. Although in reality a district may discover additional deposits or exhaust the existing ones, I argue that it is unlikely for a deposit to be fully depleted within the period under study. Even if so, the impact of the discovery is expected to persist beyond the initial exploitation phase. Additionally, due to this assumption, the district have discovered mining site before 1992 will be dropped from the analysis. Once a unit receives the treatment, it remains treated in all subsequent periods. Accordingly, once a district discovers a mineral deposit, it continues to be affected by that treatment. Although in reality a district may discover additional deposits or exhaust the existing ones, I argue that it is unlikely for a deposit to be fully depleted within the period under study. Even if so, the impact of the discovery is expected to persist beyond the initial exploitation phase. Additionally, due to this assumption, the district have discovered mining site before 1992 will be dropped from the analysis.

Assumption 2. Random Sampling:

Assumption 2 (Random Sampling): Treatments should be assigned randomly. This is difficult to satisfy in this study because the discovery of mineral deposits follows geological surveys conducted by the Vietnam Department of Geology and Minerals. Fortunately, the national survey campaign was implemented simultaneously across the country. Thus, mineral discoveries can be considered conditionally random, conditional on terrain ruggedness, and randomly timed.

Assumption 3 (Limited Treatment Anticipation): Units do not alter their behaviour in anticipation of treatment. In other words, district's economies do not respond in advance of mineral discovery. This assumption holds in this context, as discussed earlier: the timing of mineral discovery is effectively random and unanticipated.

Assumption 4 (Conditional Parallel Trends Based on a "Never-Treated" Group) and *Assumption 5 (Conditional Parallel Trends Based on "Not-Yet-Treated" Groups)*:

These are both parallel trends assumptions, but relative to different comparison groups. Unlike the classical DID framework - which assumes no pre-treatment effect or imposes that pre-treatment trends are the same and equal to those of the never-treated group, the Callaway & Sant'Anna approach allows for conditional parallel trends, where the trend similarity holds after conditioning on observed covariates.

In a Difference-in-Differences setting, this is the most important identifying assumption. However, testing this assumption is not highly regarded due to several issues associated with such tests, and the test results ultimately provide little support for the identification of ATT (Callaway and Sant'Anna, 2021). They argue that robustness analyses that assess the stability of ATT estimates even when the parallel trends assumption is potentially violated are more practical. Accordingly, this study does not formally test for pre-trends, but instead estimates ATT sequentially under Assumptions 4 and 5, with additional robustness checks presented in subsequent sections.

Assumption 6 (Overlap): At each time period after the initial year, there is a positive probability of receiving treatment, and this probability does not converge to one. In the context of this study, this means that each district has a non-zero chance of discovering a deposit, and no district has a certainty of being treated.

3.2.3. Interpretation of results

Under the assumption of parallel trends conditional on covariates X, the parameter $ATT(g,t)$ can be estimated using the following simple regression model (Callaway & Sant'Anna, 2021, p. 207):

$$Y = \tilde{\alpha}_1^{g,t} + \tilde{\alpha}_2^{g,t} \cdot G_g + \tilde{\alpha}_3^{g,t} \cdot 1\{T = t\} + \tilde{\beta}^{g,t} \cdot \left(G_g \times 1\{T = t\}\right) + \tilde{\gamma} \cdot X + \tilde{\epsilon}^{g,t}, \qquad (3.1)$$

In which, $\tilde{\beta}^{g,t}$ is equal to $ATT(g,t)$ if the treatment effect is assumed to be homogeneous with respect to covariates, and the time trends in outcomes are assumed to be independent of X.

After estimating each treatment effects group-time units, $ATT(g,t)$'s, the main policy question of this study is to assess the overall effect of the treatment across all affected units. A simple and intuitive approach, as suggested by Callaway & Sant'Anna (2021, p. 211), is to average all of the identified group-time average treatment effects, which can be expressed as:

$$\theta_W^o = \frac{1}{\kappa}\sum_{g\in G}\sum_{t=2}^{T} 1\{t \geq g\}ATT(g,t)P(G = g\ |G \leq T), \qquad (3.2)$$

Where θ_W^o is the parameter this study care about provides a summary measure of the average treatment effect across all treated units and periods, putting more weight on group-time with larger populations. This parameter reflects the average difference in outcomes between districts that experienced a mineral discovery and those that did not. Based on this estimate, the study can predict the potential aggregate impact of discovering 110 mining sites by simply scaling the average effect accordingly.

Following this, one may be interested in the effect of anticipation on the treatment, because the aggregated ATT c may not provide sufficient information about the impacts that policymakers care about. Group-specific ATT can therefore be estimated separately for each cohort that receives treatment at different points in time, as follows:

$$\theta_{sel}^o = \sum_{g\in G}\theta_{sel}(g)P(G = g\ |G \leq T), \qquad (3.3)$$

Where $\theta_{sel}(g) = \frac{1}{T-g+1}\sum_{t=g}^{T} ATT(g,t)$ is the average treatment effect of each group g. θ_{sel}^o then average the effect across group for each unit, and then can be interpreted as the ATT in the two-period DID set up.

An important parameter that I use to address hypothesis Ha regarding the effect of treatment over time is the average treatment effect by length of exposure to the treatment. Let $e = t - g$ denote the number of periods elapsed since the treatment was adopted.

$$\theta_{\boldsymbol{es}}(\boldsymbol{e}) = \sum_{g\in G}\mathbf{1}\{g + e \leq T\}P(G = g|G + e \leq T)ATT(g, g + e), \qquad (3.4)$$

Where $\theta^{es}(e)$ is the average effect of participating in the treatment e periods after the treatment is first applied. Accordingly, $e = 0$ corresponds to the on-impact effect of the treatment.

3.3. Robustness analysis

The Mekong Delta may be subject to a distinct type of "curse", often described in the literature as a fertility curse (Leonard Wantchekon and Piero Stanig, 2015). whereby regions with exceptionally favorable agricultural conditions follow development trajectories and economic structures that differ fundamentally from other areas. This distinctive context may confound the identification of the causal impact of mineral discoveries on local economic growth. For this reason, the study excludes all districts located in the Mekong Delta from the sample and re-estimates the main analyses using the restricted sample, in order to assess the robustness of the results to this form of spatial heterogeneity.

