Chapter 2

Financing the Green and Just Energy Transition: Green Fiscal Policy for Just and Fair Transition to a Green Economy

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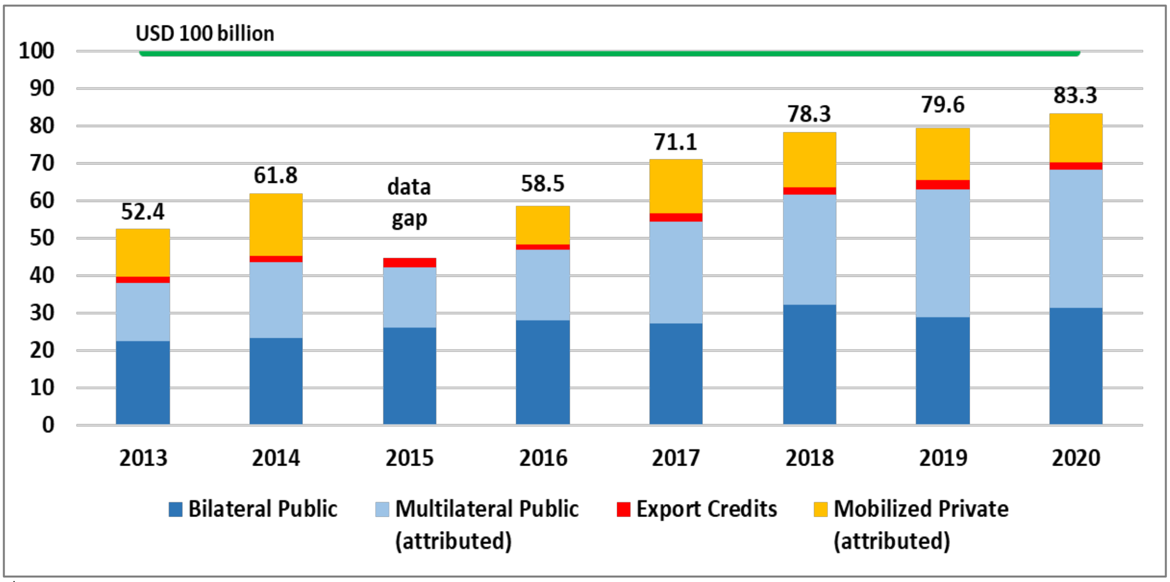
1. Introduction

1.1. Background

Green practices are essential to reduce environmental effects, adapt to climate resilience, save the planet, and improve quality of life. The amount of effort and sacrifice required from all nations worldwide to achieve this is challenging. Leaders of emerging economies demand that rich countries provide real financial contributions to reduce carbon emissions, reasoning that it is easier for advanced economies to adopt green transitions than emerging economies. These leaders are also critical of the demands of rich countries that emerging economies should contain their carbon emission rates. In parallel, development finance patterns are shifting from general funds to earmarked funds, and bilateral official development assistance is more common than multilateral assistance.

At the 15th Conference of the Parties of the United Nations Framework on Climate Change Conference (UNFCCC) in Copenhagen in 2009, developed countries committed to a collective goal of mobilising $100 billion a year for less wealthy nations by 2020 to help them adapt to climate change and mitigate further temperature increases. Regrettably, the funding promise was violated. The mobilisation of private climate finance was lower than anticipated (Figure 2.1) and mostly took place in middle-income countries with relatively conducive enabling environments and relatively low-risk profiles. The Organisation for Economic Co-operation and Development (OECD) reported that the amount was only $7.6 billion in 2019, including $14 billion from the private sector. Also, the multilateral development banks only committed $66 billion in 2020 with $38 billion to low-income and middle-income economies to support climate finance (OECD, 2022). Therefore, in anticipation that this trend will persist, emerging economies should investigate alternative sources of financing.

Figure 2.1. Aggregate Trends of Climate Finance Provided and Mobilised by Developed Countries
($ billion)



$ refers to US dollars.
Source: OECD (2022).

With the increasing concern about the threat of climate change amongst all nations, Indonesia continues to design a strategic plan to contribute substantially to addressing climate change issues. At COP26 in Glasgow in 2021, Indonesia signed the Global Coal to Clean Power Transition Statement agreeing to accelerate the net zero carbon emissions target by 2060. The Indonesian Ministry of Energy and Mineral Resources (MEMR) is examining opportunities for the early retirement of coal-fired power plants (CFPPs) (later known as the 'Coal Phase-Out' plan) with a total capacity of 9.3 gigawatts (GW) before 2030[1], which can be accomplished with a total of up to $48 billion in funding support. Specifically, the coal phase-out plan will be split into two schemes: 5.5 GW without a replacement for a renewable energy facility and 3.7 GW with a renewable energy replacement facility. The plan is referred to in Presidential Regulation Number 112 of 2022, on Accelerated Development of Renewable Energy for Electrical Supply (PR 112/2022). It states that the coal-based power plants (CFPP) will operate no later than 2050 while simultaneously fostering the development of renewable energy.

Although deciding not to be bound to stop issuing new licences, subject to special conditions, or to stop constructing CFPPs that do not use carbon capture and storage technology (i.e. unabated coal-fired power plant), Indonesia has shown determination to

[1] The Institute for Essential Services Reform estimates in IESR, Agora Energiewende, and LUT University (2021) that Indonesia must shut down CFPPs with a total capacity of 10.5 GW before 2030 (1.2 GW higher than the government's initial plan), to meet the Paris Agreement's 1.5°C global average temperature target.

take progressive steps toward decarbonising the energy sector and to promoting an equitable energy transition by expanding the use of renewable energy to offset the phasing out of CFPPs, thereby reducing the nation's vulnerability to future worldwide environmental crises, both in terms of risk and severity.

With cooperation from the Government of Indonesia's (GoI) Ministry of Finance and Ministry of State-Owned Enterprise, the National Energy Council and the MEMR are preparing a comprehensive road map and energy transition strategy in Indonesia. The primary objective is to progressively reduce reliance on fossil fuels (especially coal) while simultaneously expanding the capacity of renewable energy sources and maximising energy efficiency. The focus of the policy is to make renewable energy the primary option, thereby reducing the dependency on coal over time.

It is noteworthy that the implementation of the coal phase-out plan is complex to execute as it forces the GoI to decide between pursuing higher growth opportunities or prioritising environmental protection. In its latest update to the 2025–2045 National Long-Term Development Plan, the GoI has restated its ambition to achieve the targets set out in the Golden Indonesia 2045 Vision. Indonesia aims to escape the middle-income trap by 2041 through achieving an average national economic growth rate of 6%–7% per year from 2025, reaching a gross national income level of $23,000–$30,300 in 2045. This would be on a par with developed countries, reducing the poverty rate to less than 1%, and decreasing income inequality. To realise that vision, Indonesia needs to optimise all available resources, including abundant and comparatively low-cost fossil energy sources. According to the MEMR, coal contributed the most to the provision of primary energy in Indonesia in 2020 (38.46%), followed by oil and liquefied petroleum gas (32.82%), natural gas (17.44%), liquefied natural gas (11.28%), biofuel (3.8%), hydropower (3.16%), other renewable energy (2.11%), geothermal (2.01%), wind power (0.08%), solar power (0.05%), and biogas (0.01%). In short, the coal phase-out plan may require Indonesia to sacrifice a once-in-a-lifetime opportunity to achieve the country's 2045 vision. This is economically costly.

On top of that, the coal phase-out is financially costly to put into practice. The decision to implement the CFPP early retirement programme will necessitate significant funding from numerous parties. The GoI indicated that if completed before 2030, the early retirement of 5.5 GW CFPP and its replacement with a renewable energy facility will cost $25–$30 billion. In addition, the cost of investing in renewable energy and other forms of sustainable energy is estimated to be between $20–$25 billion per year until 2030 and will continue to rise thereafter. This increases the cost burden required to implement the coal phase-out plan and to develop renewable energy to achieve the goals stated in PR 112/2022 by 2050.

Indeed, the sooner the coal phase-out plan is implemented, the greater the GoI's opportunity to avoid the risk of financial losses from stranded assets in the CFPP sector, which is estimated to reach $26 billion after 2040. However, bringing forward the closure of CFPP was conditional on receiving sufficient financial help from multilateral institutions, the private sector, and developed countries to build new capacity into the renewable energy sector while ensuring electricity remains affordable when it switches to renewable sources. Only development partners, governments, and private sector operators from countries with a good reputation for addressing climate change will be considered for the blended green finance funding required for the coal phase-out plan.

Given this situation, it is necessary to assess the impact of implementing the coal phase-out plan in Indonesia in terms of economic cost. Few studies in recent years have estimated the costs required to implement the plan to phase out coal in Indonesia, and those studies that have been conducted have restricted the scope of the estimation to financial cost calculations. Assessing the economic impact is important because the cost burden of the coal phase-out plan is certainly greater than the aggregated calculations of the financial costs associated with closure, replacement, or investment in renewable energy. From a microeconomic standpoint, the coal phase-out plan could significantly affect the welfare of economic agents (i.e. households and firms). Filling in the cost calculation gap can provide a solid basis for formulating appropriate compensation policies (i.e. fiscal policies) in response to the implementation of the coal phase-out plan.

This study will assess the potential economic costs or losses that may result from the implementation of the coal phase-out plan and will produce long-term economic projections based on alternative scenarios to keep Indonesia's commitment to decarbonising the energy sector as realistic as possible. An empirical approach will be used to investigate how the coal phase-out plan may affect consumers (households) and producers (manufacturing firms), as well as the regulator of the public sector (government) using the following key measures: (i) changes in households' welfare, (ii) changes in firms' investment return, and (iii) changes in government tax revenues.

Recognising the need for large amounts of funding to implement the coal phase-out plan, as well as the fact that climate financing cannot be solely reliant on funds provided by international development partners that are less than what was promised, the GoI needs to take immediate action to anticipate the economic costs or losses associated with the coal phase-out plan. Designing an adequate fiscal policy framework that eases the just energy transition and accelerates the stages of the coal phase-out plan could be an essential first step. Hence, the analysis results of the economic losses calculation should be followed by proposed recommendations for fiscal policy options, adjusted to the most realistic scenario, with the objective to compensate for the negative effects of the coal phase-out plan on people and businesses.

In terms of fiscal policy discussion, this study will focus on how to innovate government spending and revenues with an emphasis on creating incentives for transitioning to a greener economy (e.g. lowering taxes on capital goods expenditures). Because of the broad range of green-oriented fiscal policies, the study will limit the scope of fiscal policy options discussed to those that intersect with areas of manufacturing firms' business investment, government taxes and subsidies, and households' income and consumption in relation to the coal phase-out plan. Finally, this study will analyse challenges and barriers to adoption of those proposed green fiscal policy options in Indonesia.

1.2. Research Objectives

The study has two research objectives. The first objective is to assess the economic impact of the operation of CFPPs and the economic losses caused by the coal phase-out plan's implementation. The second objective is to design feasible green-towards fiscal policies to compensate for, and finance, a rapid coal phase-out and just energy transition.

1.3. Research Contributions

This study provides two contributions. First, a well-documented policy framework for supporting the implementation of green and just energy transition in Indonesia is established. Second, we provide empirical evidence to advocate for a more pragmatic approach to implementing a coal phase-out strategy.

2. Policy Context

2.1. Coal Phase-Out Worldwide

Coal transition began in 2015, when the United Kingdom (UK) became the first government to implement a coal phase-out strategy, putting out the plan ahead of the 2015 Paris climate summit.

However, the concept of coal phase-out has garnered significant traction amongst nations worldwide in the last few years, due to growing concern about climate change and its adverse environmental impact. All the scenarios prescribed by the Paris Agreement to achieve the 1.5 degrees Celsius temperature rise limit necessitate a swift reduction in coal consumption (International Energy Agency, 2021a). According to estimations from the International Energy Agency, unabated coal usage in the global energy sector must decline by 55% by the year 2030 and be completely phased out by 2040 to achieve carbon neutrality by 2050 (International Energy Agency, 2021b).

