

The determinants of financing of coal-fired power plants

Tebatjo Makhafola
WITS Business School

A thesis presented in partial fulfillment of the Master of Management in Finance and Investment degree to the Faculty of Commerce, Law, and Management, University of the Witwatersrand.

February 2024

WITS
UNIVERSITY



DECLARATION

I, Tebatjo Makhafola declare that this research report entitled ‘The determinants of financing of coal-fired power plants’ is my unaided work. I have acknowledged, attributed, and referenced all ideas sourced elsewhere. I am hereby submitting it in partial fulfillment of the requirements of the degree of Master of Finance and Investment at the University of the Witwatersrand, Johannesburg. I have not submitted this report before for any other degree or examination to any other institution.

TL Makhafola

Tebatjo Makhafola

Signed at Johannesburg on 24th February 2024

Name of candidate	Tebatjo Makhafola
Student number	853869
Telephone numbers	076 808 0797
Email address	853869@students.wits.ac.za
First year of registration	2022
Date of proposal submission	18 May 2023
Date of report submission	24 February 2024
Name of supervisor	Dr Chengete Chakamera

ABSTRACT

Coal-fired power stations have been the key driver of energy generation for many decades in many economies. Generating electricity using coal is regarded as reliable because coal-fired power plants can provide a continuous power supply. However, as reliable as they are, coal-fired power plants pose environmental challenges, from greenhouse gas emissions to air pollution.

This research paper aims to investigate factors other than environmental concerns, that determine the funding of coal-fired power plants (research objective one), to investigate the economic effect of changes in the funding of coal-fired power plants (research objective 2) as well as to investigate whether there is a causality between funding for coal-fired power plants and renewable energy output (research objective 3). The panel data ordinary least square regression model was used for investigating the determinants of coal-fired power plants and for investigating the economic impact of changes in funding of coal-fired power plants. The Dumitrescu-Hurlin Panel causality analysis was performed to investigate the causality between coal funding and renewable energy output.

Regarding the determinants of coal funding, the results show that interest rate, unemployment rate, access to electricity, GDP per capita, and inflation have a significant influence on funding for coal-fired power plants. However, financial depth and emissions do not have a significant influence on funding for coal-fired power plants. Funding for coal-fired power plants is found to have a significant influence on economic growth. The study further found that there exists a unidirectional causality relationship between funding for coal-fired power plants and renewable energy output, flowing from funding for coal-fired power plants to renewable energy output.

As the results show that coal fundings tend to decrease as the economy grows, these findings imply that investors in coal-fired power plants and coal-producing companies should consider diversifying their investment portfolio to other alternative energy sources that have growth potential, like renewable energy. Based on the causality results, the implication is that policymakers may be making decisions concerning funding for coal-fired power plants in line with those decisions made to achieve sustainability through renewable energy.

Table of Contents

DECLARATION.....	2
ABSTRACT.....	3
LIST OF TABLES.....	6
LIST OF FIGURES.....	7
LIST OF TABLES AND FIGURES IN THE APPENDICES.....	8
ACKNOWLEDGEMENTS.....	9
CHAPTER 1: INTRODUCTION TO THE RESEARCH.....	10
1.1. Background.....	10
1.2. Problem Statement.....	11
1.3. Significance of the study.....	13
1.4. Research Questions:.....	14
1.5. Research Objectives:	14
1.5. Structure of the research report	14
CHAPTER 2: LITERATURE REVIEW.....	15
2.1. Theoretical literature.....	15
2.2. Empirical literature	16
2.2.1. Outlook of the Coal Industry.....	16
2.2.2. Renewable energy.....	16
2.2.3. Energy security	18
2.2.4. Sources of funding for coal-fired power plants.....	18
2.2.5. Efforts to limit fossil fuel funding.	20
2.2.6. Carbon Capture Technology.....	21
2.2.7. Determinants of coal funding results from other studies	22
2.2.8. The economic impact of changes in funding for coal-fired power station projects. ...	23
2.2.9. Relationship between coal funding and renewable energy output.	23
2.3. Research gaps	24
2.4. Conclusion	24
CHAPTER 3: RESEARCH STRATEGY, DESIGN, PROCEDURE ANDMETHODS	25
3.1. Introduction.....	25
3.2. Data.....	25
3.2.1. Variables	25
3.3. Models	25
3.4. Procedure and Analytical Methods.....	27
3.4.1. Preliminary analysis.....	27
3.4.1.1. Descriptive analysis	27
3.4.1.2. Stationary tests.....	27
3.5. Classical linear regression.....	28
3.6. Specification/ Diagnostics tests.....	28
CHAPTER 4: PRESENTATION OF RESEARCH RESULTS	29

4.1. Introduction	29
4.2. Descriptive statistics	29
4.3. Stationary tests	31
4.4. Main results of the study	32
4.4.1.1. Presentation of results	32
4.4.1.2. Specification checks.....	33
4.4.1.3. Interpretation and discussion of regression coefficients	33
4.5. Research objective 2: Economic impact of changes in coal funding	36
4.5.1. Presentation of results	36
4.5.1.1. Interpretation of diagnostic results.....	37
4.5.1.2. Interpretation and discussion of regression coefficients	37
4.6. Research objective 3: To investigate whether there is a causal relationship between coal funding and renewable energy output.	39
4.6.1.1. Analysis of Rorrelation Results	39
4.6.2. Causality analysis	40
4.6.2.1. Interpretation and discussion of causality results	40
4.7. Conclusion	41
CHAPTER 5: CONCLUSION AND SUMMARY	42
5.1. Introduction	42
5.2. Summary of the findings.....	42
5.3. Implications and Recommendations.....	43
5.3.1. Implication and Recommendations to investors.....	43
5.3.2. Implication and Recommendations to governments/ policymakers	43
5.3.3. Implication and Recommendations to coal-producing companies	44
5.3.4. Implication and Recommendations to researchers/ scholars	44
5.4. Limitations	44
5.5. Possible areas for future research	44
REFERENCES.....	45
APPENDICES	55

LIST OF TABLES

Table 1: Descriptive test results	29
Table 2: Stationarity test results	30
Table 3: Selected determinants of coal funding.....	31
Table 4: Multicollinearity Results.....	31
Table 5: Effect of coal funding changes on economic growth	35
Table 6: Multicollinearity results	35
Table 7: Correlation results	38
Table 8: Causality between coal funding and renewable output	39

LIST OF FIGURES

Figure 1: Global coal investment	11
Figure 2: South Africa – Coal Exports by Destination in Jan-Sep	12
Figure 3: Global Coal Imports	12
Figure 4: Progress towards renewable energy source targets for EU-27	17

LIST OF TABLES AND FIGURES IN THE APPENDICES

Appendix A 1: Data information	54
--------------------------------------	----

ACKNOWLEDGEMENTS

I would like to express my ton of gratitude to the Almighty God and everyone who gave me support during this Master's study.

To my supervisor, Dr Chengete Chakamera, I appreciate the kindness, open door policy, effective communication, guidance, constructive criticism, and excellent display of leadership during this study.

To Global Energy Monitor, thank you very much for your kindness and support when I requested the information regarding funding for coal-fired power plants.

To the Makhafola family, friends, and key relations, I appreciate the unconditional support and encouragement that you have givenme which enabled me to complete my Masters.

To my employer, Standard Chartered Bank, particularly Sizwe Mankazana and Niel de Bruin, thank you very much for your support and for creating a healthy environment that enabled me to complete my Masters.

CHAPTER 1: INTRODUCTION TO THE RESEARCH

1.1. Background

There are global efforts to move away from coal to renewable energy sources. According to Edianto, Trencher, and Matsubae (2022), despite the global efforts to move away from coal, there is still the construction of new coal-fired power plants around the world in countries like South Africa, Bangladesh, Indonesia, China, and India. Furthermore, the study by Edianto et al., (2022) stated that the construction of coal-fired power plants in developing countries is mostly assisted by developed countries through financial support.