3.4. Extended analysis

In addition to the main econometric framework presented below, this study further examines several hypotheses and ideas proposed in the existing literature in order to assess whether the empirical setup is theoretically consistent and to provide additional empirical support for these arguments. One such hypothesis is put forward by Dou et al. (2022), who argue that the poor economic performance observed in mineral-rich regions primarily stems from inherent geographical disadvantages rather than from resource abundance itself. They suggest that mineral deposits are often formed through geological processes associated with rugged terrain, which in turn creates a habitat that is unfavourable for human settlement and economic development. This implies that, without adequately controlling for geographical factors, any observed negative effects may not be attributable to mineral resources or extraction intensity per se, but rather to the inherent economic disadvantages of remote and rugged areas. This hypothesis can be tested using a basic regression framework by examining how the coefficient on mineral discovery changes as geographical controls are progressively introduced; if the inclusion of these controls renders the estimated effect of mineral discovery statistically insignificant, the hypothesis is supported.

The second idea examined in this study builds on the causal concerns raised by van de Ploeg (2011) instrumental variable idea proposed by Xie et al. (2021). While van de Ploeg highlights the endogeneity between economic outcomes and resource-related variables, Xie et al. address this issue by incorporating instrumental variables such as mineral reserves. In the present context, however, using mineral reserves as an instrument would lead to perfect correlation with the independent variable, since the key explanatory variable is the discovery of mineral deposits and reserves are necessarily surveyed prior to discovery by the Vietnam Institute of Geosciences and Mineral Resources. Therefore, a valid instrument must affect the probability of discovering a mineral deposit without directly influencing economic development. Although terrain ruggedness is sometimes used as a strong instrument for mineral production, it also directly affects economic outcomes (Nunn and Puga, 2012), making it more appropriate as a control variable rather than an instrument. Instead, this study employs magnetic anomalies as an instrument for mineral discovery, as magnetic anomaly is a widely used indicator in mineral geology for prospecting, detecting, and assessing mineral potential. Geophysical studies show that gravity and magnetic anomalies are commonly used to preliminarily identify areas with mineral potential prior to detailed geological analysis (Hinze, 1960; Babu, 2003; Tao, Wang and Zhang, 2019) and these indicators are considered cost-effective tools for locating regions with a high likelihood of mineral deposits. Magnetic anomaly serves as a valid instrument because it is driven solely by the presence of magnetic minerals in the Earth's crust, generating deviations from the background magnetic field, and therefore has no direct channel through which it could affect economic activity. In Vietnam, the Geophysical Federation has successfully discovered mineral deposits through airborne surveys measuring magnetic and gravitational parameters. However, gravity anomaly data are classified as state secrets for national security reasons, and as a result, this study relies exclusively on magnetic anomaly as the instrumental variable.

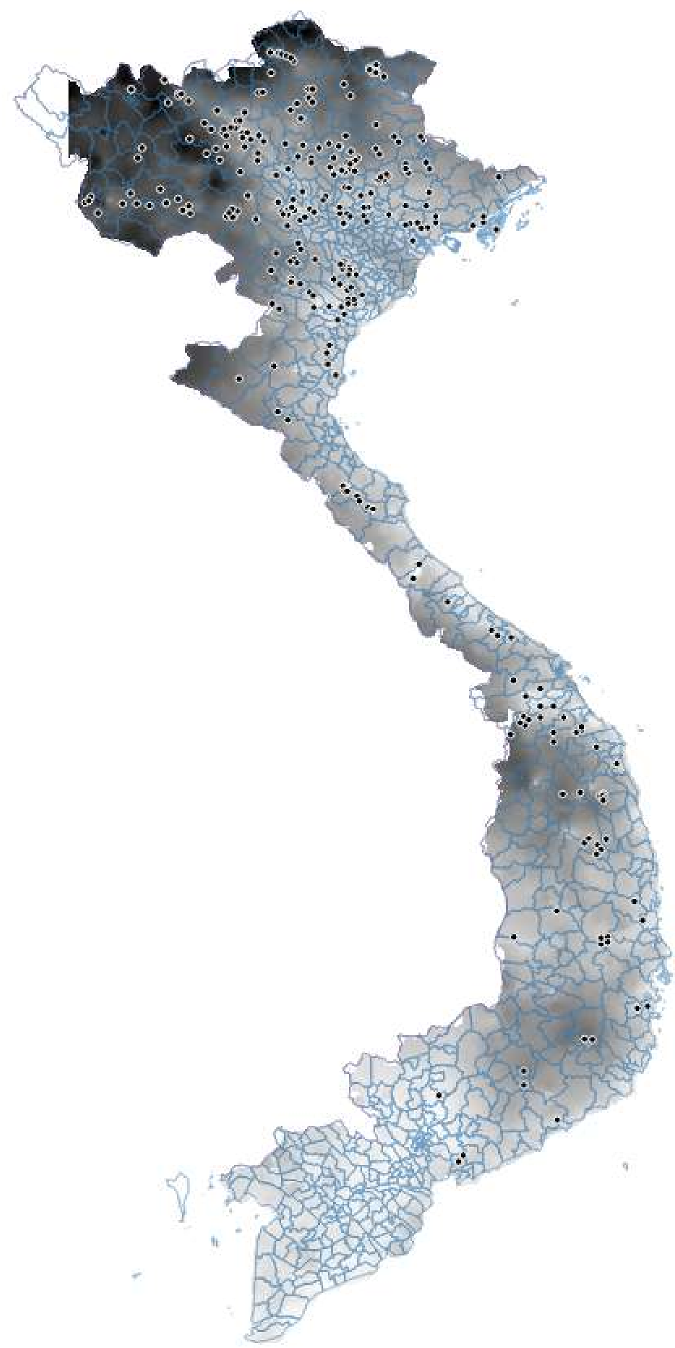

Figure 2 Spatial distribution of mineral deposits and magnetic anomalies in Vietnam

4. RESULT

4.1. Statistics description

Before turning to the causal estimations, I first examine descriptive statistics to compare districts with mineral discoveries ("treated") and those without ("untreated"). This comparison reveals substantial pre-treatment differences between the two groups, both in economic outcomes and in geographical characteristics. In 1992 (the baseline year), treated districts exhibit significantly lower average nighttime light intensity (4.20) than untreated districts (5.58), with a gap of approximately 1.38 units that is statistically significant at the 10% level. Notably, this gap widens by 2000, the difference in average nighttime light intensity between untreated and treated districts increases to 2.23 units and becomes statistically significant at the 5% level. As a consequence, nighttime light growth over the period 1992–2000 is substantially lower in treated districts. While untreated districts experience an average increase of 0.128, treated districts record an average growth of only 0.054, implying a difference of approximately 7.4 percentage points. From a practical perspective, these figures suggest that even prior to any causal analysis, districts where mineral deposits were discovered already exhibited systematically weaker economic growth, proxied by nighttime lights, than districts without discoveries.