There is a notable upsurge in the global impetus toward coal phase-out. During COP26, a resolute commitment was made to relegate coal power to the annals of history. This commitment was exemplified by 47 nations signing the Global Coal to Clean Power Transition Statement, accompanied by 11 countries, including Indonesia, announcing fresh phase-out pledges. These Glasgow Breakthroughs have been embraced to ensure that clean power emerges as the most cost-effective and dependable alternative for all countries to meet their power requirements efficiently by 2030.

The consequences of coal phase-out are something that many countries need to consider. It impacts the economy in several ways, including triggering a decline in economic activities (Trencher, et al., 2022), jobs losses (Burke, Best, and Jotzo, 2019; ILO, 2022; Vogt-Schilb and Feng, 2019), and damaging social-cultural identity (McDowall, 2022). The impact will be more severe in those areas which are dependent on coal for their economic activities. Unstable coal prices could create severe economic problems for those areas that are reliant on coal, and it could create problems of stranded assets for the power sector (Gray et al, 2018). Thus, every country needs to prepare an enabling environment before deciding to implement a coal phase-out policy.

Several countries, such as Canada, Germany, and the UK, have successfully implemented a coal phase-out policy that includes policy measures to mitigate the cost of phasing out coal from the economy. In addition to strategies that all of the countries implemented, fiscal policy was one of the enablers for success, ensuring the transition was smooth. The fiscal policies of Canada, Germany, and the UK are shown in Table 2.1.

Table 2.1. Fiscal Policy for Coal Transition from Benchmarking Countries

Countries	Fiscal Policy Measures
United Kingdom	▪ Carbon tax ▪ Compensation for ex-miners and community (training and jobs opportunity outside mining) ▪ Reclamation ▪ Infrastructure investment
Germany	▪ Compensation payment for power plant ▪ Social security for employee ▪ Subsidy for grid charge after 2023
Canada	▪ Carbon tax ▪ Compensation for coal power companies to develop gas and renewable energy power plant ▪ Support for workers (pension bridge, training, counselling, etc.)

Source: Compiled from Brauers, Oei, and Walk. (2020), Macintyre (2014), Fothergill (2017), Littlecott, Uise Burrows and Skillings. (2018), Oei et al., (2020), Agora Energiewende and Aurora Energy Research (2019), Keles and Yilmaz (2020), and Krawchenko and Gordon (2021).

The coal phase outs in Canada, Germany, and the UK yield insightful lessons that demonstrate the intricate nature of such endeavours, highlighting the range of forces at work, including environmental imperatives, economic realignments, and regulatory initiatives. A salient lesson is the indispensability of a holistic approach that embraces robust stakeholder engagement, well-structured policy frameworks, nuanced mitigation strategies for adversely affected communities, and judiciously adjustable temporal frameworks. Effective communication strategies that explain the rationale and growing benefits of the policy, alongside international collaboration and cross-learning, also increase efficacy. The importance of significant investment in innovative solutions, research, and steadfast long-term planning is pivotal, and reinforces the complex and interwoven fabric that characterises coal phase outs and their intricate socioeconomic ramifications.

The Russia–Ukraine conflict has become one of the major hurdles to implement the coal phase-out agenda. The conflict creates additional concerns about energy security for countries in the European Union while opening opportunities for fossil fuel producing countries. The conflict has meant that Russia, previously the leading supplier of natural gas, coal, and oil to the European Union countries, has disturbed the energy market, leading to energy security issues for many European countries. Germany, for instance, who had a clear commitment to phase out coal by 2038 has sought alternative sources of energy than Russia's natural gas by reviving two coal power plants, while the Czech Republic has revived their coal mining activities for energy security[2]. The situation has also opened opportunities for coal producing countries to continue their activities as there are potential buyers for the coal. Thus, the coal phase-out plans of several coal producing countries may be in jeopardy if they are not supported by ambitious renewable energy.

2.2. Coal Phase-Out in Indonesia

In 2021, President Joko Widodo announced a net zero emission target of 2060 and ordered the state electricity company, *Perusahaan Listrik Negara* (PLN), to stop building new coal plants outside of the projects agreed in the 2021–2030 *Rencana Usaha Penyediaan Tenaga Listrik* (Electricity Supply Business Plan). At COP26, Indonesia also agreed to the Global Coal to Clean Power Transition Statement, which contains a pledge to move away from sustainable coal power generation by the 2040s or sooner. Later in 2022, the government announced the Indonesia Energy Transition Mechanism (ETM) Country Platform, and the Just Energy Transition Partnership (JETP) — a commitment to mobilise $20 billion in public and private capital to reach peak electricity sector emissions in 2030 and reach net zero in 2050. In the same year, the government also released PR 112/2022. Its provisions for the acceleration of the delivery of renewable energy to produce electricity has become the legal basis for the government's support for the coal phase-out initiatives.

Indonesia is the 7th largest nation in terms of the number of CFPPs deployed (Cui et al.,

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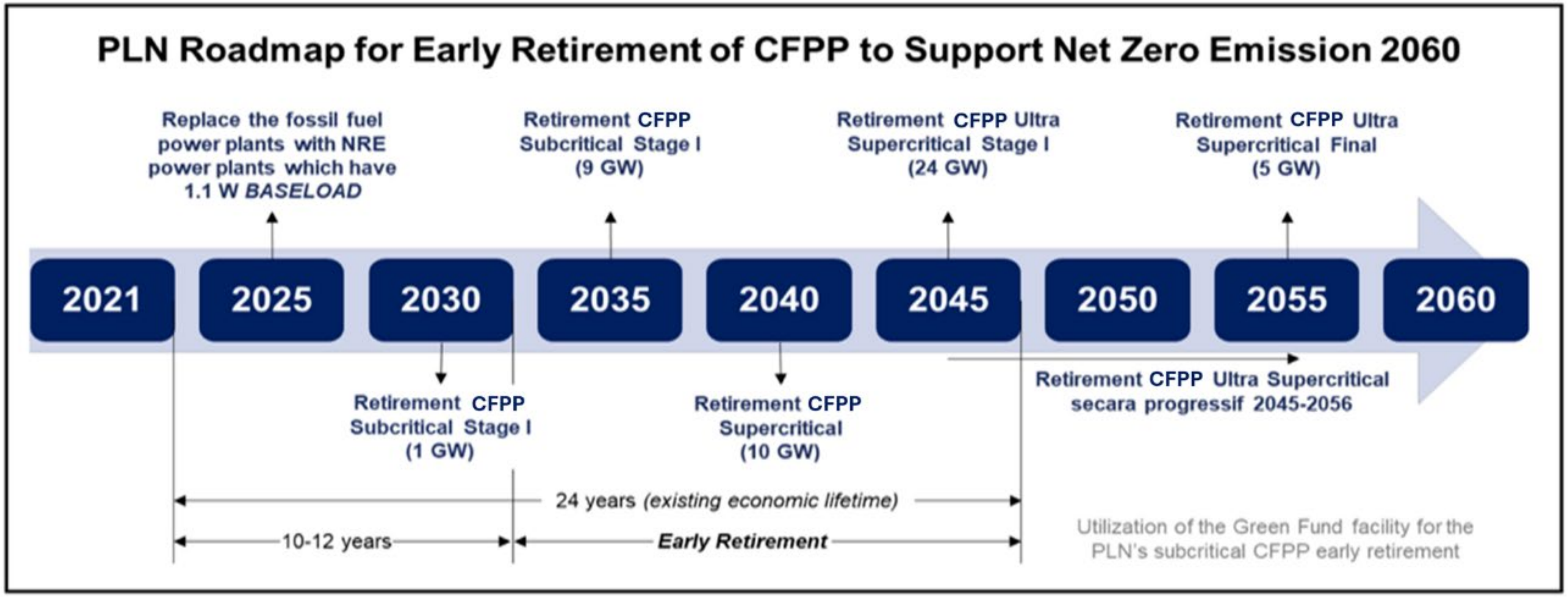
[2] Euronews.green (2022).

2022), boasting a current operational count of approximately 86 CFPPs, collectively yielding an installed capacity of 40.2 GW as of 2022 (MEMR, 2023). Predominantly concentrated within the Java, Bali, and Sumatra regions, these operating CFPPs produce a substantial surplus capacity in relation to historical benchmarks and precedent standards. Given this, careful consideration should be given to curtailing or deferring new generation capacity until there has been a resumption of load growth to pre-pandemic levels. This is anticipated to materialise around 2029–2030 (Fiscal Policy Agency, 2023). In response, there has been a collaborative effort between the MEMR and PLN, culminating in the development of a comprehensive retirement strategy for these power plants. Characterised by a phased approach, PLN's preliminary scheme envisions the phased retirement of an initial 1 GW of power plants before 2030, followed by a series of subsequent retirements extending until 2055, culminating in the decommissioning of the final unabated CFPP. This intricate trajectory aligns with Indonesia's aspirations to achieve its net zero emission 2060 targets (Figure 2.2).

Figure 2.2. State Electricity Company Pathway for Coal Fired Power Plant Early Retirement



CFPP = coal-fired power plant; GW = gigawatt; NRE = New and Renewable Energy; PLN = State Electricity Company - *Perusahaan Listrik Negara*.
Source: Fiscal Policy Agency (2023).

2.3. Fiscal Policy Instruments

Coinciding with COP26 in 2021, President Joko Widodo took a significant step by signing Presidential Regulation No. 98/2021 on The Implementation of Carbon Pricing to Achieve the Nationally Determined Contribution Target and Control over Greenhouse Gas Emissions in the National Development (PR 98/2021). This regulation focuses on the carbon economic value for achieving nationally determined contribution targets and for controlling greenhouse gas (GHG) emissions. It is widely recognised that this regulation will play a pivotal role in helping Indonesia reach its GHG emission reduction targets, as outlined in the Nationally Determined Contribution (NDC) for climate control. Moreover, the regulation, known as the Carbon Economic Value Presidential Regulation, is expected to serve as a catalyst for increased funding and investment in initiatives that promote environmentally friendly practices, ultimately leading to a reduction in GHG emissions.

PR 98/2021 lays out the government's strategies for deploying economic tools to both mitigate climate change and adapt to it. A notable instrument is the Tax Regulation Harmonization Law, known as Law No. 7 of 2021. The introduction of the carbon tax is designed to incentivise economic entities to shift towards low-carbon green economic activities or to decrease their emission outputs. The carbon tax is set to be implemented from 2025, initially targeting the CFPP sector through a cap-and-tax emission-based taxation mechanism. The stipulated tax rate stands at a minimum of Rp30 or around $2 per kilogram of carbon dioxide (CO_2), in accordance with the provisions outlined in Law No. 7 of 2021 concerning Tax Regulation Harmonization.

3. Empirical Results

3.1. Impact of Coal-Fired Power Plants on Economic Development

This section presents the results of the empirical estimation of the impact of operating CFPPs on economic development from a macro-level perspective and discusses the implications of the findings. The results will serve as a benchmark before predicting the impact of CFPPs at micro level, i.e. on households and manufacturing firms.

Tables 2.2 and 2.3 show compact estimation results of the impact of operating CFPPs on gross domestic product (GDP) at the provincial level in Indonesia in the period 1976–2022, examining four specifications and using level and log transformations of GDP as a measurement indicator, respectively. As the numbers of the provincial GDP have been proportionally weighted to be comparable with the national GDP, it is argued that the estimated coefficient can also be indicative of the national level to some extent.

Table 2.2. Impact of Operating Coal-Fired Power Plants on Growth Rate

Independent Variables	Dependent Variable: Provincial GDP (log)			
	(1)	(2)	(3)	(4)
Presence of CFPP	1.336***	1.029***	-0.009**	-0.014**
(1 if implemented, 0 otherwise)	(0.076)	(0.088)	(0.005)	(0.005)
Control variables	No	Yes	Yes	Yes
Fixed effects for regions	No	No	Yes	Yes
Fixed effects*linear trends	No	No	No	Yes
Adj. R-square	0.166	0.190	0.999	0.999
Observations	1536	1536	1536	1536

CFPP = coal-fired power plant; GDP = gross domestic product.
Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Standard errors are reported in parentheses.
Source: Authors' calculation (2023).