The transition to renewable energy is led by advanced economies like the United Kingdom (UK). According to the recent data reported by Bank Track (2023), just 7% of global banks' energy financing goes to renewable energy sources, indicating low financial support from banks through loans and bond underwriting channeled towards clean energy. According to Zhao & Alexandroff (2019), international public financing makes up the majority of financing in the developing countries' power sector and according to Edianto Et al., (2022), international public financing has supported coal rather than renewables. According to Chen and Schmidt (2017), between the period 2013 and 2017, overseas financing for coal from government-affiliated financial institutions was three times more than the funding provided for renewables. Edianto Et al., (2022) found that China, Japan, and South Korea make up the majority of this funding.

According to the Independent Energy Agency (2023), coal investment rose in 2022 and it is expected to rise again in 2023 as shown in Figure 1. Furthermore, the Independent Energy Agency published that the global investment in coal increased by 20% from 2021 levels and the majority of the investment occurred in China and India. This increase in investment in coal is driven by a strong demand for coal as it reached an all-time high in 2022 and high prices of coal which rose to unprecedented levels in October 2021.

Global coal investment rose in 2022 – surpassing 2019 levels – and is set to rise again in 2023

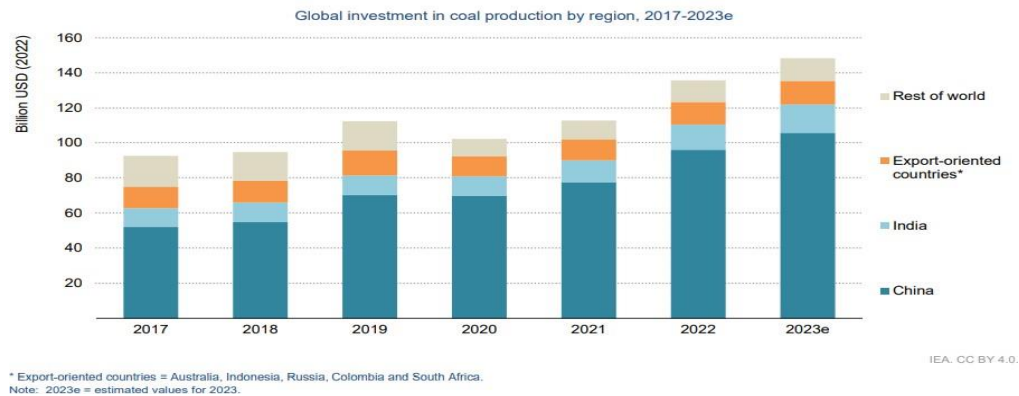


Figure 1: Global coal investment

Source: Independent Energy Agency, 2023.

Empirically, there are a few studies that examined a similar issue such as a study by Edianto, Trencher & Matsubae (2022), that dealt with the question of “*What factors drive the flow of international financing towards coal or renewables?*” and found that factors influencing the flow of international financing towards coal or renewables are the absence of strong policies on renewables and carbon price adoption. The study by Spencer, Colombier, Sartor, Garg, Tiwari, Burton, and Wiseman, (2018) found that previous transitions in the coal regions led to job losses. The findings of the studies suggest that coal and project funding are influenced by the political and macro environment in general. This position is consistent with the study by Blondeel, Van de Graaf, and Haesebrouck (2020), which found that weak environmental governance and political transparency influence the flow of financing towards coal-fired power plants. The relevance of this study is to investigate the factors that drive investment in coal-fired power plants, other than climate change, as well as investigate the economic impacts of changes in funding for coal-fired power station projects and lastly investigate whether there is a causal relationship between coal funding and renewable energy output. The study examined the funding of coal-fired power plants in five countries, namely: South Africa, India, Indonesia, Vietnam, and South Korea for a period of 12 years from 2008 to 2020.

1.2. Problem statement

Policymakers in advanced economies advocate for a global shift away from coal-based energy sources, mainly for environmental reasons, yet many emerging and developing economies have significant coal reserves that they can use to advance their development. Interestingly, when the risk to energy supply increases in advanced economies, policymakers in these economies revert to the use of coal-based sources. The study by Zhang and Chen (2023) found that.

Germany has since relaxed its regulations on coal mines and coal power plants and has returned to the use of coal as a safe measure to hedge against the natural gas dependency on Russia. Furthermore, according to Wacket and Riham (2022), Germany slowed down its carbon neutrality pace during the COVID-19 pandemic by removing the article on carbon neutrality by 2030. Another observation of interest is that coal-rich economies continue to experience large and sometimes increasing coal exports. According to Hellenic Shipping News (2022), South Africa's Coal Export to the EU countries was up 582.7% during 2022 as shown in Figure 2.

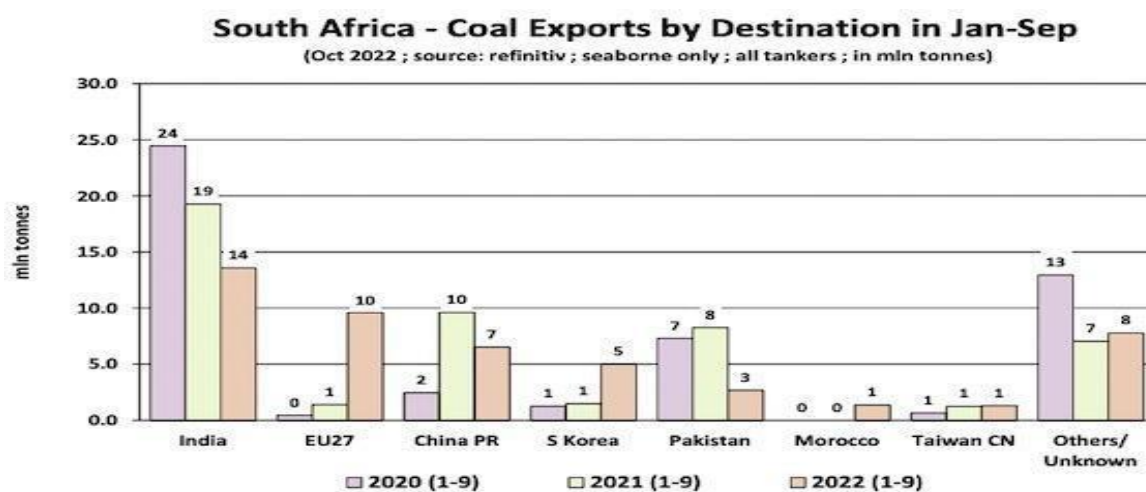


Figure 2: South Africa – Coal Exports by Destination in Jan-Sep
Source: Hellenic Shipping News (2022)

It is this contrast between policy announcements and actual developments that gives reason to believe that other possible factors are driving the funding and consumption of coal. As seen in Figure 3, coal imports globally are increasing, especially to the advanced economies, whilst on the ground level, other economies are persuaded to move away from using coal, which gives rise to the research problem of this study. The problem is that, apart from environmental concerns, it is not clear which other factors may significantly influence the funding for coal-powered plants. Thus, we conjecture that perhaps advocacy for the move away from coal-based sources may be informed by more considerations than climate change.

1.3. Significance of the study

This study is essential in the current times, which is the time of global efforts to shift from coal-energy sources to cleaner. The study will outline the relevance of this study to different stakeholders, namely, investors, policymakers, coal-producing companies as well as society.