These initial differences can be partially explained by disparities in geographical and climatic conditions. Consistent with the argument of Dou et al. (2022), treated districts tend to be located in more disadvantaged natural environments. The average terrain ruggedness index among treated districts is nearly twice as large (approximately 1.81) as that of untreated districts (0.97), and treated districts also exhibit significantly higher average elevation (0.300 versus 0.185 kilometers above sea level). This pattern indicates that mineral-rich districts are disproportionately located in mountainous and rugged areas, which have historically been less developed due to high transportation costs and limited access to markets (Nunn and Puga, 2012). Treated districts are also systematically located farther from the coastline, suggesting a more inland position and weaker access to trade routes and commercial centres. In addition, land quality and agricultural potential are less favourable in treated districts: the average caloric suitability index, a proxy for potential agricultural productivity, is lower in treated districts (24.15) than in untreated ones (25.48), and this difference is statistically significant. In other words, districts with mineral discoveries not only start from a lower level of economic development, but also face structural natural disadvantages such as less fertile land and greater remoteness, which may naturally constrain economic growth.

Climatic patterns further reinforce the spatial concentration of these differences. Untreated districts are much more likely to be located in tropical climates conducive to agriculture. For instance, 42.7% of untreated districts fall within the tropical savanna climate zone (Aw), compared to only 13.2% among treated districts. By contrast, the majority of treated districts (68.9%) are located in temperate climates with dry winters and hot summers (Cwa), a climate type prevalent in northern highland regions, whereas only about one-third of untreated districts fall into this category. These differences are statistically significant and highlight that mineral discoveries are concentrated in specific geo-climatic regions, particularly highland areas with temperate climates, while untreated districts are more commonly located in lowland tropical regions. This pre-existing heterogeneity underscores the importance of controlling for geographical and climatic factors and cautions against simple comparisons that may conflate the effects of mineral discovery with underlying regional characteristics. In sum, treated districts are initially poorer and more geographically disadvantaged than untreated districts, raising serious concerns about the plausibility of the parallel trends assumption in a standard Difference-in-Differences framework. This study addresses these concerns by incorporating relevant covariates and adopting more flexible econometric specifications, as discussed in the Method section.

Table 1 Variable description

Variables	Description	Mean	Std. dev.	Min	Max
Light 1992	Average intensity of light in year 1992	5.209	9.164	0.000	62.400
Light 1993	Average intensity of light in year 1992	5.381	9.053	0.000	63.000
Light 1994	Average intensity of light in year 1992	5.312	9.242	0.000	63.000
Light 1995	Average intensity of light in year 1992	6.287	10.118	0.000	63.000
Light 1996	Average intensity of light in year 1992	6.460	10.306	0.000	63.000
Light 1997	Average intensity of light in year 1992	7.243	10.994	0.000	62.429
Light 1998	Average intensity of light in year 1992	8.191	11.267	0.000	63.000
Light 1999	Average intensity of light in year 1992	8.465	11.516	0.000	63.000
Light 2000	Average intensity of light in year 1992	7.176	11.086	0.000	63.000
Light growth	Average intensity of light growth 1992 – 2000	0.108	0.402	-1.000	3.502
Ever treated	District had discovered at least one mineral deposit before 2000	0.268	0.443	0	1
Newly treated	District had discovered at least one mineral deposit 1992 to 2000	0.017	0.129	0	1
Terrain ruggedness	Average terrain ruggedness index	1.196	1.464	0.000	6.261
Slope	Average terrain slope	7.076	14.991	0.000	250.311
Elevation	Average elevation above mean sea level	0.216	0.309	0.001	1.545
Distant to coastline	Shortest bird-fly distant to coast	122.938	98.033	0.255	466.909
Caloric suitability	Potential agricultural productivity	25.121	2.462	15.855	31.505
Am	Tropical, monsoon	0.215	0.411	0	1
Aw	Tropical, savannah	0.348	0.477	0	1
Cwa	Temperate, dry winter, hot summer	0.430	0.495	0	1
Cwb	Temperate, dry winter, warm summer	0.008	0.092	0	1
Magnetic median		-16.436	30.980	-124.170	24.604
Observations	710				

Table 2 Summary statistics for main variables

	Untreated districts	Treated districts	Diff.	P-val on Diff.
Light 1992	5.579	4.198	1.381	0.075
Light 2000	7.772	5.547	2.225	0.018
Light growth	0.128	0.054	0.074	0.031
Terrain ruggedness	0.973	1.808	-0.835	0.000
Slope	6.840	7.722	-0.882	0.488
Elevation	0.185	0.300	-0.115	0.000
Distant to coastline	115.891	142.222	-26.331	0.001
Caloric suitability	25.477	24.147	1.330	0.000
Am	0.235	0.163	0.071	0.040
Aw	0.427	0.132	0.295	0.000
Cwa	0.335	0.689	-0.355	0.000
Cwb	0.006	0.016	-0.010	0.197
Observations	520	190		

4.2. Average treatment effect on the treated

This section presents robustness comparisons between specifications with and without covariates. Models that exclude covariates implicitly assume homogeneous growth trends across districts, an assumption that is unlikely to hold given the substantial pre-treatment differences documented previous section. I then estimate the causal impact of mineral discovery on local economic development using the staggered DID framework proposed by Callaway and Sant'Anna (2021). This approach allows treatment timing to vary across units and conditions on observed covariates, thereby relaxing the unconditional parallel trends assumption. The results are organized into four layers: (i) aggregated average treatment effects, (ii) cohort-specific (group-time) effects based on the year of first mineral discovery, (iii) dynamic effects by event time, and (iv) dynamic effects by calendar time. Throughout, we distinguish between specifications without covariates, relying on unconditional parallel trends, and those with covariates. Given the pronounced baseline differences between treated and untreated districts, estimates that condition on covariates are considered more credible.

The table below reports regression results with geographical controls. Estimates from the two-way fixed effects (TWFE) model suggest a statistically significant negative association between mineral discovery and economic growth. However, as shown in the subsequent staggered DID analysis, this negative effect weakens or disappears once treatment timing heterogeneity and covariate adjustment are properly accounted for. Comparing specifications with and without covariates thus highlights the importance of controlling for geographic and natural endowments when assessing the economic effects of mineral discoveries.