Column 1 in Tables 2.2 and 2.3 records results from the unconditional staggered difference-in-differences (DID). Column 2 considers control variables for the number of active CFPPs in operation and their characteristics, for example: the accumulated capacity of electricity generated by CFPPs, the combustion technology used by CFPP, heat rates, capacity factors, emission factors, annual CO_2 production, and the CFPP's lifespan. Other relevant variables are included such as the population level, the GDP ratio of the agricultural sector to the manufacturing sector, the classification of eastern–western zones, the number of provinces that rely on coal extraction, and the year of economic decentralisation and regional proliferation. All variables are measured at the provincial level. Several dummies that historically caused economic disturbances (e.g. the Asian Financial Crisis 1997–1998, the Global Financial Crisis 2007–2008, and the coronavirus disease (COVID-19) pandemic, are also incorporated into the model. Column 3 presents the results of the regression accounting for fixed effects for years and provinces. Column 4 includes region-specific linear trends to account for possible systematic differences in trends across regional–distribution service offices pairs defined by PLN. In particular, when the dependent variable is in logarithmic form as presented in Table 2.3, the effect of the CFPPs is represented as a percentage change by $100(e^{\beta}-1)$.

The estimation results in Table 2.2 provide an interesting finding. The unconditional staggered DID estimates a positive effect of approximately $14.5 billion on GDP level which statistically differs from zero. In terms of log GDP, the effect is quantified as a point estimate of 1.34.

Table 2.3. Impact of Operating Coal-Fired Power Plants on Gross Domestic Product

Independent Variables	Dependent Variable: Provincial GDP ($ billion)			
	(1)	(2)	(3)	(4)
Presence of CFPP	14.470***	4.952**	-9.460***	-3.440***
(1 if implemented, 0 otherwise)	(1.791)	(2.031)	(1.676)	(1.212)
Control variables	No	Yes	Yes	Yes
Fixed effects for year and province	No	No	Yes	Yes
Fixed effects for regional*linear trends	No	No	No	Yes
Adj. R-square	0.040	0.089	0.693	0.914
Observations	1536	1536	1536	1536

$ refers to US dollars; CFPP = coal-fired power plant.
Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Standard errors are reported in parentheses.
Source: Authors' calculation (2023).

Nevertheless, both estimates are overestimated since adding more controls and fixed effects provides lower estimates. Column 2 controls for time-variant covariates, providing lower estimates by one-third (i.e. seven-tenths in logarithmic form). One possible explanation is that the time-variant provincial characteristics correspond to the likelihood of being part of the CFPPs but tend to increase the economic output. Column 3 adds year and province to capture time-specific shocks and time-invariant differences, respectively. Surprisingly, the inclusions alter the previous estimates in Columns 1 and 2, with the estimated effect indicating the opposite direction and resulting in a relatively smaller effect. It suggests that the presence of active CFPPs is likely to have a negative relationship with GDP level. The point estimate is statistically significant at the 5% level.

At this point, interpretation should be taken with caution because the DID regression model provides a quasi-experimental setting that employs longitudinal data from treatment and control groups to produce an appropriate counterfactual condition in estimating the causal effect. Instead of asserting that the presence of CFPPs would lead to a decrease in the GDP level, it is more acceptable to explain that GDP will grow further but will result in higher reported figures in the absence of CFPPs operation.

Finally, the last column adds regional–distribution service specific linear time trends, resulting in an adjustment to a reduced point estimate. The active CFPPs operation is now associated with a lower GDP level by an average of 1.4% or roughly equivalent to a $3.44 billion reduction per year at 2010 constant prices, *ceteris paribus*, serving as our baseline estimate. In comparison to the realised GDP level of Indonesia (2022) in a constant local currency price unit, the estimated impact contributed by CFPPs operation in a specific province will result in a proportionate number of 0.26% of national GDP.

Further, presuming that the CFPP locations are currently expanding to 27 out of 34 provinces, the total annual impact on average would be predicted to reach $92.88 billion per year. The figures are proportional to 7.13% of Indonesia's real GDP in 2022.

There are several explanations for the empirical results. First, in the long run, operating CFPPs will significantly increase GHG emissions (e.g. CO_2 and methane) and will contribute to global warming and climate change through more frequent and severe natural disasters that damage ecosystems and infrastructure, disrupt economic activities, and increase human suffering. All of these, in turn, can reduce economic growth. Various economic sectors (e.g. agriculture, fisheries, tourism, health, and infrastructure) may be negatively impacted by climate change. More large-scale carbon emissions emitted by the CFPPs also trigger rising temperatures, which can increase the risk of drought since at higher temperatures, water dissipates more rapidly resulting in dryer soil. Dryer soil will lower crop yield output and livestock productivity, and these effects can reduce income, exacerbate poverty, reduce growth in the agriculture sector, as well as other specific economic sectors with stronger backward and forward linkages to this sector, and ultimately will have a negative impact on national welfare and economic development.

Second, CFPPs can reduce GDP growth by harming the environment and human health. Producing pollutants such as particulate matter, sulphur dioxide, nitrogen oxides, and mercury can cause respiratory diseases, cardiovascular problems, neurological disorders, and premature deaths. The health and environmental costs of coal pollution can reduce GDP by lowering human productivity, increasing health expenditure, and degrading social welfare (Rokhmawati et al, 2023).

Finally, the CFPPs influence GDP because they can impede investments in cleaner and more efficient energy sources, including renewable ones. CFPPs rely on a limited, non-renewable resource that is susceptible to coal price fluctuations due to changes in demand and supply, geopolitical factors, and environmental regulations. These variables can increase the price of coal-based electricity generation and create uncertainty for investors and consumers. On top of that, CFPPs have high capital costs and long lifetimes, which lock in carbon-intensive infrastructure for decades. CFPPs can reduce the flexibility and resilience of the power system to cope with changing demand patterns and limit the potential for economic diversification and technological innovation in low-carbon sectors.

The rationale for the results of the estimation is consistent with prior research. CFPPs will have a positive impact on the ratio of GDP-to-investment cost (Hartono et al., 2020) but it will still be less than renewable power plants such as geothermal, wind, and hydro energy. Moreover, the results are consistent with previous research on the effects of carbon dioxide emissions on economic growth. For instance, Dong, Xu, and Fan (2020) demonstrated a long-term equilibrium relationship between industrial structure upgrading, economic growth, and carbon emissions – in which an increase in carbon emissions will restrict the promotion of industrial structure upgrading and have a detrimental impact on economic growth. The results are also supported by Narayan and Narayan (2010) who found that the country's long run income elasticity is smaller than the elasticity in the short run and found that the long-term impact of CO_2 emissions reduces developing countries' economic growth as their income elasticity in the long-term is less than in the short-term.

However, this study acknowledges a limitation caused by the presence of spatial spillover effect which may cause a potential bias in estimation. Emissions produced by CFPPs can exceed inter-regions because they are not confined by provincial boundaries. The pollutants can travel across the atmosphere and affect the climate of other provinces or the larger region. Hence, the estimated coefficient could be underestimated at the province level. However, as the provincial GDP is weighted to the national average, the potential bias of aggregate impact can be minimised and is still within acceptable ranges.

3.1.1. Heterogeneity Analysis

To gain a deeper understanding of the estimation results, the benchmark specification (last column in Tables 2.2 and 2.3) is employed on different subsamples based on the setting of emission standards for CFPP in the Association of Southeast Asian Nations (ASEAN) region (Nian, Kresnawan, and Suryadi, 2021). The purpose is to observe the different effects of the CFPPs on economic levels and growth in each subsample which are categorised into two divisions: (i) subcritical CFPPs, and (ii) non-subcritical CFPPs which includes supercritical and ultra-supercritical types.

Table 2.4 reports the estimates, revealing consistent estimates of coefficients but differing size of magnitudes between subsamples. The characteristics are twofold. First, both in terms of GDP level and log GDP, the subcritical CFPPs have a larger estimated impact compared to the non-subcritical CFPPs. The results align with the fact that subcritical CFPPs are less efficient and generate more emissions than their supercritical and ultra-supercritical counterparts. Second, the effects statistically differ from zero, except for the non-subcritical CFPPs subsample. This finding emphasises the disadvantages of using subcritical CFPPs that are associated with less advanced technology.

Table 2.4. Estimated Impact on Economic Level and Growth (Subsamples) of Operating Coal-Fired Power Plants

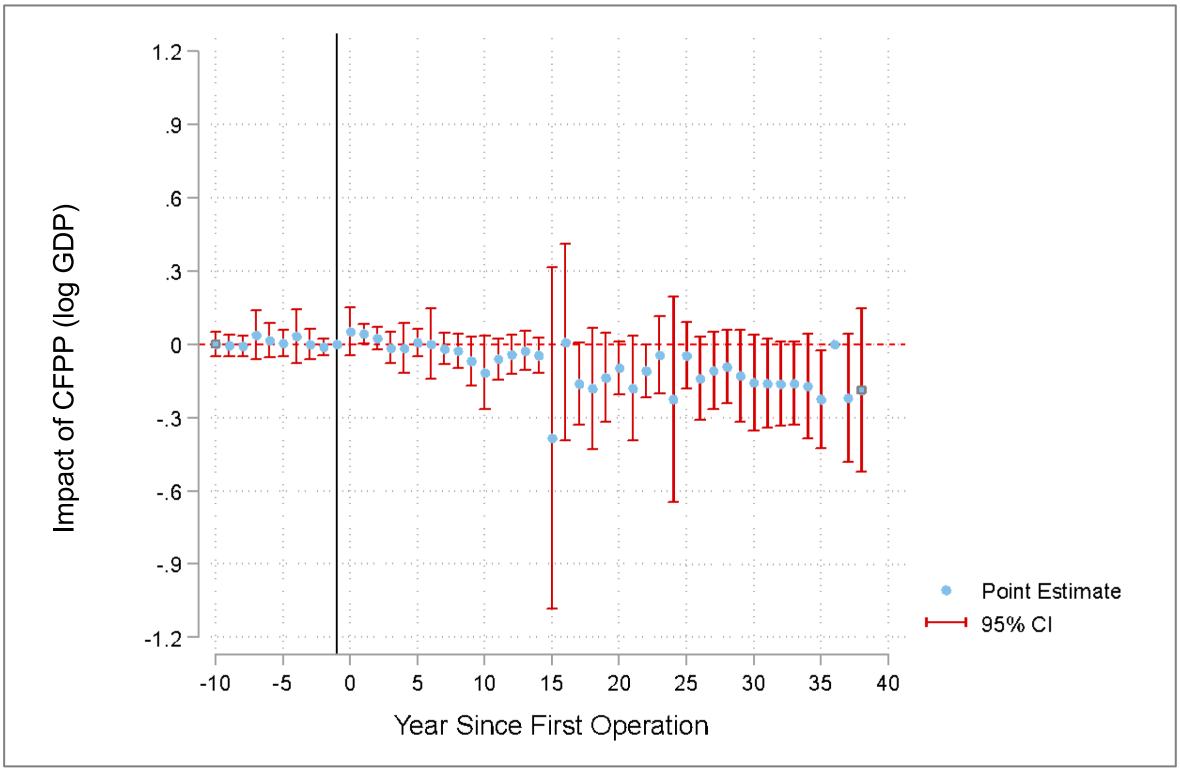
Independent Variables	Dependent Variable: Provincial GDP			
	GDP Level ($ billion)		Log GDP	
	Only Subcritical	Excluding Subcritical	Only Subcritical	Excluding Subcritical
	(1)	(2)	(3)	(4)
Presence of CFPP	-4.125***	-2.835	-0.023***	-0.012
(1 if implemented, 0 otherwise)	(1.284)	(1.909)	(0.005)	(0.008)
Control variables	Yes	Yes	Yes	Yes
Fixed effects for regions	Yes	Yes	Yes	Yes
Fixed effects*linear trends	Yes	Yes	Yes	Yes
Adj. R-square	0.914	0.914	0.999	0.999
Observations	1520	1588	1520	1588

$ refers to US dollar; CFPP = coal-fired power plant; GDP = gross domestic product.; US = United States.
Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Standard errors are reported in parentheses.
Source: Authors' calculation (2023).

3.1.2. Dynamic Treatment Effects

The structure of the dataset used in this study allows for an examination of the dynamic treatment effects of the presence of CFPPs activities. Figure 2.3 presents these effects over time. The results indicate that the effects on GDP were positive in the short run but tended to be negative in the long run with the magnitude of the effects growing over time.