Investors must understand the factors that influence the funding for coal-fired power plants. Possessing such knowledge may enable investors to assess the risk element of their investments as well as assess whether their investments are viable in the long run given the looming transition of energy sources from fossil fuel-based sources to renewable energy sources. A better understanding of the determinants of funding for coal-fired power plants will enable investors to make informed decisions, including decisions on whether they must diversify their investment portfolio to include investments in alternative energy sources like renewable energy.

Policymakers play a significant role in shaping the direction of energy policy. This study is relevant to them because understanding the factors that influence the funding of coal-fired power plants will enable them to draft effective energy policies and regulations that are aligned with economic growth as well as sustainability.

Coal-producing companies may find this study relevant in shaping the sustainability of their business model. Given the outcome of this study that suggests that funding for coal-fired power plants negatively affects economic growth, coal-producing companies may:

- i. Consider shifting towards renewable energy to avoid environmental degradation and adverse effects on economic growth.

- ii. Continue exploiting coal for energy but that should couple with considerable investments in carbon capture technologies and other measures that address the negative externalities of coal use.

A better understanding of what determines the funding of coal-fired power plants as well as the economic impact of funding coal-fired power plants will assist society in collectively influencing the energy policy. Furthermore, the study is significant to society at large as it sheds some light on factors that influence the decision on the investment in coal-fired power plants, as well as how economic factors affect such decisions.

1.4. Research Questions:

- 1.1.1. What are the determinants of funding levels for coal-fired power stations?
- 1.1.2. What are the economic impacts of changes in funding for coal-fired power station projects?
- 1.1.3. Is there a causality between coal funding and renewable energy output?

1.5. Research Objectives:

- 1.1.4. To investigate the determinants of coal-fired power plant funding.
- 1.1.5. To investigate the economic impact of changes in funding for coal-fired power station projects.
- 1.1.6. To investigate whether there is a causal relationship between coal funding and renewable energy output.

1.5. Structure of the research report

This research starts with the introduction which includes the background, problem statement, significance of the study, research questions, and research objectives (Chapter 1). Then the literature review (Chapter 2), methodology (Chapter 3), discussion of results (Chapter 4), and conclusion, summary, implications, and recommendations (Chapter 5), follow each other in that order.

CHAPTER 2: LITERATURE REVIEW

In this chapter, the reader will be provided with the findings from other literature on the financing of coal-fired power plants. Section 2.1 presents applicable theories that provide insight into this study, section 2.2 presents empirical studies that have been conducted on the topic, and section 2.3 concludes the chapter.

2.1. Theoretical literature

According to Bilgen (2014), energy is essential for economic and social development and the improvement of life in all countries. As a result of economic growth and development worldwide, there is an energy demand. According to Martí-Ballester (2019), energy production mainly comes from fossil fuels which accounts for 82 percent of the global primary energy supply over the past four decades.

Among the theories that are applied to this research are the transition theory as well as Rostow's theory. According to Roemer and Haggerty (2021), transition theory examines the patterns and mechanisms that are driving large-scale, long-term, and non-linear social change. According to Wilson (2012), the transition theory seeks to "unravel socioeconomic, political, cultural, and environmental complexities of social transitions from one state of organisations to another." This theory has been applied in contexts such as policy changes as seen in the study by Loorbach and Rotmans (2010), and socio-technical transitions of energy systems as seen in Geels and Schot (2007). According to Geels and Schot (2007), transition studies that are in the form of empirical research often focus on, amongst others, technical aspects of energy changes. Transition theory applies to this research because it is wary of the global shift of energy sources, from fossil fuel to renewable energy sources. Furthermore, as stated above, the transition theory is concerned with examining the factors that drive large social change, and this study seeks to examine the factors that drive the funding of coal-fired power plants, which will in turn lead to a transition in societal energy sources.

Rostow's theory (1960b) outlines economic development stages. One of the stages of economic development that Rostow (1960b) outlines is the take-off stage, and in this stage, the rate of investment must increase from 10.5% to 12.5% of the net national product. Furthermore, the take-off stage by Rostow (1960b) mentions the emergence of at least one primary growth sector that employs the latest technologies. As the world seeks to transition from coal energy sources

to renewable energy sources, such economies must ensure that they employ the latest technologies in the renewable energy sector to achieve the take-off stage of economic development and increase the level of investment in the net national product. As part of the overhead capital required in the take-off stage, electricity is among the requirements. Electricity shortage has been a challenge in many developing countries, affecting their developmental progress, and hence sound energy policies informed by research are imperative.

2.2. Empirical literature

2.2.1. Outlook of the coal industry

According to Marti-Ballester (2019), the oxidation of carbon in fuels during the process of combustion to generate energy produces greenhouse gas emissions. In 2015, about 60% of global carbon dioxide emissions contributed to global warming and climate change. According to the Intergovernmental Panel on Climate Change (2018), coal usage as a form of generating electricity must fall by two-thirds by 2023 and to nearly zero by 2050 so that the global temperature increase can be below 1.5 degrees. Marti-Ballester (2019), further stated that in mitigating climate change, the European Union implemented an energy policy strategy that was focused on three key objectives, namely; (1) to reduce greenhouse gas emissions by 40% compared to 1990 levels, considering future international climate agreements, (2) increasing the share of renewable energies to 27% in 2030 and (3) achieving the 30% energy efficiency target for the horizon of 2030 in the 2007 reference scenario. In achieving these objectives, the European Union intends to deploy legislative measures (e.g., Renewable Energy Directive-2009/28/EC, Energy Services Directive-2006/32/EC, and others), the creation of an internal EU energy market, the creation of the EU-Emissions Trading Scheme and energy sector subsidies and programs as enriched in the International Energy Agency.

2.2.2. Renewable energy

According to Böhringer, Keller, and Van der Werf (2013), policymakers across OECD countries embarked on initiatives that seek to promote renewable energy initiatives. Those renewable energy source schemes were under the banner of curing socio-economic problems like climate change and unemployment. In 2009, the European Union (2009) committed to increase the share of renewable energy sources to 20 percent in 2020. According to the European Environment Agency (2023), the European Union achieved its commitment to increase its share of renewable energy sources to 20 percent in 2020 as shown in Figure 4.

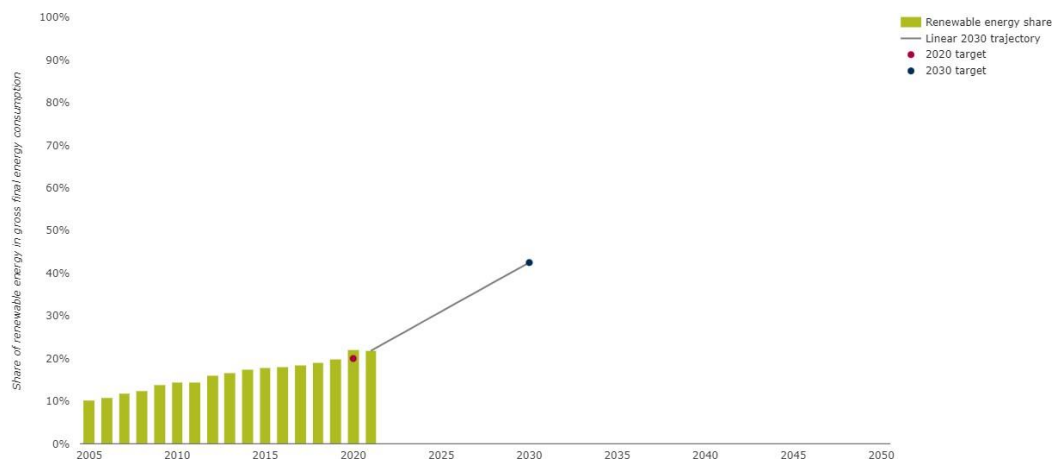


Figure 4: Progress towards renewable energy source targets for EU-27

Source: European Environment Agency, 2023.