Table 3 Mining site discovery aggregated treatment effect (full sample)

A. Conditional average treatment effect					
	Partially aggregated				Single parameters
TWFE					**-1.905** **(1.153)**
Simple weighted average					0.543 (0.348)
Group-specific effects	**g = 1993**	g = 1994	g = 1995	g = 1996	
	0.826	0.594	0.310	0.579	0.524
	(0.149)	(0.837)	(0.632)	(0.747)	(.350)
Event study	e = 0	e = 1	e = 2	e = 3	
	0.383	-0.198	0.567	0.888	0.410
	(0.519)	(0.332)	(0.515)	(0.706)	(.4184)
Calendar time effects	**t = 1993**	t = 1994	t = 1995	t = 1996	
	2.317	-0.232	0.475	0.187	0.661
	(1.039)	(0.279)	(0.527)	(0.595)	(.319)
B. Unconditional average treatment effect					
	Partially aggregated				Single parameters
TWFE					**-3.792** **(1.054**)
Simple weighted average					-0.345 (0.620)
Group-specific effects	**g=1993**	**g=1994**	g=1995	**g =1996**	
	-1.665	**-1.109**	0.074	**-1.759**	-0.196
	(0.150)	**(0.138)**	(1.159)	**(0.106)**	(0.308)
Event study	e = 0	e = 1	e = 2	e = 3	
	-0.161	-0.230	-0.194	0.269	-0.079
	(0.114)	(0.389)	(0.642)	(1.286)	(0.550)
Calendar time effects	**t** = 1993	t = 1994	**t = 1995**	t = 1996	
	-0.066	-0.328	**-0.599**	-0.556	-0.312
	(0.098)	(0.303)	**(0.294)**	(0.423)	(0.511)

Notes: This table reports average treatment effect estimates of mineral deposit discoveries on district-level nighttime light intensity using a staggered difference-in-differences framework following Callaway and Sant'Anna (2021). Panel A reports estimates under the conditional parallel trends assumption, conditioning on time-invariant geographical and climatic covariates, while Panel B reports estimates under the unconditional parallel trends assumption. The row **"TWFE"** reports the coefficient on a post-treatment indicator from a conventional two-way fixed effects regression. The row "**Simple weighted average**" reports the weighted average of all available group-time average treatment effects (equation 3.2). The rows labelled "**Group-specific effects**" report average treatment effects by cohort, where g indexes the year in which a district first experiences a mineral deposit discovery (equation 3.3). The rows labelled "**Event study**" report average treatment effects by length of exposure to treatment, where $e = t - g$ (equation 3.4). The rows labelled "Calendar time effects" report average treatment effects by calendar year t. The column "Single Parameters" presents further aggregations of each type of treatment effect parameter. All estimates are obtained using the doubly robust inverse probability weighting estimator (DR-IPW). Standard errors are reported in parentheses.

Baseline result

As a benchmark, a standard Difference-in-Differences regression using a two-way fixed effects (TWFE) specification, imposing homogeneous treatment effects and using all untreated units as the comparison group, suggests a negative average impact of mineral discovery. In the TWFE model with district and year fixed effects, the post-discovery coefficient is approximately −1.905 (in nighttime light units) and statistically significant. This estimate implies that, on average, districts experience a decline in nighttime light intensity relative to trend following a mineral discovery. However, as discussed above, TWFE estimates can be biased in settings with heterogeneous treatment effects or staggered treatment timing. In particular, TWFE implicitly combines comparisons across cohorts and periods in a way that may place disproportionate weight on negative changes among later-treated units (Goodman-Bacon, 2021).

In contrast, when applying the estimator proposed by Callaway and Sant'Anna, which explicitly accommodates staggered adoption and conditions on covariates, we find no evidence of a uniform negative effect. The simple weighted average ATT, aggregating group-time treatment effects, is estimated to be positive but small, at approximately 0.543, and statistically indistinguishable from zero (0.348). In other words, once baseline differences across districts are properly accounted for and treatment effects are allowed to vary by cohort, the overall effect of mineral discovery on nighttime lights is close to zero. Although the point estimate reverses sign and becomes slightly positive, it is imprecisely estimated. The sharp contrast between the TWFE and staggered DID results highlights how a "naïve" DID approach can be misleading. After accounting for treatment heterogeneity, there is no clear evidence of an average mining discovery effect, neither a resource curse nor a resource boon, that applies uniformly across districts. Instead, the effects appear to be more nuanced and contingent on the timing of discovery and the number of years elapsed since discovery.

Group-specific Treatment Effects

The effects of mineral discovery are not homogeneous across districts; instead, they vary substantially with the timing of discovery. The cohort-specific ATT estimates (group-time effects) reported in Table 3 Mining site discovery aggregated treatment effect (full sample) reveal a strong positive effect for the earliest treated cohort, while little to no effect is observed for later cohorts. Districts that discovered mineral deposits in 1993, the earliest treated group in the sample, experienced a significant increase in nighttime light intensity relative to the control group. The estimated ATT for the 1993 cohort is approximately 0.826 with a small standard error (0.149), indicating a large and statistically significant positive effect at the 1% level. This finding suggests that early mineral discoveries were associated with substantial economic benefits by the late 1990s. The result is aligned with the argument of Matheis (2016), and can be interpreted as evidence that districts discovering mineral resources shortly after the onset of market-oriented reforms in the early 1990s were better positioned to attract investment, infrastructure development, or other economic spillovers, which translated into observable growth in nighttime lights.

In contrast, districts that discovered mineral deposits in 1994, 1995, or 1996 exhibit much smaller ATT estimates that are not statistically different from zero. For example, the estimated effect for the 1994 cohort is around 0.594 but with a large standard error (0.837), the effect for the 1995 cohort is even smaller, at approximately 0.310 (0.632). Similarly, the 1996 cohort shows an ATT of about 0.579 (0.747), which is also statistically insignificant. From a practical perspective, later mineral discoveries do not translate into clear economic improvements, or declines, by the end of the observation period. A plausible explanation is that later cohorts had less time for mineral discoveries to be translated into productive mining activities and associated economic outcomes before 2000. Mineral development typically involves lengthy processes of verification, investment, and infrastructure deployment, and the resulting benefits, such as employment creation, energy provision, and service-sector expansion, may take several years to materialize in the data. By 2000, the 1993 cohort had up to seven years of potential exposure to post-discovery effects, whereas the 1996 cohort had at most four years. The stark contrast between the strong positive effect for the 1993 cohort and the near-zero effects for the 1995-1996 cohorts therefore suggests that early interventions generate benefits only after a sufficient time lag, while later interventions may not yet have had time to take effect within the sample period.

Importantly, none of the cohorts exhibit statistically significant negative effects. That is, there is no evidence that mineral discovery harmed local economic development in any cohort.

Concerns about an immediate local "resource curse", whereby new mineral discoveries lead to economic decline, are not supported by these results. If anything, only the earliest cohort shows a clear positive impact. When aggregated, the average of the cohort-specific effects is approximately 0.524 and statistically insignificant, reinforcing the conclusion that the overall average effect of mineral discovery is close to zero. This aggregate masks substantial heterogeneity, combining positive effects for early discoveries with null effects for later ones. These findings underscore the value of the staggered DID design, a single pooled estimate would obscure this timing-based heterogeneity. Instead, the results highlight that timing plays a crucial role, potentially reflecting differences in policy environments, global commodity prices, or local readiness to exploit mineral resources across periods.