Figure 2.3. Event Study Analysis: The Dynamic Effect of Coal-Fired Power Plants on Economic Development



CFPP = Coal-fired power plant; CI = Confidence interval; GDP = Gross domestic product.
Source: Authors' calculation (2023).

The full sample estimate shows that the effect ranges from 2.4% to 5.2%, which is statistically significant at the 5% level for the first three years since the CFPPs have been fully operational. After the third year of operation, point estimates are toward negative values but statistically not different from zero. On average, the effect becomes statistically significant at the 10% level when the CFPPs have been in operation for 17 years. A plausible explanation for why the impact is likely to revert to an upward trend in some periods of observation could be the establishment of new additional CFPPs in the respective locations which can balance the diminishing benefits of existing units. However, the overall trend of the dynamic effect of CFPPs on economic development is decreasing. This result suggests that the economic benefits of CFPPs as an alternative energy source for electricity generation cannot be maintained for a prolonged period unless technological advancements can improve efficiency and manage the negative externalities (Raihan et al., 2023). The figure also reveals that the parallel trend, an important assumption for the DID regression model, is likely to hold. An anticipatory effect is undetected since the point estimates for the lead term are statistically insignificant (i.e. *p*-value is 0.4222).

The result also suggests that the dynamic effect is heterogeneous across CFPPs and more evident for subcritical CFPPs subsample. Figure 2.4 suggests that the downward trend of dynamic estimate for subcritical CFPPs declines faster than the non-subcritical group. This finding raises concerns regarding the issuance of a CFPPs establishment and operation licence permit, in which the public policy stakeholder should take the minimum technological aspect of CFPPs into account. Last, the dynamic effect results broadly validate our baseline findings that the negative effect of CFPPs on economic development continues to grow over time.

Figure 2.4. Event Study Analysis: The Dynamic Effect of Coal-Fired Power Plants on Economic Development

(a) Subcritical Coal Fired Power Plant Subsample

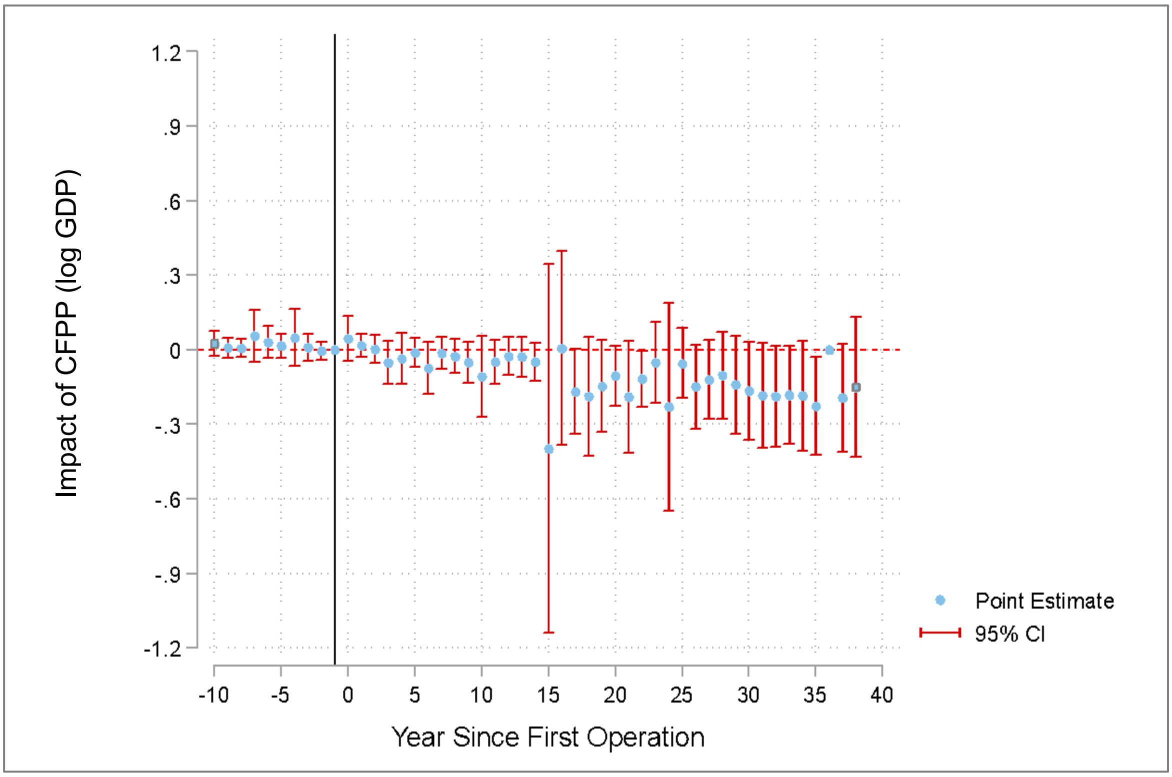
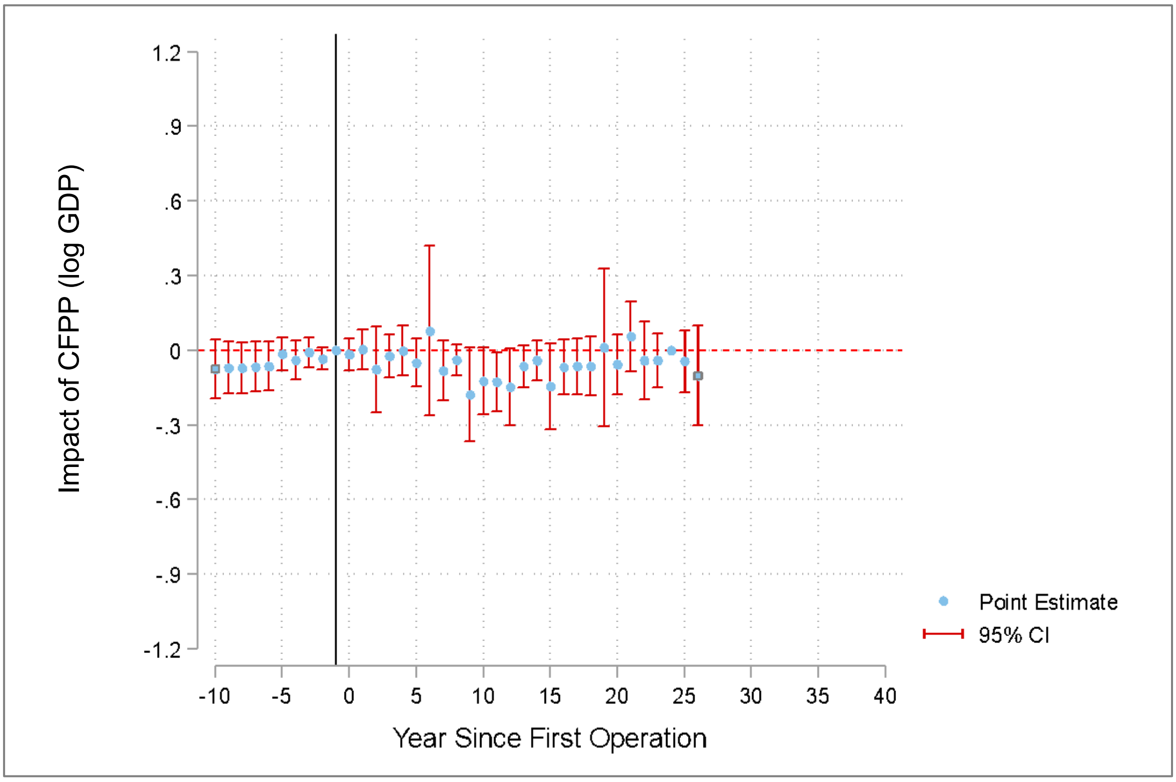


Figure 2.4. *Continued*

(b) Supercritical and Ultra-Critical Coal Fired Power Plant Subsample



CFPP = Coal-fired power plant; CI = Confidence Interval; GDP = Gross domestic product.
Source: Authors' calculation (2023).

3.2. Impact of Coal-Fired Power Plants on Households

This section discusses the estimation results of the presence of CFPP on household expenditure. Table 2.5 shows the results of estimating household expenditure indicators, based on the presence of CFPPs, at household level for the period 2011–2022, examining four different specifications. It also considers average monthly household expenditure and its logarithmic forms as outcome variables, respectively. Column 1 presents the unconditional staggered DID. Column 2 adds control variables including average household size, percentage of household heads with high school diplomas or higher, percentage of household heads working in the formal sector, and percentage of gross regional domestic product (GRDP) from the mining sector. Column 3 adds district and year fixed effects. Column 4 includes district-specific linear trends. In Panel B, as the dependent variable is in logarithmic scale, we can interpret the resulting coefficients as the percentage change in the monthly household expenditure.

Table 2.5. Impact of Coal-Fired Power Plants on Household Monthly Expenditure

	Dependent Variable: Monthly Household Expenditure			
	(1)	(2)	(3)	(4)
Panel A: Dependent Variable at Level				
Presence of CFPP	17.499***	13.999***	50.989***	48.244***
(1 if implemented, 0 otherwise)	(0.414)	(0.398)	(2.689)	(2.693)
Adj. R-square	0.000	0.077	0.155	0.156
Observations	3640146	3640146	3640146	3640146
Panel B: Dependent Variable at Log				
Presence of CFPP	0.075***	0.063***	0.174***	0.168***
(1 if implemented, 0 otherwise)	(0.001)	(0.001)	(0.006)	(0.006)
Adj. R-square	0.001	0.109	0.260	0.261
Observations	3640146	3640146	3640146	3640146
Control Variables	No	Yes	Yes	Yes
FE for year and district	No	No	Yes	Yes
FE for regional*linear trends	No	No	No	Yes

CFPP = coal-fired power plant; FE = fixed effects; GDP = gross domestic product.
Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Standard errors are reported in parentheses. Control variables include average household size, percentage of household heads with a high school degree or higher, percentage of household heads working in the formal sector, and percentage of GDP from the mining sector.
Source: Authors' calculation (2023).

Table 2.5 Panel A shows the impact of CFPP operation on the average monthly household expenditure for the period 2011–2022. The unconditional model shows positive and significant effects (Column 1); however, this figure is likely to suffer from bias. Subsequent regressions using various sets of control variables reduce the magnitude of the effect. Column 2 shows the results after controlling for district characteristics which were likely to affect both treatment and outcome variables. Column 3 adds district and year fixed effects to control for time-invariant heterogeneity within each district as well as common linear trend across districts. Adding further adjustment in the form of interaction terms between region and year fixed effects refines our point estimates of the CFPP impact on household expenditure in Column 4. Using the full specification in Column 4, the average monthly expenditure of households in CFPP districts is around $48.24 higher than that of households in non-CFPP districts.

The positive and statistically significant effects hold when the same model is estimated with the logarithmic form of monthly household expenditure, as shown in Table 2.5 Panel B. Results from all four different specifications follow the same general patterns seen in Panel A. As the dependent variable is in logarithmic scale, the resulting coefficients can be interpreted as the percentage change in total household expenditure. Column 4 presents the model with a full set of controls, showing that households in CFPP districts spend about 0.168% more each month on average than those in non-CFPP districts.

To put these estimated effects into context, we calculate the monetary benefit received by households in CFPP districts per year and compare the resulting figure with the 2022 GDP for comparison. We consider only the coefficient from the fully specified level model (Panel A Column 4). Multiplying the estimated coefficient by the total number of households in CFPP districts, the positive effect on household expenditure is estimated to reach approximately $7.95 billion per year at the national level. This figure is proportional to 0.84% of the 2022 real GDP.

Table 2.6 presents the estimation results of the impact of CFPPs in the district on the average monthly household electricity expenditure. The model specification mirrors that of Table 2.5. Looking at the full specification, we find that the presence of CFPPs is associated with higher average monthly household electricity expenditure by around $1.77 (Panel A Column 4). Upon estimating the same model using the logarithmic form of monthly household electricity expenditure, we observe that the average monthly electricity expenditure of households in CFPP districts is approximately 0.257% higher compared to households in non-CFPP districts (Panel B Column 4). These effects are statistically significant at 1% level.