The justification for promoting renewable energy sources by Member states was under the banner of:

“Promoting the security of energy supply, promoting technological development and innovation and providing opportunities for employment and regional development “as well as being “an important part of the package of measures needed to reduce greenhouse gas emissions and comply with Kyoto Protocol”.

According to Lauber and Johnson (2015), the Kyoto Protocol, which was adopted in 1997, called for Greenhouse gas emissions to be reduced by 2008-2012. Consequently, the European countries accepted the obligation to reduce their Greenhouse gas emissions by 8% from those of 1990. This adoption was received differently by different European states. Countries like Poland advocated for the continuation of coal use, whilst countries like Germany, the conservative government of Germany announced the energy transformation by the reduction of the amount of fossil fuels from 80% to 20% of energy supply by 2050. Still in the case of Germany, Renn, and Marshall (2016) stated that until 2010, half of the domestically produced energy came from coal and lignite, and the remaining sourcing was from nuclear, gas as well as renewables. However, the share of renewable energy sources drastically increased since 2010. According to Marti-Ballester (2019), public finance is important to provide incentives that will encourage the development of clean energy projects in their early stages as it allows firms to lower the high cost and the high risk that come about because of renewable energy

Technology research activity. The authors further argued that the mobilization of private climate finance required to accelerate global clean energy innovation, the mutual funds specialized in renewable energy could play an important role as a sustainable investment vehicle.

2.2.3. Energy security

Energy security is an important factor to be considered in the transition from fossil fuel to renewable energy sources. Energy is an important resource in our lives and livelihoods, hence, any initiative to drive a transition of energy sources without taking any due consideration of energy security is likely to have detrimental effects. According to Renn et al., (2016), there are examples of elements that threaten energy security, namely, oil price hikes, unstable political regimes in the Middle East and Russia, and lastly the depletion of North Sea oil as well as in the gas fields. The study by Bugge, Kjær, and Blum (2006) stated that there is a need for coal-fired power plants so that there is the assurance of electricity supply in the future.

2.2.4. Sources of funding for coal-fired power plants

The study conducted by Ma and Gallagher (2021), stated that the Group of 20 (G20) is at a better place to commit to limiting all overseas fossil fuel financing, and in so doing, they must start by limiting finance of coal projects from the private and public sectors. Furthermore, the G20 must put a policy framework in place for disclosure, and transparency and just transition to realising a low-carbon global economy. In May 2021, the Group of 7 (G7) Climate and Environment Ministers took a resolute that international investment in unabated coal must stop now, as well as committing that by the end of 2021, there should be an end to new government support for unabated international thermal coal power generation. In 2015, the Organisation for Economic Co-operation and Development (OECD) passed the Sector Understanding on Export Credits for Coal-Fired Electricity Generation whose purpose was to limit financing for unabated coal in official export credits.

According to Ma et al., (2021), the private sector from the G7 and other advanced economies constitute the larger portion of the overseas coal finance in the world economy. China is considered the largest public financier of abroad coal plants. This assertion is evidenced by the funding provided by the Chinese policy banks towards coal projects abroad, namely, the Export-Import Bank of China and the China Development Bank. The research by Ma et al.,

(2021), further made findings that the Export-Import Bank of China and the China Development Bank accounted for US\$15.6 billion or 50 percent of global public finance towards coal-fired power plants. Japan accounted for about 30 percent of global public finance towards coal-fired power plants, whilst South Korea accounted for 11 percent.

According to Ma et al., (2021), it appears that the public finance institutions of several Western countries, including the USA, have made withdrawals from coal projects that were under consideration for funding in 2021. Furthermore, Ma et al., (2021) found that between 2013 and 2018, Chinese public finance accounted for 16 GW or 40 percent of coal-fired power projects. In addition, over the years, the commercial sector contributed about 6 percent of the total Chinese capital-funded coal power generation projects outside of China.

According to Ma and Schücking (2021), China was the last remaining public financier of abroad coal plants, of which it financed 32GW of overseas capacity, which accounted for about 13 percent of the coal power capacity overseas that is operational or under development between 2013 and mid-2019. The finance was through Chinese public and/or commercial entities, including policy banks, commercial banks, and equity banks. The remaining 87% of public and private finance for abroad coal projects was funded by entities outside of China. The independent research suggests that Japanese and Western institutional investors, including commercial banks, constitute a large portion of financiers of international coal projects overseas.

Institutional investments also contributed to the coal industry. According to Schücking (2021), Institutional investors from Japan constitute the second largest in the coal industry whilst institutional investments from the UK constitute the third largest in the coal industry. According to the study conducted by Schücking (2021), the top lenders to the coal industry were commercial banks from Japan which landed USD 76 billion, US commercial banks which lent USD 68 billion and UK commercial banks which lent USD 22 billion between October 1, 2018, and October 31, 2020. The commercial banks from the three countries accounted for 52 percent of lending in the coal industry.

According to Urgewald (2018) leading environmental organisations conducted research between January 2016 and September 2018. The research was focused on the top 120 coal plant developers which accounted for about 70 percent of the global pipeline of new coal-fired power

Plants projects. The research found that during the January 2016 to September 2018 period, the top 120 coal plant developers received more than USD 100 billion in loans from 235 commercial banks, of which most of the loans were provided as corporate loans whilst the minority was in project finance. Of the USD 100 billion loans received; 30 percent came from Japanese Banks. This stance is substantiated by the report from Bank Track (2018), which found that Japanese companies are involved in coal power development around the world. 25 percent of the total loans came from the European bank. The research conducted by RAN (2019), focused on corporate lending, project finance, and underwriting of thirty-three banks from Canada, China, Europe, Japan, and the US. Furthermore, the research found that the banks contributed funding of US\$31 billion to the largest 30 coal power corporations.

2.2.5. Efforts to limit fossil fuel funding.

According to Lerven (2020), in the quest to reduce the funding of coal projects, central banks and financial supervisors have a critical role to play in channeling capital flows as well as managing the resilience of the financial system. Lerven (2020) suggested that the role that the central banks can play is through monetary policy intervention, by shifting capital away from coal towards a low-carbon economy.

According to Yukhananov, and Volcovici (2013), around July 2013, the World Bank board agreed to a new energy strategy that would limit financing of coal-fired power stations to address the impacts of climate change. In its efforts to balance environmental efforts, the World Bank amended its lending policies for new coal-fired power projects by restricting financial support to countries that have “no feasible alternative to coal”. Analysts hope that the World Bank’s strategy to restrict new coal-fired power plants would consequently categorise coal as a risky investment and compel countries to alternative energy sources. The new strategy may also be derailed by donors and the private sector that continues to finance coal. The World Bank has come under immense criticism for calling for action to cut emissions of carbon dioxide whilst they are funding coal-fired power plants, which are seen as the causes of rising pollution from heat-trapping gases. The World Bank defended its stance by arguing that providing funding for coal-fired power stations is sometimes necessary so that energy can be made available to the poorest countries in the world. According to Xiahou, Springer, and Mendelsohn (2022), coal-fired power plants are cheap to build and run in most developing countries. According to Yukhananov, and Volcovici (2013), Brazil and China as part of

Emerging markets, have in the past blocked propositions that sought to limit coal financing at the bank. As of 2013, the last project for a coal-fired plant that was approved by the World Bank was in 2010 in South Africa, however, the USA, Netherlands, and Britain showed little to no support due to environmental concerns. In 2013, then US President Barack Obama stated that the US should stop investing in coal projects overseas as well as multilateral banks, this is in the quest to address climate change. The research conducted by Gao, Davidson, Busby, Shearer, and Eisenman (2021) studied the factors that led to the cancellation of coal phasing out in Vietnam and Indonesia. In Vietnam, the study found that fuel switching, public opposition, and national planning were the dominant rationales that led to the cancellation of the coal phase-out, whilst the reasons for coal cancellation were diverse in Indonesia.