Event-time Treatment Effects

Next, I examine the dynamic path of treatment effects in event time, that is, how the impact evolves before and after mineral discovery. The event-study framework allows us to assess the plausibility of the parallel trends assumption and to detect dynamic patterns such as anticipation effects or delayed responses. Event-time ATT estimates are indexed by e, the number of years since the initial discovery. An event-study plot (Figure 4a) is constructed for the full sample, and the corresponding estimates are reported in Table 3. Notably, I find no evidence of diverging pre-treatment trends between treated and control districts in the years leading up to discovery, which is consistent with the conditional parallel trends assumption once covariates are included. At the year of discovery ($e = 0$), the estimated effect is positive but statistically insignificant, at approximately 0.383 nighttime light units (0.519). This suggests that mineral discovery, on average, is not accompanied by an immediate economic boom or downturn. This finding is intuitive, as discovery alone does not generate output or income in the absence of active extraction.

In the years following mineral discovery, the point estimates of the ATT increase gradually, suggesting a delayed positive effect; however, these estimates are imprecisely estimated. One year after discovery ($e = 1$), the estimated effect is slightly negative (–0.198) and statistically insignificant. Two years after discovery ($e = 2$), the ATT turns positive (approximately 0.567), and by three years after discovery ($e = 3$) it increases further to about 0.888, though with a large standard error. At e = 3, the magnitude of the point estimate is comparable to the cohort-specific effect for the 1993 discovery cohort, which is consistent with the idea that early-treated cohorts require several years to realize the economic benefits of mineral discovery. Nevertheless, even at e = 3, the estimated effect is not statistically significant at conventional, the monotonic increase in point estimates from near zero at e = 0 to positive values at e = 3 suggests that, if mineral discovery generates economic benefits, these benefits are likely to materialize with a lag, consistent with the typical timeline of mining projects.

Importantly, the confidence intervals of the dynamic treatment effects include zero at all post-treatment horizons, implying that no statistically robust positive effect can be established even three or more years after discovery. At the same time, there is no evidence of anticipation effects prior to e = 0, treated districts do not exhibit statistically significant upward or downward trends relative to the control group before discovery once covariates are conditioned on. Overall, the event-time analysis showed there is no immediate economic shock following mineral discovery, but there are indications of a gradually emerging positive effect over time, albeit not strong enough to draw firm conclusions within the 1992-2000 observation window. With data extending beyond 2000, it would be possible to assess whether treated districts eventually diverge from their counterfactual development paths. Nonetheless, the absence of any statistically significant negative post-discovery effects reinforces the conclusion that mineral discovery does not depress local economic activity in the short run.

Finally, we examine calendar-time effects to assess whether the estimated impacts coincide with particular years or common exogenous conditions. The Callaway and Sant'Anna framework allows ATT estimates to be aggregated by calendar year t, averaging the treatment effects across all units that have been treated by that year. The results do not reveal a consistent time pattern: for most years in the 1990s, the calendar-time ATT_t estimates are small and statistically insignificant. One notable exception is 1993, where ATT_{1993} is positive and statistically significant (2.317). This spike coincides with the large effect observed for the 1993 cohort, indicating that early-discovery districts generated a one-time divergence in that year. After 1993, calendar-time effects revert to values close to zero (for example, $ATT_{199} \approx 0.475$, statistically insignificant). This pattern suggests the absence of broad macroeconomic shocks during the latter half of the 1990s that differentially affected mining and non-mining districts; instead, the estimated effects are primarily driven by cohort timing. In sum, treatment effects are heterogeneous across cohorts and exhibit a delayed pattern over time, with only the earliest mineral discoveries generating a clearly positive economic impulse by the late 1990s. On average, after controlling for geography and treatment timing, mineral discovery does not produce a uniform effect on local economic development in Vietnam during this period.

4.3. Robustness test

To assess whether the main findings are driven by region-specific dynamics, particularly those associated with the Mekong Delta, we re-estimate all specifications after excluding districts in this region. Figure 4 compares the event-study profiles for the full sample (Figure 4.a) and the sample excluding the Mekong Delta (Figure 4.b).

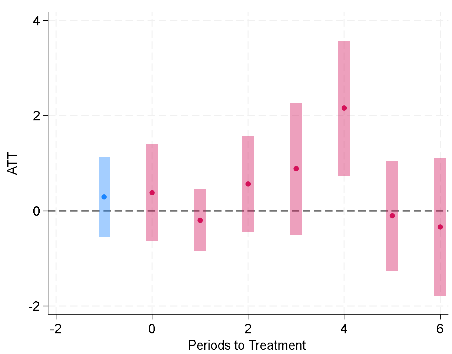

Figure 4.b Full sample

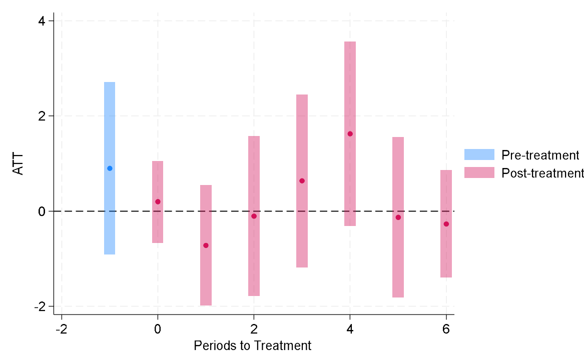

Figure 4.c Excluded Mekong Delta

Overall, the qualitative patterns remain unchanged. In both samples, the two-way fixed effects (TWFE) estimates suggest a negative average effect of mineral discovery, with larger magnitudes when covariates are not conditioned on. However, once the staggered DID framework is applied, the simple weighted average ATT is close to zero and statistically insignificant in both the conditional and unconditional specifications. This indicates that the negative TWFE estimates are not robust to accounting for treatment heterogeneity and differential timing. Excluding the Mekong Delta does not alter the main conclusion, there is no robust evidence of a uniform negative impact of mineral discovery on local economic activity. The similarity between the full-sample and excluded-sample results indicates that the baseline findings are not driven by the distinct agricultural or growth dynamics of the Mekong Delta, but rather reflect broader heterogeneity in the timing and local context of mineral discoveries.