Table 2.6. Impact of Coal-Fired Power Plants on Average Monthly Electricity Expenditure

	Dependent Variable: Monthly Household Electricity Expenditure			
	(1)	(2)	(3)	(4)
Panel A: Dependent Variable at Level				
Presence of CFPP	1.147***	1.054***	1.902***	1.771***
(1 if implemented, 0 otherwise)	(0.018)	(0.018)	(0.118)	(0.118)
Adj. R-square	0.001	0.053	0.157	0.157
Observations	3640146	3640146	3640146	3640146
Panel B: Dependent Variable at Log				
Presence of CFPP	0.151***	0.141***	0.252***	0.257***
(1 if implemented, 0 otherwise)	(0.002)	(0.001)	(0.009)	(0.009)
Adj. R-square	0.003	0.106	0.313	0.314
Observations	3373979	3373979	3373979	3373979
Control variables	No	Yes	Yes	Yes
FE for Year and District	No	No	Yes	Yes
FE for Regional*Linear Trends	No	No	No	Yes

CFPP = coal-fired power plant; FE = fixed effects; GDP = gross domestic product.
Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Standard errors are reported in parentheses. Control variables include average household size, percentage of household heads with a high school degree or higher, percentage of household heads working in the formal sector, and percentage of GDP from the mining sector.
Source: Authors' calculation (2023).

3.3. Impact of Coal-Fired Power Plants on Manufacturing Firms

This section presents the results of the empirical estimation of the impact of operating CFPPs on manufacturing firms' performance at the micro-level and discusses the implications of the findings. The results serve as a basis to measure the economic impact of developing baselines and alternatives to a coal phase-out scenario.

Table 2.7 shows a compact estimation result of the impact of operating CFPPs on manufacturing firm's return on investment (ROI) in Indonesia during the period 2000–2020, using level and log transformations of ROI as a measurement indicator and examining four specifications of each. The observation of analysis is at firm level, categorised based on the UN Statistics Division 2-digits codes of the International Standard Industrial Classification (ISIC) of all economic activities.

Table 2.7. Impact of Operating Coal-Fired Power Plants on Manufacturing Firms' Return on Investment

Independent Variables	Dependent Variable: ROI (level)			
	(1)	(2)	(3)	(4)
Presence of CFPP	0.249***	0.274***	0.231***	0.160**
(1 if implemented, 0 otherwise)	(0.027)	(0.037)	(0.046)	(0.066)
Control variables	No	Yes	Yes	Yes
Fixed effects for year and firms	No	No	Yes	Yes
Fixed effects for regional*linear trends	No	No	No	Yes
Adj. R-square	0.001	0.001	0.090	0.135
Observations	109284	109284	109284	109284

Independent Variables	Dependent Variable: ROI (log)			
	(1)	(2)	(3)	(4)
Presence of CFPP	0.038***	0.056***	0.045***	0.031***
(1 if implemented, 0 otherwise)	(0.004)	(0.006)	(0.006)	(0.009)
Control variables	No	Yes	Yes	Yes
Fixed effects for year and firms	No	No	Yes	Yes
Fixed effects for regional*linear trends	No	No	No	Yes
Adj. R-square	0.001	0.001	0.213	0.301
Observations	109284	109284	109284	109284

CFPP = coal-fired power plant; ROI = return on investment.
Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Standard errors are reported in parentheses.
Source: Authors' calculation (2023).

Column 1 depicts the results from the unconditional staggered DID. Column 2 considers control factors for company size in terms of number of employees, total quantity of kilowatt hours of electricity used to conduct production operations, and the total units and characteristics of active CFPPs within the regions where the firms are located (for example, accumulated capacity of electricity generated as well as combustion technology used by those CFPPs). Several dummies that historically caused economic disturbances (e.g. the Asian Financial Crisis 1997–1998, the Global Financial Crisis 2007–2008, and the COVID-19 pandemic), are also incorporated into the model.

Column 3 presents the results of the regression accounting for fixed effects for years and province. Column 4 includes region-specific linear trends to account for three possible systematic differences in trends, namely: ISIC–province pairs, ISIC-province pairs, and firm-province pairs. When the dependent variable is in logarithmic form, the effect of the CFPPs is represented as a percentage change by $100(e^{\beta}-1)$.

The estimate results in Table 2.7 are as anticipated. The unconditional staggered DID estimates that the presence of CFPP operations has a 0.249-point positive impact on firms' return investment on average, which statistically differs from zero. As the ROI has already been expressed as a percentage unit, the coefficient can be directly interpreted as percentage point changes. In terms of log ROI, the effect is quantified as a 3.8% increase.

The estimates in Column 1 seem to be overestimated since adding more controls provides lower estimates, except in Column 2 when no fixed effects are included. The effect of time-varying firm characteristics on ROI is stronger when covariates are controlled for, which leads to a higher estimate. Column 3 adds year and firm fixed effects to capture time-specific shocks and time-invariant differences, respectively, which provides lower estimates.

Finally, the last column adds ISIC–province pairs, ISIC-province pairs, and firm-province specific linear time trends, thereby correcting for an upward bias and resulting in lower estimates. The active CFPPs operation is now associated with an increase in ROI level by an average of 0.16 percentage point – *ceteris paribus*, serving as our baseline estimate. In the absence of CFPPs operation, under the counterfactual setting, the manufacturing firms would have a lower ROI rate.

Although literature suggests that the impact of CFPPs on manufacturing firms' ROI is complex and depends on various factors (e.g. Abeberese, 2017; Dong, Xu, and Fan, 2020). The presence of CFPPs can benefit Indonesia's manufacturing sector in several ways. Possible explanations for the empirical results are set out below.

Due to its characteristics, CFPPs have advantages over other power resources in terms of cost-effectiveness, constant energy, and reliability factors to meet energy consumption needs and to supply electricity during peak power demand as either base power or off-peak power to help the grid system avoid outages. This is especially advantageous for manufacturing firms whose machinery and equipment require a stable and consistent electricity supply (e.g. iron, steel, textiles, cement, fertiliser, and paper factories). With a lower risk of power outage, the firm spends less money on repairs and maintenance of machinery and equipment, making them more durable for long-term use. This enables the firm to streamline costs and create a larger net profit, resulting in a higher ROI. The research of Xu, et al. (2022) supports this explanation, indicating that electricity supply is crucial for the profitability and productivity of businesses. Grainger and Zhang (2019) suggest that more reliable electricity supply within a region would substantially boost local manufacturing firms' outputs, thereby contributing to an increase in the ROI.

To obtain a more intuitive explanation, we attempted to calculate the monetary value of a ROI experienced by manufacturing firms that gain a positive impact from the presence of CFPPs. Multiplying the estimated coefficient by the total realised investment of each firm within their respective treatment periods, the positive impact on ROI is estimated on average at $7.87 million per firm per year or annually equivalent to a total of $43.6 billion at the national level. In comparison to the realised GDP level of Indonesia (2022) in a constant local currency price unit, the figures are proportional to 3.34% of Indonesia's real GDP in 2022.

To provide a broader insight into the impact of CFPPs on manufacturing firms, the benchmark specification (last column in Tables 2.7) is used to analyse whether there is an impact on the firm's electricity consumption. In addition, a heterogeneity analysis is performed to fully understand the estimation results by employing the benchmark specification (last column in Tables 2.7) on different subsamples on varying sizes of manufacturing firms in terms of total workers (e.g. medium-size firms and larger-size firms) according to the Central Bureau of Statistics of Indonesia criteria.

Table 2.8 reveals consistent estimates of coefficients but differing sizes of magnitude between subsamples. The presence of CFPPs have influenced the manufacturing firms to increase their electricity consumption by an average of 14.3%, *ceteris paribus*. Interestingly, the effect is statistically significant and more pronounced for large-sized firms than for medium-sized firms. This finding demonstrates that large manufacturing firms can benefit more from the presence of CFPPs. As the CFPPs provide a cost-effective, reliable, and sufficient electricity supply, manufacturing firms can utilise their machinery and equipment at higher rates.

Table 2.8. Estimated Impact of Operating Coal-Fired Power Plants on Manufacturing Firms' Electricity Consumption (Subsamples)

Independent Variables	Dependent Variable: ROI (log)		
	All Sample	Medium-size Firms	Large-size Firms
	(1)	(2)	(3)
Presence of CFPP	0.143***	0.070	0.194***
(1 if implemented, 0 otherwise)	(0.038)	(0.044)	(0.052)
Control variables	Yes	Yes	Yes
Fixed effects for firms	Yes	Yes	Yes
Fixed effects*linear trends	Yes	Yes	Yes
Adj. R-square	0.371	0.428	0.282
Observations	109284	53626	55108

CFPP = coal-fired power plant; ROI = return on investment.
Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Standard errors are reported in parentheses.
Source: Authors' calculation (2023).

3.4. Estimating the Economic Cost of Accelerating the Coal Phase-Out Plan in Indonesia

In this subsection, we develop three different scenarios to evaluate the economic cost consequences of implementing the coal phase-out plan or not, and also take into account various implementation schedules when deciding to implement it. Scenarios one and two will be explored first.

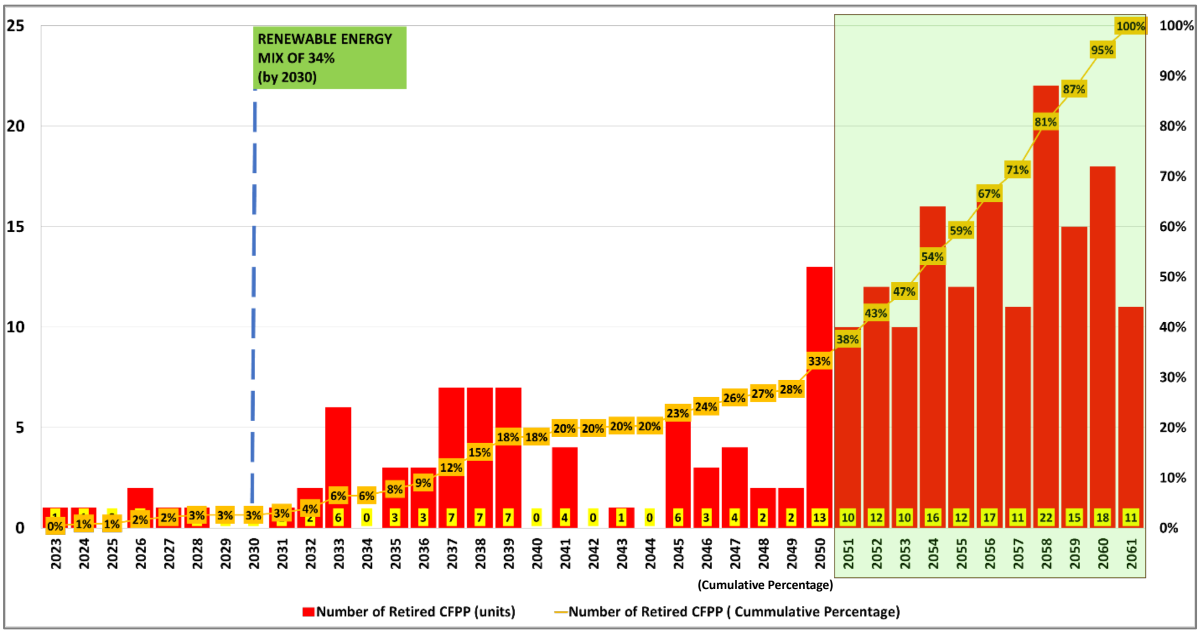
The first scenario is to abandon the coal phase-out plan option. In this model, the coal phase-out plan will not be accelerated at any cost and thus can be viewed as business-as-usual. No new permits or licences will be issued by the government for the additional establishment of CFPPs. The transition to renewable energy sources will occur when the CFPPs reach the end of their lifespan and need to be replaced.

The second scenario involves taking action towards the coal phase-out plan. In that model, the coal phase-out plan will be accelerated. However, the timing of implementation can vary. For example, accelerating the execution of a plan by a few years depends on the economic life usage of CFPPs. As a consequence, the economic costs associated with accelerating the planned execution timeline will vary depending on how early the plan is started. Another consideration is that the switch to renewable energy sources will happen in proportion to the amount of electricity capacity supply that needs to be replaced on time for every gigawatt of electricity lost when an extra CFPP unit shuts down early.