According to Mathews, Miller, Song, Schobert, Botha, and Finkleman (2013), substantial amounts of coal would still be used for the foreseeable future in the U.S. until alternative energy resources are effective, and this will be the case even if constraints on CO₂ emissions were mandated. The argument seems to suggest how reliable coal is as a source of energy for the U.S. economy. Mathews et al., (2013), further argued that there is a projected estimation of a 6% increase in coal use between 2008 and 2035. This suggests that the use of coal is not likely to decline and suggests that coal is a major tool for energy security. As argued by Mathews et al., (2013), there is a sense of reluctance to move away from coal, and coal will still be consumed for the foreseeable future until an alternative energy source is found. From the authors' agreement, it is crystal clear that coal is more reliable and there is an element of energy security through coal. Perhaps given the number of jobs that were created by the coal industry, one might start to think about the levels of jobs that would be created by alternative energy sources, in our case renewable energy sources.

2.2.6. Carbon Capture Technology

According to Hetti, Karunathilake, Chhipi-Shrestha, Sadiq, and Hewage (2020), carbon dioxide capture, storage, and utilization are regarded as the sole means used to capture carbon dioxide emissions that are generated by energy systems like fossil fuel-based energy systems.

According to the study by Van Noorden (2013), the European region has fallen behind North America in its quest to demonstrate systems for capturing greenhouse gas emissions from the power plants industry as it increases its use of coal. Around December 2013, announcements

suggested Europe's troubles in launching large carbon capture storage (CCS) projects. A fund was set up by the European Commission around 2011 in support of carbon capture storage (CCS) projects, however, the fund could not find a single project to finance. The funds were instead given to renewable-energy projects. No country is finding an easy model to fund CCS, about four projects have successfully stored gas on a small scale in the underground. There is no large carbon-capture system operating at a power plant in the entire universe. If a large power plant were to be fitted with CCS systems, the result would be an increase in the price of electricity by 50-100%, and this would require millions of dollars in subsidies.

Furthermore, according to Van Noorden (2013), the CCS industry in Europe has been delayed due to a combination of economic recession and Brussels bureaucracy. Europe as a region has preferred wind and solar projects. By July 2012, the European Commission's fund had shortlisted ten CCS projects, waiting for guarantees of co-funding from member states. Only five of the six countries in which the CCS plants were to be built did not come to the party, namely the UK, Netherlands, Italy, and Romania. As a result of this missed opportunity to step up by member states, CCS in Europe was delayed by two years. In the United States and Canada, the developers of CCS made faster progress by combining public subsidies with sales of the carbon dioxide that they capture. In 2014, two large North American projects were projected to start.

2.2.7. Determinants of coal funding results from other studies

Other studies also researched the determinants of funding for coal-fired power plants. The study by Diluiso, Walk, Manych, Cerutti, Chipiga, Workman, and Minx, (2021), found that the availability of local reserves is the driving force behind the flow of finance for the coal-fired power plant development. The study by Kurniawan (2020) found that the flow of finance for the development of coal-fired power plants was driven by high rates of economic growth as well as rising energy consumption, especially in low-income countries. Whilst the study by Blondeel, Van de Graaf, and Haesebrouck, (2020), found that weak environmental governance and political transparency are the drivers affecting the flow of finance for the development of coal-fired power plants. The study by Edianto, Trencher, and Matsubae (2022) found that the absence of strong policies supporting renewables and carbon price adoption are the driving force behind the cash flow for financing coal power plants. The study by Manych, Egli, Ohlendorf, Schmidt, Steffen, Stünzi, and Steckel (2023) found that the provision of loans

for coal-fired power plants from public banks in Japan, South Korea, and China are directly linked to the export of equipment and services. This suggests that Japan, South Korea, and China use loans for coal-fired power plants to open export opportunities for their industries. Furthermore, the findings of the study by Manych et al., (2023) suggest that unlocking export opportunities for industries could be the determinant of funding for coal-fired power plants.

Scholars such as Best (2017), Burke (2013), Kong and Gallagher (2021), Martí-Ballester (2019), Singhania and Gupta (2011), Clark, Benoit & Walters (2023), Olumuyiwa (2012), Noor & Siddiqi (2010), Okun's Law (1962), Meidani (2015), Wang and Le (2018), Okun's Law (1962), Amzi (2013), Ayodeji, Osifalujo and Taiwo (2022), included the variables mentioned in chapter in their models and those variables are believed to be possible determinants.

2.2.8. The economic impact of changes in funding for coal-fired power station projects.

The decision to fund or defund coal-fired power plants has a major economic impact. If coal-fired power plants are found to be reliable energy sources, perhaps that raises concerns about how the economy will be impacted should coal-fired power plants be phased out. The study by Nam and Burke (2023) found that the economic barriers to phasing out coal power in Vietnam center around the reliability of the electricity supply. This is reasonable because if the energy source that is deemed reliable is phased out without any concrete alternative, the electricity supply could be negatively impacted, ultimately affecting the economy. Furthermore, the study by Nam et al., (2023) found that one of the concerns for phasing out coal power is that it may result in public unrest. The authors made this argument by citing the low-cost nature of electricity prices in Vietnam, and consequently, given the capital investment required for the energy transition, phasing out coal power could increase retail electricity prices. Furthermore, Nam et al., (2023) found that the economy could be negatively impacted by the phase-out through unemployment. The authors stated that about 200,000 jobs in the mining sector could be affected by the coal phase-out. A transition from coal to a cleaner energy source could require effective institutions as well as regulations. Nam et al., (2023) found that one of the barriers to phasing out coal power in Vietnam is the lack of regulations.

2.2.9. Relationship between coal funding and renewable energy output.

According to Edianto, Trencher, & Matsubae (2022), coal combustion plays a huge part in global heating. The authors stated that to minimise the environmental impact of climate change, coal combustion needs to be minimised and that there needs to be an advocacy for renewable energy sources. This could suggest that there could be a causal relationship between coal power and

renewable energy sources. The study by Edianto et al., (2022) further made findings that suggest a link between coal power and the absence of policies that are in support of renewable energy. In their findings, the authors found that countries with no policies that are advocating for renewable energy are likely to receive financing for coal power. The study by Manych, Steckel, and Jakob (2021) stated that policy instruments that are intended to discourage capital flows for coal plants could foster financial institutions to shift funding from coal power to renewable energy. This could suggest that there could be a causal relationship between funding for coal plants and renewable energy.

2.3. Research gaps

The key motivating question for this research is empirically investigating the determinants of coal funding. The existing literature in the field of coal funding has clearly outlined who funds the coal projects, but little was elaborated on what the determinant(s) of the funding is/(are). For example, a study conducted by Ma et al., (2021) points out the sources of funding for coal projects and points out China as the largest funder of abroad coal projects. However, the study did not empirically examine what determines/ drivers of the funding for coal-fired power stations other than climate change. This study aims to address that gap.

2.4. Conclusion

This chapter attempted to illustrate who the major financiers of coal-fired power plants are. Furthermore, the chapter attempted to unravel what other authors found concerning what factors drive the flow of capital toward coal-fired power plants. Although there are efforts to transition to renewable energy sources as soon as 2050, some studies believe that the transition from fossil fuel energy sources will worsen the socio-economic issues of different countries. Furthermore, the Ukraine and Russia war has proven that during the world energy crisis, the efforts to transition from fossil fuel energy sources are moved aside as this was clear when Germany re-opened its coal mines recently so that it can ensure that there is energy security.