Table 4

A. Conditional average treatment effect					
	Partially aggregated				Single parameters
TWFE					**-2.910** **(1.699)**
Simple weighted average					0.207 (0.539)
Group-specific effects	**g = 1993** **0.888** **(0.236)**	g = 1994 0.608 (0.457)	g = 1995 0.196 (1.152)	g = 1996 -1.285 (1.140)	 0.073 (0.413)
Event study	e = 0 0.198 (0.438)	e = 1 -0.719 (0.643)	e = 2 -0.105 (0.857)	e = 3 0.638 (0.924)	 0.003 (0.617)
Calendar time effects	**t = 1993** **2.300** **(1.039)**	t = 1994 -0.233 (0.268)	t = 1995 0.452 (0.600)	t = 1996 0.139 (0.715)	 0.426 (0.458)
B. Unconditional average treatment effect					
	Partially aggregated				Single parameters
TWFE					**-4.5778** **(1.1289)**
Simple weighted average					-.5534 (.6214)
Group-specific effects	**g = 1993** **-1.8012** **(.1923)**	**g = 1994** **-1.3589** **(.1750)**	g = 1995 -.1997 (1.1644)	**g = 1996** **1.5918** **(.1325)**	 -.3722 (.3137)
Event study	e = 0 -.2273 (.1205)	e = 1 -.3398 (.3848)	e = 2 -.3835 (.6452)	e = 3 .0393 (1.2861)	 -.2278 (.5515)
Calendar time effects	t = 1993 .0169 (.1216)	t = 1994 -.3025 (.2792)	**t = 1995** **-.7205** **(.2950)**	t = 1996 -.6758 (.4295)	 -.4650 (.5193)

Notes: This table reports average treatment effect estimates of mineral deposit discoveries on district-level nighttime light intensity using a staggered difference-in-differences framework following Callaway and Sant'Anna (2021). Panel A reports estimates under the conditional parallel trends assumption, conditioning on time-invariant geographical and climatic covariates, while Panel B reports estimates under the unconditional parallel trends assumption. The row **"TWFE"** reports the coefficient on a post-treatment indicator from a conventional two-way fixed effects regression. The row "**Simple weighted average**" reports the weighted average of all available group-time average treatment effects (equation 3.2). The rows labelled "**Group-specific effects**" report average treatment effects by cohort, where g indexes the year in which a district first experiences a mineral deposit discovery (equation 3.3). The rows labelled "**Event study**" report average treatment effects by length of exposure to treatment, where $e = t - g$ (equation 3.4). The rows labelled **“Calendar time effects”** report average treatment effects by calendar year t. The column “Single Parameters” presents further aggregations of each type of treatment effect parameter. All estimates are obtained using the doubly robust inverse probability weighting estimator (DR-IPW). Standard errors are reported in parentheses.

4.4. Extended results

In addition to the main staggered Difference-in-Differences analysis, this study implements two extensions to evaluate competing explanations in the literature and address remaining sources of endogeneity. The first extension examines the terrain hypothesis proposed by Dou et al. (2022), which attributes poor economic performance in mining regions to unfavourable geography rather than to mineral resources per se. The second extension adopts an instrumental variables strategy using a two-step GMM estimator to address potential endogeneity in the timing and location of mineral discovery.

4.4.1. Dou et al hypothesis

Table 4 reports a sequence of OLS regressions of nighttime light growth between 1992 and 2000 on a binary indicator for mineral discovery, progressively adding geographical and climatic controls. Column (1) presents a naïve specification without controls, where treated districts, defined as those that discovered at least one mineral deposit by 2000, exhibit significantly lower light growth. However, as terrain ruggedness, slope, elevation, distance to the coastline, agricultural suitability, and climate-zone fixed effects are introduced (columns 2–7), the coefficient on mineral discovery rapidly shrinks in magnitude and loses statistical significance.

At the same time, the geographical variables themselves enter with strong and stable effects. Terrain ruggedness is consistently negative and highly significant, while distance to the coastline and caloric suitability also display economically meaningful associations with light growth. These patterns strongly support the terrain hypothesis: once differences in underlying geography are accounted for, mineral discovery no longer appears to be systematically associated with poorer economic performance. The negative correlation observed in simple specifications is therefore likely driven by pre-existing geographic disadvantages rather than by the causal impact of mineral resources.

Table 5 OLS regressions of nighttime light growth and mineral discovery

Light growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treated district	-0.074**	-0.024	-0.019	-0.014	-0.014	-0.008	-0.017
	(0.031)	(0.030)	(0.030)	(0.031)	(0.030)	(0.029)	(0.029)
Terrain (ruggedness)		-0.060***	-0.067***	-0.093***	-0.115***	-0.109***	-0.092***
		(0.008)	(0.009)	(0.017)	(0.019)	(0.019)	(0.018)
Slope			0.002	0.002*	0.003*	0.003*	0.003**
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Elevation				0.140*	0.053	0.032	-0.061
				(0.075)	(0.082)	(0.086)	(0.086)
Distance to coastline					0.001***	0.001***	0.001***
					(0.000)	(0.000)	(0.000)
Caloric suitability						0.008	0.014**
						(0.006)	(0.006)
Am climatic zone							-0.113***
							(0.032)
Aw climatic zone							-0.045
							(0.032)
Cwa climatic zone							-0.029
							(0.048)
Cwb climatic zone							0.273*
							(0.143)
R^2	0.007	0.051	0.056	0.060	0.107	0.108	0.118
Observations	710	710	710	710	710	710	710

Note: Treated district is a binary indicator equal to one for districts that had discovered at least one mineral deposit by 2000, and zero otherwise. The dependent variable is nighttime light growth between 1992 and 2000. These OLS specifications serve as baseline correlations and do not account for treatment timing or unobserved heterogeneity. Standard errors in parentheses are robust and clustered at the district level. All regressions include a constant. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.4.2. Instrument variables fixed effect regression

While the staggered DID framework with covariates addresses many sources of bias, the timing and spatial allocation of mineral discoveries may still be endogenous. Geological exploration efforts may be systematically concentrated in certain areas, and unobserved factors, such as historical infrastructure plans or strategic priorities, could jointly affect both discovery and economic growth. To address this concern, following van de Ploeg and Xie et al., we implement an instrumental-variables approach using a two-step GMM estimator. The instrument is the median magnetic anomaly at the district level, which reflects subsurface magnetic irregularities generated by geological structures associated with metallic mineral deposits. In geophysics, magnetic anomalies are widely used to identify areas with mineral potential prior to detailed exploration. Crucially, magnetic anomalies are determined by long-run geological processes and are therefore plausibly exogenous to modern economic development. They affect the probability of mineral discovery, but have no direct channel through which they influence economic growth except via discovery and subsequent extraction.