The economic cost of accelerating the coal phase-out plan will include: (i) the retirement cost of CFPPs; (ii) the investment cost of electricity power capacity replacement generated by renewable energy sources; and (iii) the losses of economic benefits for the impacted economic agents due to the presence of CFPPs, – i.e. households and manufacturing firms. The sum of these costs will be considered the total economic costs that should be compensated if the government decides to move forward with the coal phase-out plan to meet its emission reduction commitment.

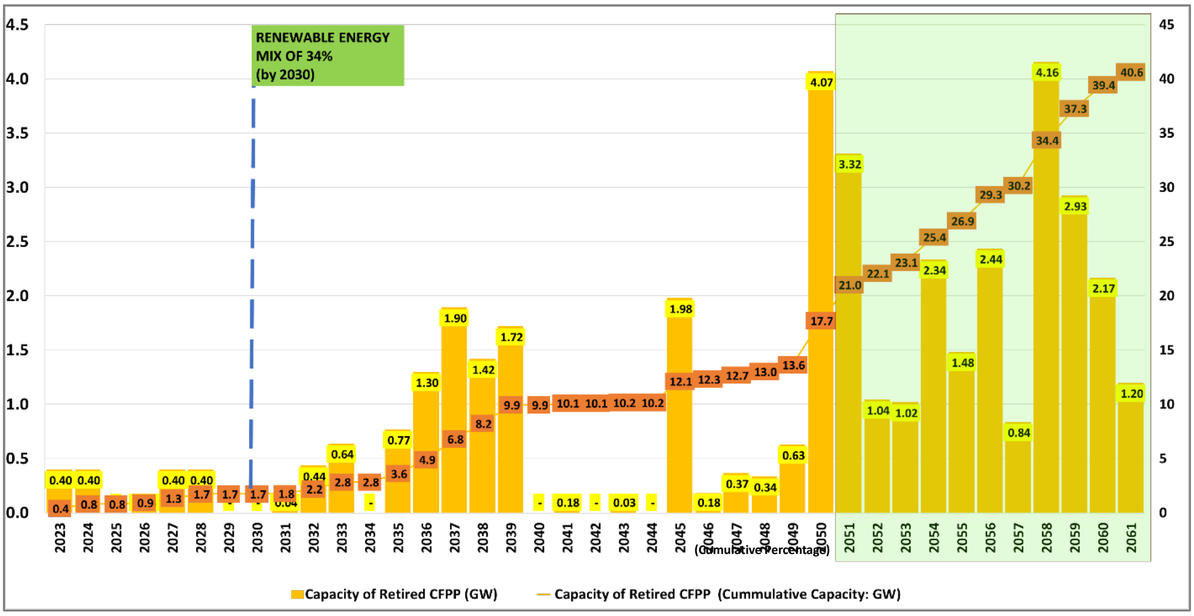
The first scenario, i.e. no implementation of a coal phase-out has a timeline for the natural path of the CFPP's operation period. The natural path sets out conditions where all CFPP units are permitted to operate until they reach the maximum limit for year of operation or economic lifetime usage. For this stage, we utilise the Global Coal Plant Tracker data collected by the Global Energy Monitor, which contains a list of existing active CFPPs in Indonesia that are currently operational. Figure 2.5 depicts the pattern of the natural path of these CFPPs' retirement since 2023, assuming they are permitted to operate at their maximum economic lifetime utilisation. Meanwhile, Figure 2.6 shows the pattern of the natural path in terms of CFPPs' GW capacity.

Figure 2.5. The Natural Path of Retirement for Current Active Coal-Fired Power Plants in Indonesia



CFPP = Coal-fired power plant.
Source: Authors' calculation (2023), based on Global Energy Monitor (2022).

Figure 2.6. Power Capacity Loss Due to the Natural Path of Retirement for Coal-Fired Power Plants in Indonesia



CFPP = Coal-fired power plant; GW = gigawatt
Source: Authors' calculation (2023), based on Global Energy Monitor (2022).

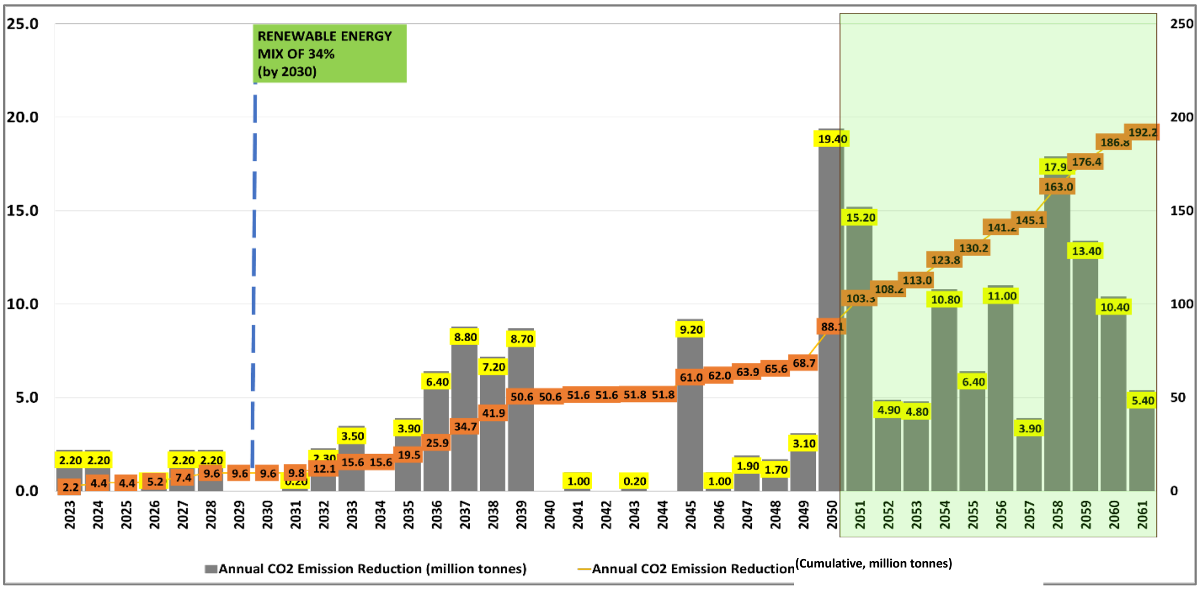
According to the natural path of CFPPs economic lifetime, 77 units (about 33% of the total number of active CFPPs) are expected to retire by late 2050. Because there are no active CFPPs currently being retired early, the only costs that arise are those of providing new renewable energy-based power plants to substitute those CFPPs due to retire at a specific point in the future. According to the GoI's plan to enable a high share of renewable energy into its national power system based on the projected load and demand growth (Ordonez, Fritz, and Eckstein, 2022), this might be effectively implemented by 2030. Consequently, during this period, there will be compensation costs involved for households and manufacturing firms as they will not be able to swiftly obtain access to new, alternative power supplies, at least not until the establishment of renewable energy-based power plants that are available to all and commercially operated.

As shown in Figure 5, the GoI will confront the dilemma of coal phase-out in the post-2050 period, when approximately 154 units, or 67% of the total number of CFPPs, are in line to normally discontinue their operation. However, the PR 112/2022 has already regulated that the CFPPs will operate no later than 2050, meaning that the 'do nothing' policy cannot be an option. The longer the CFPPs operate, the longer their negative effects on the environment will persist (i.e. the air will become dirtier due to pollutant emissions while the public's awareness of the importance of a clean environment will increase).

This, then, will be the starting point to construct the second scenario, which simulates the acceleration of the coal phase-out plan by up to eleven years from the normal time of CFPP retirement. In that way, the aim of the coal phase-out plan is to shut down all CFPPs that will be still in operation after 2050.

The third scenario is to allow those CFPPs to retire beyond 2050 and thus continue operating them until they reach their maximum economic lifetime. Eliminating the negative externalities of CFPP (i.e. reducing CO_2 emissions) should be addressed by investing in carbon capture, utilisation, and storage (CCUS) technology so their impact is less harmful to health and the environment. Figure 2.7 presents the level of annual CO_2 emission reduction when the CFPPs are normally shut down in specific years. The numbers will be a basis to calculate the necessary investment in CCUS technology. Forecasting simulations will estimate the costs to be borne under each scenario and the information will be used to seek and develop funding strategies.

Figure 2.7. The Annual Carbon Dioxide Emission Reduction Due to the Natural Path of Retirement for Coal-Fired Power Plants in Indonesia



CO_2 = carbon dioxide.
Source: Authors' calculation (2023), based on Global Energy Monitor (2022).

Table 2.9 provides a summary of the outcomes for all three scenarios. The estimated costs can be categorised into three components – investment costs associated with renewable energy establishment, costs to shut down CFPPs, and compensation costs for those households and manufacturing firms negatively impacted by the early removal of CFPPs. In contrast, the implementation of the coal phase-out policy in Indonesia will require substantial financial support, amounting to an annual average of more than $100 million.

Table 2.9. Simulation Results for All Scenarios
(in $billion)

Aspect	Scenario 1 (BAU)	Scenario 2 (Coal Phase-Out)	Scenario 3 (CCUS)
Investment cost on renewable energy	56.74	56.74	56.74
Early retirement cost of CFPP	-	27.79	-
Compensation cost for households and manufacturing firms	397.53	5,667.67	397.53
Investment cost on CCUS	-	-	21.91
Total cost (2023-2061)	**454.27**	**5,752.21**	**476.18**
Total cost per year	**11.95**	**151.37**	**12.53**

$ refers to US dollars.
BAU = business-as-usual; CCUS = carbon capture, utilisation, and storage; CFPP = coal-fired power plant.
Source: Authors' calculation (2023).

Considering the commitment made by developed economies towards assisting developing countries to pursue climate funding, it becomes apparent that scenario three (the use of CCUSs) will be the most viable option due to its comparatively lower financial requirements. The discussion of the economic costs of the coal phase-out plan, along with its fiscal consequences, and other related financing policies will be described in the next section. It is, however, important to acknowledge that the simulation results are based on the replacement conditions for the currently active CFPPs and have not yet incorporated the annual growth rate of electricity demand.

4. Discussion on Financing Framework and Policy Recommendations

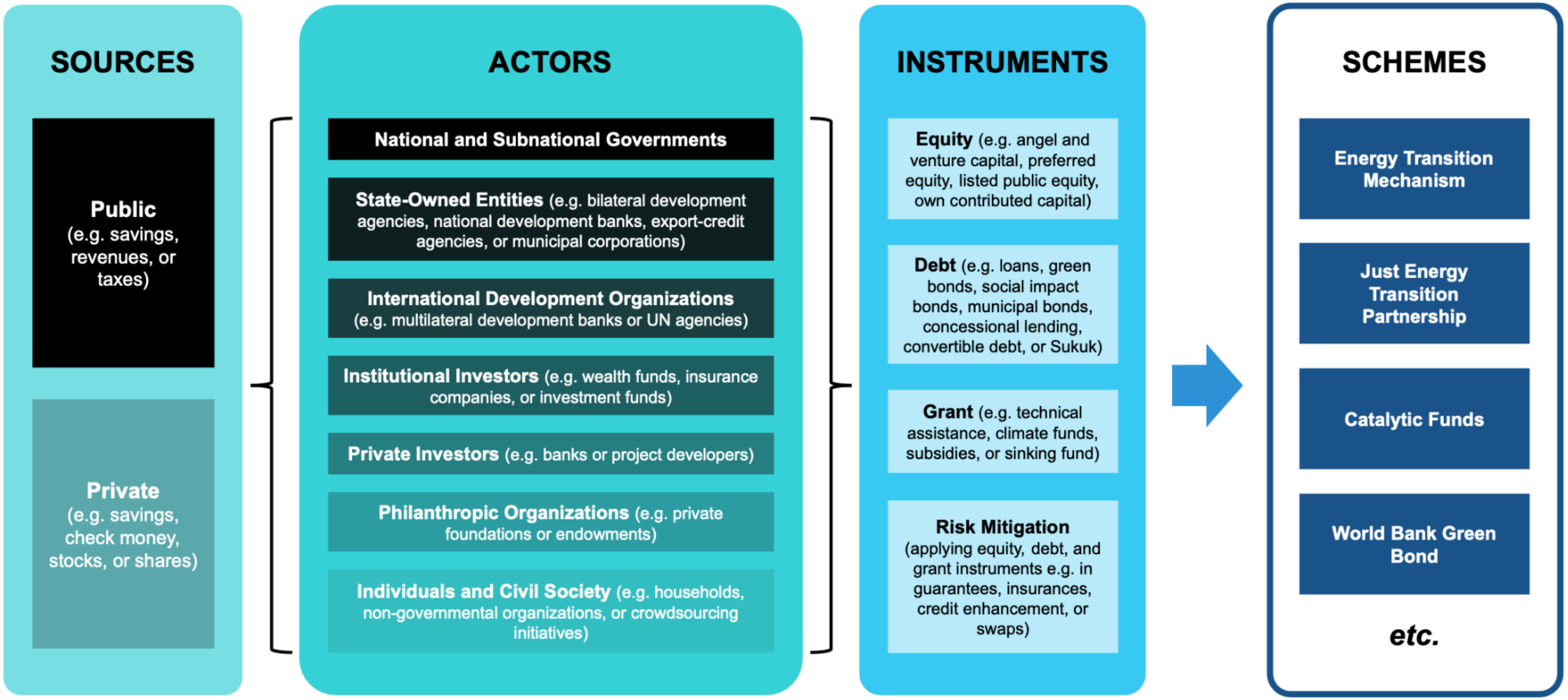
4.1. Global Initiatives to Finance Indonesia's Coal Phase-Out