CHAPTER 3: RESEARCH STRATEGY, DESIGN, PROCEDURE AND METHODS

3.1. Introduction

In this chapter, the study describes the method that was used to answer the following research questions, what are the determinants of funding levels for coal-fired power stations, what are the economic impacts of changes in funding for coal-fired power station projects, and whether there is a causal relationship between coal funding and renewable energy output. Section 3.2 describes the data and variables used in this study; section 3.3 describes the research approach; section 3.4 describes the research design and section 3.5 describes the analytical methods used in this study.

3.2. Data

3.2.1. Variables

The data relates to five countries, namely, South Africa, India, Indonesia, South Korea, and Vietnam for a period of twelve years from 2008 to 2020. The panel of countries was selected because of the availability of data relating to funding for coal-fired power plants, which influenced the research to focus on certain countries. Attempts were made to search for data from other sources that the researcher had access to, however, data only existed for the selected countries. The data regarding the funding of coal-fired power stations was sourced from Global Energy Monitor. The data is in US dollars and represents closed financing. According to Global Energy Monitor (2023), closed financing means that both a financing agreement was signed and that the funds are available for withdrawal. The data that was used in this research that was sourced from World Development Indicators (2023) are as follows: credit to private sector (as

% to GDP) representing financial depth, interest rate (as %), access to electricity (as % of population), GDP per capita growth rate (as %), CO2 emissions (in kt), inflation rate (in %), gross capital formation (% of GDP) representing capital, trade (% of GDP) and renewable energy output. The data for the unemployment rate was sourced from the World Bank (2023). Please refer to Appendix A1.

3.3. Models

Through this analysis, the research will be able to determine whether the selected possible determinants have a significant influence on the funding of coal-powered plants, thus addressing research objective 1. The specification that will be used for the estimation is as follows:

$$Y_{it} = \alpha + \beta_1 X_{1,it} + \beta_2 X_{2,it} + \beta_3 X_{3,it} + \beta_4 X_{4,it} + \beta_5 X_{5,it} +$$

$$\beta_6 X_{6,it} + \beta_7 X_{7,it} + \varepsilon_{it}$$

Where:

Y_{it} is the dependent variable for entity i at time t (Coal funding).

α is the Y-intercept when x is at zero.

$X_{1,it}, X_{2,it}, X_{3,it}, X_{4,it}, X_{5,it}, X_{6,it}, X_{7,it}$, are independent variables (Financial depth, CO2 emissions, Lending interest rates, Inflation, Unemployment rate, Access to electricity, GDP per capita growth rate respectively).

ε_i = error term.

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ are the coefficients of the independent variables.

For addressing the second research objective of this study, the specification that will be used for the estimation is as follows:

$$Y_{it} = \alpha + \beta_1 X_{1,it} + \beta_2 X_{2,it} + \beta_3 X_{3,it} + \beta_4 X_{4,it} + \beta_5 X_{5,it} + \varepsilon_{it}$$

Where:

Y_{it} is the dependent variable for entity i at time t (Coal funding).

α is the Y-intercept when x is at zero.

$X_{1,it}, X_{2,it}, X_{3,it}, X_{4,it}, X_{5,it}$ are independent variables (Coal funding, Capital, Unemployment rate, Interest rate, Inflation respectively)

ε_i = error term.

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = coefficients of independent variables.

To investigate whether there is a causality between funding for coal-fired power plants and renewable energy output, and hence addressing research objective 3, the causality test, to be specific, the Dumitrescu-Hurlin Panel Causality, was performed. According to Dumitrescu and Hurlin (2012), the Dumitrescu-Hurlin Panel Causality analysis tests the heterogeneity of causal relationships and the heterogeneity of the regression model that is used to test Granger causality. Furthermore, according to Lopez and Weber (2017), the Dumitrescu-Hurlin Panel Causality test is essential in detecting causality in the panel data. The Dumitrescu-Hurlin (2012) model that was used is as follows:

$$y_{i,t} = a_i + \sum_{k=1}^K \gamma_i^{(K)} Y_{i,t-k} + \sum_{k=1}^K \beta_i^{(K)} X_{i,t-k} + \varepsilon_{i,t}$$

Where:

$i = 1$

N and $t = 1$.

$X_{i,t}$, and $Y_{j,t}$ are the observations of two stationary variables for individual i in Period t .

3.4. Procedure and Analytical Methods

3.4.1. Preliminary analysis

As part of initial analyses, this study considers descriptive analysis of the variables and then stationarity/panel unit root analysis.

3.4.1.1. Descriptive analysis

According to Ogieva and Ogiemudia (2019), descriptive analysis is essential as it allows the author to summarise the statistical properties of data in the quest to present them conveniently. The types of descriptive statistics that were used in this study include the mean, median, and standard deviation.

3.4.1.2. Stationary tests

In testing for stationarity, Levin, Lin & Chut was used. According to Ogiewa et al., (2019), Levin, Lin, & Chut is used to ascertain the extent to which variables in a model are stationary. According to Levin, Lin, and Chut (2002), the Levin, Lin, and Chut test assumes a common unit root process across sections. According to Im, Pesaran, and Chut, (2003), the Im, Pesaran, and Chut test allows for individual root processes varying across sections.

3.5. Classical linear regression

To address objectives one and two, this study applies the panel data ordinary least square (OLS) regression method and descriptive analysis. According to Prasada (2019), panel data is an analysis method that combines cross-section data and time series which use observational data on one or more variables in one unit continuously over some time. Furthermore, Prasada (2019) reported that the advantage of the panel data regression model is that it controls the heterogeneity of individuals with cross-section data that are assumed to be homogenous.

3.6. Specification/ Diagnostics tests

For testing autocorrelation, this study used the Durbin-Watson statistic as a measure of autocorrelation. According to Wilford and Taylor (1975), Durbin-Watson is used to test the hypothesis of no autocorrelation amongst the disturbances of linear regressions model against the hypothesis of first-order autocorrelated disturbances. For testing multicollinearity, the study used the Variance Inflation Factor (VIF). According to Salmerón, García, and García (2020), VIF is applied to diagnose the possible existence of multicollinearity, and a centered VIF of 10 is traditionally accepted threshold.

CHAPTER 4: PRESENTATION OF RESEARCH RESULTS

4.1. Introduction

This section outlines the outcomes of this research. In arriving at the outcomes of this study to investigate the impacts amongst the variables of interest, this study used multiple regression analysis. In performing the multiple regression analysis, the Eviews (version 13) statistical software package was used. Section 4.2 provides the descriptive statistics of the variables used in this study, section 4.3 presents and discusses the results for stationarity, section 4.4 presents and discusses the results for research objective one, section 4.5 shows and discusses the results for research objective two, section 4.6 presents and discusses the results for research objective three, and the final section (4.7) concludes the chapter.

4.2. Descriptive statistics

Table 1: Descriptive test results

<i>Variable</i>	<i>N</i>	<i>Max</i>	<i>Min</i>	<i>Mean</i>	<i>Median</i>	<i>Std. Dev</i>	<i>Skewness</i>	<i>Kurtosis</i>
Coal funding	65	6.118E+11	0	1.278E+10	3.276E+09	7.552E+10	7.86	64.78
Interest rate	65	16.95	2.8	9.38	9.67	3.2394598	-0.14	-0.25
Inflation	65	23.12	0.38	5.37	4.52	3.93075	2.07	6.19
Capital	65	39.79	12.4	29.86	31.92	6.72046	-1.02	0.17
GDP Per capita growth rate	65	7.01	-6.73	3.24	3.8	2.7202365	-1.54	3.77
Emissions	65	2458175.9	117585.1	744337.65	483978.7	669196.92	1.5	0.9
Financial depth	65	164.14	24.54	75	61.73	38.49	0.64	-0.78
Renewable energy output	65	41.12	0	3.24	3.276E+09	7.552E+10	7.86	64.78
Access to electricity	65	100	74.12	92.97	96.46	7.65	-0.84	-0.55
Unemployment rate	65	25.54	1	8.1	4.39	7.7625667	1.24	0.07