In the first stage, magnetic anomaly strongly predicts whether a district experiences a first mineral discovery during 1992–2000, consistent with geological intuition. In the second stage, the predicted discovery indicator is used to estimate its effect on nighttime light growth. Table 5 reports the IV-GMM estimates for the full sample (column 1) and for a sample excluding districts in the Mekong Delta (column 2). Standard identification diagnostics, including the Anderson canonical correlation LM test, the Cragg–Donald Wald F statistic, and Anderson–Rubin weak-instrument-robust inference, indicate that the instrument is relevant and that inference is robust to potential weak-instrument concerns. Particularly, The Anderson canonical correlation LM statistics (14.14 for the full sample and 9.44 for the sample excluding the Mekong Delta) reject the null of underidentification, suggesting that magnetic anomaly provides meaningful variation for predicting mineral discovery. Similarly, the Cragg–Donald Wald F statistics (13.92 and 9.42, respectively) are close to or above conventional thresholds used to assess weak instruments in exactly identified or near-identified settings, indicating acceptable first-stage strength. In addition, the Anderson–Rubin Wald statistics, which provide inference robust to weak instruments, do not reject the null of no effect at conventional levels.

Turning to the second stage results, column (1) shows that for the full sample, the estimated effect of mineral discovery on nighttime light growth is positive (0.939) but imprecisely estimated, with a standard error of 0.829. The estimate is statistically indistinguishable from zero, indicating no robust evidence of an average positive or negative impact of discovery on local economic activity. In economic terms, the magnitude of the coefficient is modest and does not point to a large "windfall" effect associated with mineral discovery. When districts in the Mekong Delta are excluded (column 2), the point estimate becomes negative (−2.034) and marginally statistically significant at the 10 percent level. However, this estimate is accompanied by a relatively large standard error (1.077), and its magnitude remains sensitive to sample composition. Importantly, the confidence interval still includes economically moderate effects, and the sign change relative to the full sample suggests heterogeneity rather than a stable negative causal effect. This pattern is consistent with the idea that region-specific dynamics, rather than mineral discovery per se, may influence local economic trajectories.

The IV-GMM results closely align with the covariate-adjusted DID findings. In the full sample, the estimated effect of newly treated districts on nighttime light growth is positive but imprecisely estimated and statistically indistinguishable from zero. When excluding the Mekong Delta, the point estimate becomes negative and marginally significant, but remains economically modest and sensitive to sampling variation. Importantly, across specifications, confidence intervals include zero, and there is no evidence of a large positive windfall or a systematic negative "resource curse" effect. The consistency between the IV-GMM estimates and the staggered DID results strengthens the credibility of the identification strategy. If endogenous exploration were driving the null DID findings, one would expect IV estimates to differ substantially. Instead, the IV-GMM results confirm that any bias from non-random discovery is unlikely to mask a sizable causal effect. The IV estimates suggest that even for districts whose discovery status is shifted by geological potential, mineral discovery during the 1990s did not generate a statistically significant average impact on local economic activity.

Table 6 IV-GMM estimates of mineral discovery on nighttime light growth

Light growth	(1)	(2)
Newly treated	0.939 (0.829)	−2.034* (1.077)

Controls	Yes	Yes
Under identification test (Anderson canon. corr. LM statistic)	14.14	9.44
Weak identification test (Cragg-Donald Wald F statistic)	13.92	9.42
Weak-instrument-robust inference (Anderson-Rubin Wald F statistic)	1.39	5.53
Observation	703	571

Notes: Column (1) reports two-step GMM instrumental-variable estimates for the full sample, while column (2) reports corresponding estimates excluding districts in the Mekong Delta. The control variables include terrain ruggedness, average slope, mean elevation, distance to the coastline, caloric suitability, and climate zone fixed effects (Am, Aw, Cwa, and Cwb). Newly treated is a binary indicator equal to one if a district experienced its first mineral deposit discovery during the period 1992–2000, and zero otherwise, and is instrumented by the squared magnetic anomaly. Standard errors are robust.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Together, the extended analyses reinforce the main conclusions of the paper. The terrain-based regressions demonstrate that apparent underperformance in mining districts is largely attributable to unfavourable geography rather than to mineral discovery itself. The IV-GMM estimates address remaining endogeneity concerns and independently confirm the absence of a robust average effect. These results contribute to the resource economics literature by highlighting that mineral discovery is not an automatic economic turning point; instead, geography and timing play a dominant role in shaping local development outcomes.

5. CONCLUSION

This study examines the causal impact of mineral deposit discoveries on local economic development in Vietnam during the period 1992-2000, using district-level nighttime light data and a multi-period DID framework following Callaway and Sant'Anna. This approach allows for staggered treatment adoption across units and enables the estimation of heterogeneous treatment effects over time and across groups, thereby addressing common biases inherent in traditional two-way fixed effects models. The identical results on the average treatment effect across all treated units and periods fail to reject H0, implying that the overall impact of mineral discoveries on local economic activity is relatively small. Moreover, the additional Ha that mineral discovery generates short-run economic gains is not supported, event-time ATT estimates for up to three years after treatment provide no statistically significant evidence of immediate effects. In conclusion, there is no resources curse recorded at district level of Vietnam, conversely the discoveries of mining even positively affect the economics in the early stage of economy, and the scale of the effects are vary depending on the timing of discovery.

Furthermore, regression-based analyses show that districts in which mineral deposits were discovered differ substantially in their geographic and natural characteristics from districts without discoveries. When these factors are not controlled for, naïve estimates and TWFE models suggest the presence of a local "resource curse." However, once the conditional multi-period DID framework is applied, the results provide no evidence of a uniform average effect of mineral discovery. Instead, the estimated effects are highly heterogeneous. Positive impacts are concentrated among districts that experienced mineral discoveries earliest in the sample period, while later-discovery cohorts exhibit no statistically significant effects during the observation window. This pattern suggests that mineral discovery is not an immediate or universal economic shock, rather, its effects depend critically on the timing of discovery and the local geographic context.

An important robustness dimension of the analysis concerns the role of the Mekong Delta. Given its exceptionally fertile land, dense agricultural activity, and distinct development trajectory, the Mekong Delta may follow fundamentally different growth dynamics that could mask or dilute the effects of mineral discovery elsewhere. Re-estimating the main models after excluding all Mekong Delta districts yields results that are qualitatively consistent with the main findings. In particular, the staggered DID estimates, both conditional and unconditional, continue to show average treatment effects close to zero and statistically insignificant. This similarity indicates that the baseline null results are not driven by the unique agricultural advantages or growth patterns of the Mekong Delta, but instead reflect broader heterogeneity in treatment timing and geography across Vietnam.