Indonesia has committed to reduce its emissions in accordance with the Paris Agreement goal. This commitment is stated in the Indonesia Enhanced NDC which was submitted in September 2022. In this newest document, Indonesia has increased its unconditional emission reduction target from 29% in the First NDC to 31.98% in the Updated NDC, and its conditional target from 41% in the Updated NDC to 43.20% in the Indonesia Enhanced NDC (GoI 2022).

The implementation of the NDC requires large investments from public and private sources. The Enhanced NDC document refers to the 3rd Biennial Update Report which states the estimated finances needed to achieve the unconditional target from 2018–2030 as about $281 billion and the conditional target as about $281 billion. Of that, state funds can only contribute around 34% and the rest should be provided from non-state funding sources (Luthfyana and Mafira, 2023).

Considering this massive investment gap, it is imperative that Indonesia seeks funding from other sources. Figure 2.8 shows the financing framework for climate change projects that Indonesia could leverage. While funding could be found from either public or private funds, the financing schemes need not perfectly align with this dichotomy. At present, there are various schemes that blend public and private funds, especially for climate-related programmes (e.g. blended finance). One of the main challenges in climate change finance, however, is the coordination between public and private funds so that green projects can be delivered in an effective and efficient way.

Figure 2.8. Green Financing Framework



Source: Adapted from New Climate Economy (2016).

Various global financing initiatives are available for Indonesia to tap into to finance its energy transition (Table 2.10). For instance, the country has secured a global commitment under JETP financing of approximately $20 billion. Financing mechanisms under the JETP scheme blend equity investments, grants, concessional and commercial loans, and guarantees. However, challenges remain in terms of the type of financing instruments offered under the scheme. At present, only a small percentage of financing under the JETP programme comes in the form of grants.

Table 2.10. Available Financing Schemes to Combat of Climate Change

No	Schemes	Committed Amount	Instrument Types	Channelling Institutions	Funding Sources
1	Energy Transition Mechanism	1a. ADB's Energy Transition Mechanism and the World Bank Group			
		$500 million from CIF-ACT; $2.2 billion from ADB & WBG; $2 billion from GoI & private sector	• grants • concessional loans • market-rate loans • RBL • FIL through PT SMI, & project loans	• ADB • WBG	• GoI • Climate Investment Fund: CIF-ACT • Multilateral development banks: ADB & WBG • Private sector: International Finance Corporation, ADB, & private sector
		1b. Indonesia's Energy Transition Mechanism Country Platform			
		Contribution from GoI to be confirmed	GoI contribution • state budget • concessional loans • market-rate loans • carbon credit revenues	• PT SMI	GoI; • Ministry of Finance • Ministry of Energy and Mineral Resources • Ministry of State-Owned Enterprise • Ministry of Environment and Forests
		1c. State Electricity Company Energy Transition Mechanism			
		PLN has indicated a need for $726 billion	• equity • debt • grants	-	• PLN & partners

No	Schemes	Committed Amount	Instrument Types	Channelling Institutions	Funding Sources
		until 2060			
		1d. Indonesian Investment Authority's Energy Transition Mechanism			
		Undisclosed for CFPP retirement: $2 billion for the Green Fund	• equity & • debt	• Indonesia Investment Authority	• Indonesia Investment Authority
2	Just Energy Transition Partnership	$20 billion committed to Indonesia ($10 billion public funds & $10 billion private capital)	• grants • concessional loans • market-rate loans • guarantees • private investments	• International Partners Group (Public) • Glasgow Financial Alliance for Net Zero (Private)	• Governments of IPG countries: Canada, Denmark, France, Germany, Italy, Japan, Norway, UK, US. • Private financial institutions: Bank of America, Citi, Deutsche Bank, HSBC, Macquarie, MUFG, Standard Chartered
3	ASEAN Catalytic Green Finance Facility	$1.8 billion	• loans • technical assistance	• ADB	• ADB • Agence Française de Développement • CDP • Economic Development Cooperation Fund • European Investment Bank • EU • Foreign, Commonwealt

No	Schemes	Committed Amount	Instrument Types	Channelling Institutions	Funding Sources
					h & Development Office • Green Climate Fund • KfW
4	Clean Energy Financing Partnership Facility	Realisation: $284.4 million to 235 projects (as of 2022)	• debt & • grants	• ADB	• Governments of Australia, Canada, Japan, Norway, Spain, Sweden, & UK • Global Carbon Capture and Storage Institute
5	Global Green Growth Institute	$1 billion in 2021	• grants	• Global Green Growth Institute	• Governments of Australia, Denmark, Germany, Indonesia, the Republic of Korea, Mexico, Norway, Switzerland, UAE, & UK
6	Green Climate Fund	$9.3 billion between 2024–2027	• grants • debt • equity • guarante e	• World Bank interim trustee & • UNFCCC	• Established by 194 countries party to the UNFCCC
7	World Bank Green Bond	Realisation: $16.5 billion (as of 2022)	• debt bonds	• World Bank	• Fixed income investors

ADB = Asian Development Bank; ASEAN = Association of Southeast Asian Nations; CDP = Carbon Disclosure Project; CIF-ACT – Climate Investment Fund: Accelerating Coal Transition Investment Programme; CFPP = coal-fired power plant; EU = European Union; FIL = Financing Intermediary Loan; GoI = Government of Indonesia; HSBC = Hong Kong & Shanghai Banking Corporation; IPG = International Partners Group; KfW = Kreditanstalt für Wiederaufbau; MUFG = Mitsubishi UFJ Financial Group, Inc; PLN = State Electricity Company - Perusahaan Listrik Negara; PT SMI = PT Sarana Multi Infrastruktur (Persero); RBL = Result-Based Lending; UAE = United Arab Emirates; UK = United Kingdom; UNFCC = United Nations Framework Convention on Climate Change; US = United States; WBG = World Bank Group.
Source: Authors' collection from various documents (2023).

Another financing initiative is the ETM. The GoI has just launched the ETM Country Platform in November 2022 aimed at providing finance to accelerate the national energy transition by mobilising private and public funds sustainably. The GoI has chosen the state-owned *PT Sarana Multi Infrastruktur* as the Country Platform Manager and tasked them with developing a co-operative financing and investing framework for ETM programmes in Indonesia. Programmes under the ETM will mainly be funded with blended financing schemes with fundings from various parties.

4.2. Fiscal Support for Just Energy Transition

The GoI could only provide limited funding resources for phasing out coal. However, they could play a critical role in accelerating coal phase-out by providing various fiscal supports. The Minister of Finance has issued several regulations, for example *Peraturan Menteri Keuangan (*PMK*)* pertaining to fiscal incentives for coal phase-out, particularly for the advancement of renewable energy, in alignment with the provisions outlined in Law No. 30 of 2007 on Energy. The law grants the GoI the authority to offer resources and incentives to both corporations and individuals to promote the provision of renewable energy. This adheres to a range of tax and duty regulations, which provide tax incentives for strategic endeavours relating to income tax, value-added tax, and import taxes and duties. The fiscal instruments and their corresponding implementing regulations are presented in Table 2.11.

Table 2.11. Summary of Regulations on Fiscal Incentives for Renewable Energy Development

Fiscal Incentives	Detailed Instruments	Regulations
Tax and duty allowances	▪ Investment tax deduction equivalent to 30% of fixed capital investment, applied as 5% over 6 years; ▪ Accelerated depreciation and amortisation; ▪ Exemption from Article 22 import tax on machines and equipment, excluding spare parts; depending on the imported goods, this can be as much as 7.5% of the declared	✓ Government Regulation No. 78 of 2019 on Income Tax Facilities for Investment in Certain Industries and/or Regions; ✓ PMK No. 89 of 2015 as amended by PMK No. 11 of 2020 on Procedures for Provision of Income Tax Facilities for Investment in Certain Industries and/or Regions as well as Transfer of Assets and Sanctions for

Fiscal Incentives	Detailed Instruments	Regulations
	value; ▪ VAT exemption on imported goods, excluding spare parts; ▪ Import duty exemption; ▪ Reduction of tax on dividends remitted to non-residents to 10% or less depending on the prevailing tax treaty; ▪ Extension of tax loss carry forward from 5 years up to 10 years, subject to certain criteria.	Domestic Taxpayers; ✓ PMK No. 21 of 2010 on Provision of Tax and Duty Facilities for Renewable Energy Activities; ✓ PMK No. 176 of 2009 as amended by PMK No. 188 of 2015 and PMK No. 76 of 2012 on Import Duty Exemption for Investment in Equipment, Goods and Materials for Industrial Development.
Tax holiday	▪ Corporate income tax holidays for investment in 'pioneer industries' including 'economic infrastructure,' which includes renewable energy power plants.	✓ PMK No. 130 of 2020 on Provision of Corporate Income Tax Reduction Facilities; ✓ Investment Coordinating Board Regulation No. 7 of 2020.

$ refers to US dollars.
PMK = *Peraturan Menteri Keuangan.* VAT = value-added tax.
Sources: Authors' summary from Government Regulation No. 78 of 2019 on Income Tax Facilities for Investment in Certain Industries and/or Regions; PMK No. 89 of 2015 as amended by PMK No. 11 of 2020 on Procedures for Provision of Income Tax Facilities for Investment in Certain Industries and/or Regions as well as Transfer of Assets and Sanctions for Domestic Taxpayers; PMK No. 21 of 2010 on Provision of Tax and Duty Facilities for Renewable Energy Activities; PMK No. 176 of 2009 as amended by PMK No. 188 of 2015 and PMK No. 76 of 2012 on Import Duty Exemption for Investment in Equipment, Goods and Materials for Industrial Development; PMK No. 130 of 2020 on Provision of Corporate Income Tax Reduction Facilities; Investment Coordinating Board Regulation No. 7 of 2020.

Aside from tax-related fiscal incentives, the GoI could provide incentives in other forms. It could, for example, conduct budget tagging to help private stakeholders to identify relevant projects. Budget tagging allows the government to earmark specific funds or budgets for coal phase-out projects. By clearly identifying these allocations, private stakeholders can readily identify and access relevant projects, thereby encouraging their active involvement and investment in the transition away from coal. This approach has been recognised as instrumental in channelling funds toward sustainable initiatives and projects (World Bank, 2019).