Notes: Std Dev stands for standard deviation

Source: Author's computation

Table 1 reports descriptive statistical results including the mean, median, standard deviation, skewness and kurtosis of the variables for all five countries from 2008 to 2020. The variables are natural and not in logs. In terms of the mean, all the variables, have a positive mean, which suggests on average, the

data are above zero. We observe that all variables, except emissions, have a small deviation from the mean based on the standard deviation, suggesting that the data is close to the mean. The emissions variable has a large deviation from the mean, suggesting that the data sets are largely spread out from the mean. In terms of the skewness, we observe that coal funding, inflation, Emissions, Financial depth, Renewable energy output, and Unemployment rate are positively skewed. This means that the variables are concentrated on the left whilst the tail is extended to the right, resulting in fewer unusually high values. The variables Interest rate, Capital, GDP per capita growth rate, and Access to electricity are negatively skewed, this means that the majority of the data points are concentrated on the right and the tail is extended to the left, resulting in a few unusual low values. In terms of kurtosis, we observe that Coal funding, Inflation, Capital, GDP per capita growth rate, Emissions, Renewable energy output, and Unemployment rate have a positive kurtosis, implying that they have a trait of usually extreme deviations from the mean as well as high probabilities for outliers. Lastly, we observe that Interest rate, Financial depth, and Access to electricity have a negative kurtosis, indicating that there are less extreme deviations from the mean, implying that there are lower probabilities for outliers.

4.3. Stationary tests

In this section, the checks on the stationary of the variables will be done. A stationarity test is performed to understand the characteristics of the panel data.

Table 2: Stationarity test results

<i>Variable</i>	<i>Im, Pesaran & Shin (IPS)</i>		<i>Levin, Lin & Chu (LLC)</i>	
	<i>Level</i>	<i>First Difference</i>	<i>Level</i>	<i>First Difference</i>
Coal funding	-60.798***	-49.790***	-134.776***	-112.802***
Financial depth	-0.334	-0.687	-1.978***	-0.819
Emissions	-0.942	-1.726**	-1.862***	-1.557**
Capital	-1.211	-3.808***	-2.845***	-5.533***
Inflation rate	-2.744***	-6.437***	-4.075***	-8.853***
Interest rate	-0.690	-3.238***	-1.984**	-4.323***
Renewable energy output	0.365	-1.209***	-1.964**	-2.449***
Access to electricity	-0.717	-0.905	-2.171**	-9.265
Unemployment rate	-2.032**	-8.067***	-2.711***	-4.248***

Note: *** and ** indicate significance at 1% and 5%, respectively. We include individual intercepts for all test equations with automatic lag selection based on the (AIC).

Source: Author's computations

Table 2 shows the results for stationarity based on Levin, Lin, and Chu t which assumes a common unit root process, and Im, Pesaran, and Shin unit root tests which assume the individual root process. The number of lags was automatically selected based on the Akaike information criterion (AIC). For testing the unit root using the Akaike information criterion. The null hypothesis of the two tests is that there is a unit root, or the series is non-stationary. If the p-value is less than or equal to 5%, then the null hypothesis will be rejected. All the variables were found to be stationary at the level using LLC. For IPS, coal funding, Inflation rate, and Unemployment rate were found to be stationary at level. Capital, emissions, interest rate, and renewable energy output were found to be stationary at 1st difference using IPS. Financial depth and access to electricity were found to be stationary at 2nd difference using IPS.

4.4. Main results of the study

4.4.1. Research objective 1: Determinants of coal funding levels

This section presents the determinants of funding for coal-fired powered power projects.

4.4.1.1. Presentation of results

Table 3: Selected determinants of coal funding

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>
Financial depth	0.011	0.007	1.501
Emissions	-0.106	0.217	-0.491
Interest rate	0.220**	0.101	2.170
Inflation	-0.640***	0.221	-2.887
Unemployment rate	-0.119***	0.030	-3.935
Access to electricity	-0.152***	0.032	-4.657
GDP Per capita growth rate	-0.530***	0.228	-2.322
C	14.22	5.96	2.38
R-squared	0.397	Durbin Watson stat	1.68
Adjusted R-squared	0.316		
F-statistic	4.900		
Prob(F-statistic)	0.000		

Note: *, **, and *** indicate significance at 10%, 5%, and 1% levels respectively.

Number of countries: 5. Number of observations: 60

Source: Author's computations

Table 4: Multicollinearity results

<i>Variable</i>	<i>Coefficient Variance</i>	<i>Uncentered VIF</i>	<i>Centered VIF</i>
Financial depth	5.38	30.55	6.12
Interest rate	0.01	84.05	8.66
Unemployment rate	0.00	8.68	4.22
Access to electricity	0.00	752.98	5.11
GDP per capita growth rate	0.05	7.74	1.90
Emissions	0.04	670.66	2.33
Inflation	0.04	4.05	4.05

Source: Author's computations

4.4.1.2. Specification checks

Before the results are interpreted and discussed, the diagnostics checks are briefly explained. Adjusted R-squared is a statistical measure that considers the model's explanatory power. Based on the results in Table 3, the adjusted R-squared is 0.32, which indicates that there was a variation of 32% in the proportion of coal funding due to changes in unemployment rate, access to electricity, financial depth, emissions, GDP per capita growth rate, inflation rate, and interest rates at 99% confidence level. Even though the adjusted R-squared is not large enough, it is shown from the F-statistics that there is a joint significant effect of the independent variables on the dependent variable, and now in the sub-section, the regression coefficients are interpreted and discussed. The Durbin-Watson statistic test is used as a measure of autocorrelation in the regression model presented. From the results in Table 3, the Durbin-Watson statistic is recorded at 1.68, which is closer to 2 and therefore acceptable as it is not far away from 2, which indicates non-autocorrelation. The multicollinearity test was performed using the Variance Inflation Factors (VIF). The results in Table 4 show that the centered VIF is less than 10 on all variables. This means that the variables are not highly correlated and there is a low risk of multicollinearity.

4.4.1.3. Interpretation and discussion of regression coefficients

The coefficient of financial depth is statistically insignificant at all three significant levels as indicated in Table 3. Therefore, the results suggest that financial depth is not a significant determinant of funding for coal-fired power plants. A possible explanation for the result is that financing could be committed to renewable energy players in the private sector, instead of players in the coal-fired power plants industry due to environmental concerns that the coal industry poses.

The coefficient of the unemployment rate variable is statistically significant at the 1% significance level as indicated in Table 3. A negative relationship exists between the proportion of funding for coal-fired power plants and the unemployment rate as the coefficient for the unemployment rate is -0.119%. This means that a unit increase in the unemployment rate will lead to a decrease in funding for coal-fired power plants by 0.119%. A possible reason why when unemployment increases, funding for coal-fired power plants tends to decrease could be that an increase in the unemployment rate suggests that the economy may be facing downturns which negatively affects

economic activities, resulting in lower energy demand. The study by Imran, Mughal, Salman, and Makarevic (2015), found that a higher unemployment rate has a significant negative impact on the GDP per capita growth rate (a proxy for economic growth). Hence, when energy demand gets lower, funding for coal-fired power plants may be lowered as well.