In addition, the study extends the analysis by using magnetic anomaly as an instrumental variable to address endogeneity in mineral deposit discovery. The IV-GMM results align with the main findings, reinforcing the credibility of the identification strategy and confirming that the estimates are not driven by non-random selection into mineral exploration. Overall, the study demonstrates that natural resource discovery does not inherently lead to either an economic curse or a blessing at the local level. Instead, underlying geographic conditions and spatial heterogeneity play a central role in shaping post-treated economic early trajectories.

6. DISCUSSION

Future research direction: Future studies could expand the set of geological instrumental variables by combining magnetic anomaly with gravity anomaly. From a geological perspective, these two indicators capture different physical characteristics of the Earth's crust and are often used jointly in mineral exploration. While magnetic anomaly is sensitive to the presence of magnetically susceptible metallic minerals, gravity anomaly reflects variations in subsurface material density. Combining both measures could strengthen instrument relevance and allow for more stringent tests of the exclusion restriction. However, the present study is unable to incorporate gravity anomaly due to data access constraints, as the data provider indicates that gravity anomaly is considered sensitive for national defence and security purposes and therefore cannot be publicly released. If data access improves in the future, integrating these two types of geological anomalies would represent a substantial methodological contribution. In addition, future research could extend study period to examine the long-run effects of mineral deposit discoveries. The 1992–2000 period primarily captures short- and medium-run impacts, whereas key economic consequences of natural resources, such as structural transformation, capital accumulation, or environmental degradation, often materialize only in the long run. Although conducting an event-study analysis after 2000 is largely infeasible due to the limited number of newly discovered deposits, or because discoveries occurred mostly in districts that had already been treated, future studies could instead focus on the effects of extraction intensity or the volume of minerals exploited. Extending the study period, however, introduces new econometric challenges, particularly endogeneity arising from unobserved shocks. In such settings, an instrumental-variable strategy based on geological characteristics, as employed in this study, could continue to play a central role in addressing these endogeneity concerns, and would be even more powerful if gravity anomaly data were also available.

Limitation: The first limitation is the relatively small sample size due to the limited number of observations during the 1992–2000 period, which reduces the precision of some estimates. This may contribute to many estimates being statistically insignificant, even when the sign of the coefficients suggests that economically meaningful effects may exist. Second, as discussed above, the study is unable to incorporate gravity anomaly due to data access restrictions.

Relying solely on magnetic anomaly, while still exhibiting acceptable instrument relevance, may limit cross-validation across geological instruments. Third, the study does not account for spillover effects across districts. Recent studies indicate that economic development and the impacts of the mining sector exhibit spatial dependence (Moomen and Dewan, 2016; Ouedraogo, 2016). In cases where mining activities negatively affect the local economy through environmental damage or spending effects, they may simultaneously generate positive effects in neighbouring districts by supplying inputs to industrial areas at lower transportation costs, as documented for counties in Wyoming and Maine, United States (James and Aadland, 2011). These opposing forces may offset each other and result in statistically insignificant net effects. Therefore, future research should explicitly incorporate spatial spillovers to estimate the spillover effects of the mining sector.

Policy implication: The research finds no significant negative effect of mining site discovery, confirming that discovery itself does not immediately alter the local economic structure, but may instead operate through subsequent extraction activities. Mineral discoveries may even generate positive effects in the early stages of economic development, potentially by attracting investment once deposits are identified. Leveraging this advantage, Vietnam could strengthen communication and signalling around large-scale mineral discoveries to attract both domestic and foreign investment.

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APPENDIX

Explanation of Dutch disease Core Model with labour mobile

Figure 1 illustrated the labour market, where schedule L_S is demand for labour curve of service (non-tradable goods) sectors, L_T implied labour demand curve of tradable-goods-producing sectors, in which L_M is only demand for manufactured sector. The vertical axis respect to wage and horizontal axis is the number of labours in demand, thus the distant to O_S and O_T is the number of labour demand in service sector and tradable-goods-producing sector, respectively.

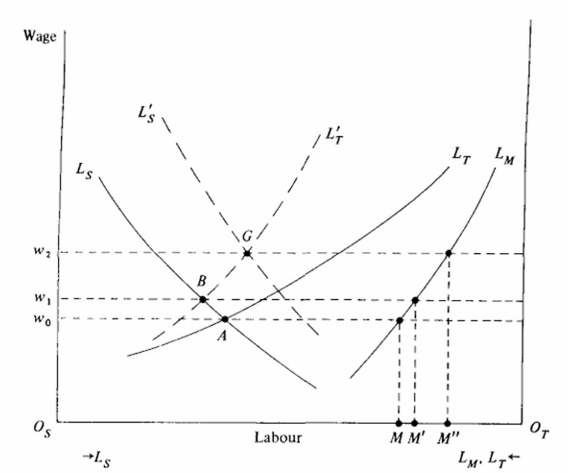

Fig. 1. Effect of the boom on the labour market.

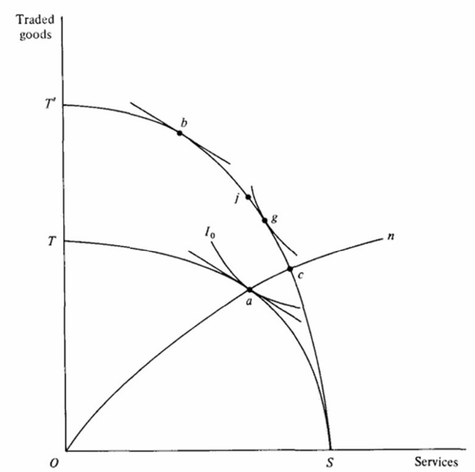

Fig. 2. Effect of the boom on the commodity market.

Figure from Corden & Neary (1982, p. 828-829)

Suppose there is a boom in energy sectors, for instance, a new oil field is discovered. A demand for labour in that sectors will rise, thus, shift the total labour demand curve of tradable goods upward to L'_T, meanwhile others manufactured L_M stay remaining. The new equilibrium point B changed from pre-boom equilibrium A, raise the wage rate from w_0 to w_1. Hence, labour move from service sectors and manufactured sectors to booming sectors, resulting in de-industrialize due to the decrease in manufactured labour. This is so-called *resource movement effect.*

Turning to Figure 2, where TS is the pre-boom production possibilities curve. Because the boom does not affect the services outcome but it increase the amount of possible output of tradable goods sectors, hence, shifts TS out asymmetrically to $T'S$. Now the new equilibrium c is the intersection of $T'S$ and income-consumption curve On, implied the demand for service goods rise along On curve. Respond to that situation, higher demand for labour in service sectors shift L_S schedule to L'_S. Wage one again raised tow_2, worsen *resource movement effect*