Another way the GoI could contribute to the rapid phase-out of coal would be to introduce a carbon tax and carbon credit. A carbon tax places a financial burden on carbon emissions, providing a direct economic incentive for industry to reduce its carbon footprint. Carbon credits allow companies that have reduced their emissions below a certain level to sell the excess reduction as credits to other companies, thereby promoting emissions reductions in a market-driven manner. Revenue from such a carbon tax system can be reinvested in renewable energy projects or used to provide subsidies for clean energy technologies, thereby encouraging the adoption of sustainable alternatives and accelerating the phase-out of coal. This approach is consistent with the principles of environmental economics and promotes the internalisation of external environmental costs (Tietenberg and Lewis, 2018). Furthermore, this method is also in line with global best practices, as evidenced by countries such as Denmark and Sweden, which have effectively used carbon pricing mechanisms to incentivise the transition to cleaner energy sources (World Bank, 2019).

4.3. Managing the Socioeconomic Impact of Coal Phase-Out

Although it may have unfavourable effects, Indonesia must phase out coal if it is to meet its carbon commitment. In terms of energy sources used to generate electricity nationally, coal continues to be the most common choice. Accordingly, it is imperative to guarantee that electricity can meet present and future demand by decreasing the significant role that coal plays. Phase-out of coal also implies the possibility of primary economic sector loss for coal-dependent regions at the regional level. The coal industry in these areas may support a sizeable number of direct and indirect jobs, as well as local government revenue, by taxes, royalties, and dividends from state-owned businesses. For this reason, moving away from coal may have a negative economic effect on areas that rely heavily on it.

Considering the possible negative effects of the transition from coal to renewable energy, JETP is being pushed to make sure that no population segment is sacrificed in the process of expanding renewable energy sources. In the context of JETP, there are several policy suggestions that can be made.

- To address the challenges associated with transitioning away from coal in regions heavily dependent on this fossil fuel, the GoI can support regional and local governments. This assistance can facilitate the transition of these areas from coal-based economies to more sustainable alternatives. A viable approach is to implement a variety of incentive programmes. For example, the GoI could establish incentive schemes that encourage investments aimed at replacing coal-related activities in these coal-dependent regions. In this way, the government can help promote economic diversification, job creation, and infrastructure development, ultimately mitigating the impact of the coal phase-out on these communities.

- With the implementation of coal phase-out initiatives, central and local governments have the chance to provide households with important support. Reskilling training programmes for employees who might suffer due to the shift away from coal-based industries are one crucial kind of support. Through the development of new skills and competencies, these employment opportunities enable workers to consider different industries and career paths. In addition to helping the workforce avoid the negative effects of the phase-out of coal, governments can support a more diverse and sustainable economy that supports larger environmental and economic objectives by funding reskilling initiatives.

5. Conclusion

The results of empirical analysis in this study are summarised as follows. From the macro-level perspective, the presence of CFPPs have a significantly unfavourable influence on the economic development of Indonesia, measured by GDP and its growth rate. This is because the operation of CFPPs entails negative externalities that can potentially impact the productivity of specific economic sectors through the mechanism of environmental risks. The outcomes become evident when comparing the effect of subcritical and non-subcritical CFPPs. Subcritical CFPPs exhibit lower efficiency levels and emit greater quantities of pollutants compared to their supercritical and ultra-supercritical counterparts. This underlines the drawbacks associated with the utilisation of subcritical CFPPs, which results in increased economic costs. The findings of the analysis indicate that the total annual economic costs of CFPPs are estimated to amount to $92.88 billion, equivalent to roughly 7.13% of Indonesia's actual GDP in 2022.

From the micro-level perspective related to the household sector, the estimation results showed that CFPPs have a positive impact on the average monthly expenditure per household at the city level, with the effect quantified as $18.83 or equivalent to a 0.8% increase. Additionally, the presence of CFPPs is associated with increased monthly electricity spending by an average of approximately $48.24 per household per year, an increase of approximately 6.1%, which corresponds to a national total of $15.5 billion annually. Compared to Indonesia's realised GDP level (2022) in a constant local currency price unit, the figures are proportional to 0.61% of Indonesia's real GDP in 2022.

From the micro-level perspective regarding the manufacturing business sector, the estimation results showed that the presence of CFPPs operations has a positive impact on the return on assets of companies, with the effect quantified as an increase of 0.16 percentage points or equal to 3.1%. The use of CFPPs can lead to a reduction in the risk of power outages and thus increases the lifespan of companies' machines and systems. This, in turn, improves cost optimisation, resulting in higher net profits and ultimately a higher ROI. Another consideration is that a more reliable electricity supply within a region would significantly increase the output of local manufacturing companies, thereby helping to increase ROI.

The results also show that large manufacturing companies can benefit more from the presence of CFPPs as they can utilise their machines and equipment more quickly. The findings of the analysis indicate that, on average, the positive impact on ROI is estimated at $7.87 million per company per year, for a total annual value of $43.6 billion nationally. Compared to Indonesia's realised GDP level (2022) in a constant price unit in local currency, the figures are proportional to 3.34% of Indonesia's real GDP in 2022. From a summary of the aggregate impact of CFPPs on both the macro and micro-level perspective, it can be concluded that the presence of CFPPs results in a potential annual net economic loss.

The simulation model shows that the economic cost consequences of implementing the coal phase-out plan are of great importance. Amongst the various scenarios, the use of CCUS is the most viable option to help Indonesia achieve its goal of net zero carbon emissions by 2060.

The investments required to implement the coal phase-out require the GoI to develop various sources of financing, both public and private. The ETM and theJETP are two of the most significant global financing initiatives that the GoI could use to accelerate its energy transition. Due to their limited availability, public funds should be directed towards efforts to incentivise private sector participation in the energy transition. Beyond financial support, the GoI could play a critical role in ensuring that the coal phase-out is implemented in an equitable manner by considering the potential economic impact on coal-dependent regions.

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Appendix

Datasets and Methods for Empirical Analysis Data

The study employs multiple datasets, which are mostly obtained from Indonesia's Statistics Central Agency (BPS). Table A.1 lists the variables utilised in each dataset, along with their disaggregation levels. The brief description of each dataset is as follows.

1. National Socioeconomic Survey (SUSENAS).
   We utilise SUSENAS to collect socioeconomic data at the individual and household levels from the core and consumption modules. The variables include per capita spending, energy consumption, household characteristics such as size and proportion of urban population, and head of household characteristics such as age, gender, and level of education. We aggregate them at the district and provincial levels.
2. National Labour Force Survey (SAKERNAS).
   We use SAKERNAS to gather labour market statistics such as the fraction of informal labour, labour force participation rates, unemployment rates, and the number of working-age people. We aggregate them at the district and provincial level.
3. Large and Medium Manufacturing Industry Survey (SIBS).
   SIBS allows us to acquire firm-level data such as sales, earnings, and ROI, as well as industry statistics such as average worker count, foreign and domestic ownership, and so on. We aggregate them at the provincial level.
4. Village Potential Statistics (PODES).
   We utilise PODES to collect village-level topographical data such as topography and natural catastrophes. We aggregated them to the district level.
5. GRDP and other socioeconomic data from the Statistics of Indonesia at district and province levels, published by BPS regional-level offices.
6. Database of 253 existing CFPPs in Indonesia, including location, capacity, and year of operation. The database was released by Indonesian Ministry of Energy and Mineral Resources (MEMR).

Table A1. Variables and Data Sources

Datasets	Variables	Disaggregation
SUSENAS (Core and Consumption Modules)	▪ Per capita household expenditure ▪ Household characteristics	▪ Individual ▪ Household ▪ District
SAKERNAS	▪ Per capita household expenditure	▪ Individual ▪ Household ▪ District
SIBS	▪ Firms characteristic ▪ Energy consumption ▪ ROI	▪ Firm ▪ Province
PODES	▪ District-level geographical characteristics	▪ Village ▪ District
BPS Daerah	▪ GDP ▪ GDP per capita ▪ Government revenues and expenditures	▪ District
Directorate General of Mineral and Coal, Indonesian Ministry of Energy and Mineral Resources (MEMR)	▪ Location, capacity, and commercial operation date of 253 existing coal-based power plants ▪ Historical coal prices	▪ District

BPS = Statistics Indonesia (Central Bureau of Statistics - *Badan Pusat Statistik*); GDP = gross domestic product, PODES = Village Potential Statistics; ROI = return on investment; SAKERNAS = National Labour Force Survey; SIBS = Large and Medium Manufacturing Industry Survey; SUSENAS = National Socioeconomic Survey.

Source: SUSENAS, SAKERNAS, SIBS, PODES, Local BPS Offices, and Directorate General of Mineral and Coal Ministry of Energy and Mineral Resources.

Methods

To estimate the potential impact of coal phase-out in Indonesia, we developed four econometric models: (i) Economic impact model; (ii) Household welfare impact model; (ii) Firm performance impact model; and (iv) Forecasting model.

Models 1–3 aim to estimate the effect of treatment on outcomes and are estimated using the DID approach. In this approach, we compare the difference between treatment and control groups (the first difference) for the period before and after the treatment (the second difference) has occurred. In our case, the treatment refers to the presence of CFPP in a region (district or province). Model 4 aims to forecast outcome variables in the future based on parameters obtained from Models 1–3.

Model 1: Economic Impact

Coal phase-out could bring an adverse impact to regions that rely heavily on coal-related industries. To account for the non-random location of CFPP, we use the DID approach and modify the baseline equation into the following model:

$$Y_{it} = \alpha + \beta CFPP_{it} + \gamma X_{it} + \delta_i + v_t + \varepsilon_{it} \#(1)$$

where Y_{it} is the GRDP of district i at period t; $CFPP_{it}$ is a dummy variable equal to 1 if there is a CFPP in district i at period t and 0 otherwise; X_{it} is a vector of controls; δ_i is the district fixed effect; v_t is the year fixed effect; and ε_{it} is the error term. Our coefficient of interest, β, indicates the effect of the presence of CFPPs on GRDP and essentially measures how coal phase-out potentially affects the local economy in districts that have a CFPPs compared with those that do not.

The X vector includes district-level covariates as well as district and time-specific factors that may affect GRDP in each district. These include population size, provincial capital dummy, district fixed effects, and year fixed effects. The district fixed effects are included to control for unobserved factors that may cause persistent differences in regional GRDP, which may be correlated with the likelihood of having a CFPP. The year fixed effects are included to control any shocks to GRDP that are common across districts in each period.

As the year of operation of each CFPP varies across districts, Equation (1) is estimated using the staggered DID approach following (Goodman-Bacon, 2021).

Model 2: Household Welfare Impact

At the micro level, CFPP closure could potentially induce welfare changes of residents in coal-reliant regions. To investigate this, we develop a household-level model as follows:

$$W_{hit} = \alpha + \beta CFPP_{it} + \gamma X_{hit} + \delta_i + v_t + \varepsilon_{it} \#(2)$$

where W_{hit} is per capita expenditure of household h in district i at year t; $CFPP_{it}$ is a dummy variable equal to 1 if there is a CFPP in district i at period t and 0 otherwise; X_{hit} is a vector of household-level controls; δ_i is the district fixed effect; v_t is the year fixed effect; and ε_{it} is the error term.

Equation (2) is estimated using the staggered DID approach following (Goodman-Bacon, 2021).

Model 3: Firm Performance Impact

The second micro-level evaluation concerns the potential impact of coal phase-out on firms' performances. We employ a similar approach to estimate the magnitude of potential CFPP closure on businesses' ROI using the following specification:

$$R_{fjt} = \alpha + \beta CFPP_{jt} + \gamma X_{fjt} + \delta_j + v_t + \varepsilon_{jt} \#(3)$$

where R_{fjt} is the ROI of firm f located in province j at year t; $CFPP_{jt}$ is a dummy variable equal to 1 if there is a CFPP in province j at period t and 0 otherwise; X_{fjt} is a vector of firm-level controls; δ_j is the province fixed effect; v_t is the year fixed effect; and ε_{jt} is the error term.

Equation (3) cannot be estimated at district level due to the limitation of SIBS as our source of firm-level data. Thus, we aggregated our control variables to province level.

Model 4: GDP Forecasting

After obtaining estimates of the economic impact due to the operation of CFPPs at the macro and micro levels (i.e. at the company and household levels), the next step is to project how the national economy will develop in the long-term when the coal phase-out plan is gradually implemented. To do this, we build assumptions and develop model simulations of different scenarios based on whether or not the coal phase-out plan is implemented in the future, and on the speed of the phase-out timeline.