The coefficient of interest rates variable is statistically significant at the 5% significance level as indicated in Table 3. A positive relationship exists between funding for coal-fired power plants and interest rates as the coefficient for lending interest rate is 0.22%. This means that a unit increase in interest rates will lead to an increase in the funding for coal-fired power plants by 0.22%. A possible explanation is that investors could be attracted by higher returns on their investments driven by higher interest rates, and hence funding for coal in the economy tends to rise. The study by Ayodeji, Osifalujo, and Taiwo (2022) stated that in theory, higher interest rates are expected to attract more foreign direct investment because foreign investors put their resources where there is a promise of higher returns. Furthermore, Ditta, and Hassan (2017) also found that an increase in interest rate will lead to inflows of foreign direct investments. The outcome is contrary to the findings of the study conducted by Faroh and Shen (2015) which found that a higher interest rate does not attract foreign direct investment. Furthermore, the study by Harswari and Hamza (2017) found that interest rate has a negative insignificant impact on foreign direct investment.

The coefficient of GDP per capita variable is statistically significant at the 5% significance level as indicated in Table 3. A negative relationship exists between the proportion of funding for coal-fired power plants and GDP per capita as the coefficient for GDP per capita is -0.530%. This means that a unit increase in GDP per capita growth rate will lead to a decrease in the funding for coal-fired power plants by 0.530%. Burke (2013) found that as the GDP per capita of countries increases, the countries progress to fossil fuel energy, and thereafter renewable energy sources. This could suggest that as the country's GDP increases, they tend to shift from coal energy sources to renewable energy sources. This assertion is substantiated by the study by Jin and Kim (2018) which found that in the long run, a percentage increase in GDP per capita leads to a 0.2% decrease in coal consumption. Burke (2013). According to Martí-Ballester (2019), the growing concern about the use of fossil fuels on global warming, climate change, and risk for portfolios could create

investment opportunities for energy efficiencies and renewable energy projects. The outcome is aligned with the findings of the study by Kong and Gallagher (2021) which found that economic growth is not the main driver behind the expansion of coal-fired power plants across the seventeen countries in which the research was conducted.

The coefficient of the inflation rate variable is statistically significant at the 1% significance level as indicated in Table 3. A negative relationship exists between the proportion of funding for coal-fired power plants and inflation as the coefficient for inflation is -0.640%. This means that a unit increase in the inflation rate would lead to a decrease in the funding for coal-fired power plants by -0.640%. A possible reason why when the inflation rate rises, funding for coal-fired power plants tends to decrease is that a rise in inflation could lead to a rise in the construction costs, as well as other costs associated with coal-fired power plants, as a result of increased costs due to inflation, investors may reconsider investing their finances in coal-fired power plants. The study by Singhanian and Gupta (2011) found that the inflation rate is a significant determinant of foreign direct investment. A certain portion of the funding for coal-fired power plants for this research is derived from foreign sources. The study by Khan and Mitra (2014) found that high levels of inflation will negatively affect economic activities, resulting in a decrease in the capital flow in the economy.

The coefficient of access to electricity variable is highly significant at the 1% significant level as indicated in Table 3 showing the existence of a negative relationship between the proportion of funding for coal-fired power plants and access to electricity as the coefficient for access to electricity is -0.152%. This means that a unit increase in access to electricity would lead to a decrease in the funding for coal-fired power plants by -0.152%. A possible reason that explains why when access to electricity rises, funding for coal-fired power plants tends to decrease, could be because of the presence of policies and regulations that support phasing out of coal energy sources and replacing them with renewable energy sources. Increased access to electricity could be a result of increased diverse sources of energy, which in the process may be receiving increased attention and funding possibly at the expense of that which is directed towards coal-fired plants. According to Winkler, Tyler, Keen, and Marquard (2023), renewable energy technology is currently cheaper than coal.

The coefficient of emissions variable is statistically insignificant as indicated in Table 3. The results suggest that CO2 emissions are not a significant determinant of coal funding. A possible explanation as to why emissions do not seem to influence funding for coal-fired power plants could be that decisions regarding addressing environmental degradation do not necessarily affect the level of funding for coal-fired power plants. Furthermore, there could be a delay in implementing emission-related policies, as a result, funding for coal-fired power plants may not be confined by any emission-related policy.

4.5. Research objective 2: Economic impact of changes in coal funding

4.5.1. Presentation of results

Table 5: Effect of coal funding changes on economic growth

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>
Coal funding	-0.159***	0.067	-2.356
Capital	1.653***	0.391	4.220
Unemployment rate	-0.020	0.106	-0.192
Interest rate	0.497***	0.229	2.167
Inflation	-0.029	0.090	-0.321
C	-5.464	1.518	-3.597
R-squared	0.463	Durbin Watson stat	1.50
Adjusted R-squared	0.413		
F-statistic	9.131		
Prob(F-statistic)	0.000		

Note: *, **, and *** indicate significance at 10%, 5%, and 1% levels respectively.

Number of countries: 5. Number of observations: 60

Source: Author's computations

Table 6: Multicollinearity results

<i>Variable</i>	<i>Coefficient Variance</i>	<i>Uncentered VIF</i>	<i>Centered VIF</i>
Coal funding	0.00	1.08	1.08
Capital	0.15	392.09	2.10
Unemployment rate	0.01	8.66	2.11
Interest rate	0.05	57.36	1.87
Inflation	0.00	1.83	1.83

Source: Author's computations

4.5.1.1. Interpretation of diagnostic results

Before the results are interpreted and discussed, the diagnostics checks are briefly explained. Adjusted R-squared is a statistical measure that considers the model's explanatory power. Based on the results in Table 5, the adjusted R-squared is 0.41, which indicates that there was a variation of 41% in GDP per capita due to changes in funding for coal-fired power plants, capital, unemployment rate, interest rate, and inflation at 99% confidence level.

Even though the adjusted R-squared is not large enough, it is shown from the F-statistics that there is a joint significant effect of the independent variables on the dependent variable, and now in this subsection, the regression coefficients are interpreted and discussed.

The Durbin-Watson statistic test is used as a measure of autocorrelation in the regression model presented. From the results in Table 5, the Durbin-Watson statistic is recorded at 1.50, which is closer to 2 and therefore acceptable as it is not far away from 2, which indicates non-autocorrelation. The multicollinearity test was performed using the Variance Inflation Factors (VIF). The results in Table 6 show that the centered VIF is less than 10 on all variables. This means that the variables are not highly correlated and there is a low risk of multicollinearity.

4.5.1.2. Interpretation and discussion of regression coefficients

The coefficient of funding for coal-fired power plants variable is statistically significant at the 5% significance level as indicated in Table 5. A negative relationship exists between the funding for coal-fired power plants and the GDP per capita growth rate. This means that a unit increase in funding for coal-fired power plants will lead to a decrease in the GDP per capita growth rate by -0.159%. A possible explanation for why when funding for coal-fired power plants rises, GDP per capita tends to decrease as the world shifts towards cleaner energy sources, investors could be displaying low confidence in economies that still fund coal-fired power plants or coal projects. The study by Clark, Benoit & Walters (2023) seems to suggest that investors may be skeptical about the viability of investing in coal-fired power plants because of economic risks relating to climate policy changes. Furthermore, the article by IRENA (2023) reports that the global investment in renewable energy sources reached a record high in 2022. This substantiates the view about the increased investment in renewable energy sources as well as evidence that there is indeed

a shift towards cleaner energy sources. Furthermore, due to environmental concerns brought up by coal-fired power plants, an increase in the funding for coal-fired power plants could affect investment decisions as well as potentially expose the country to economic sanctions due to not abiding by the economic commitments to transition from coal to cleaner energy.

The coefficient of capital is statistically significant at the 1% significant level because its p-value of 0.005 is less than 1% as indicated in Table 5. A positive relationship exists between the capital and GDP per capita growth rate. This means that a unit increase in capital would lead to an increase in the GDP per capita by 1.550%. A possible explanation is that when investment is made in an economy, there could be an increase in job opportunities as well as an increase in infrastructure development, and both are likely to increase GDP per capita. The study by Noor & Siddiqi (2010) conducted in five South Asia countries found that gross capital formation positively affects economic growth. Furthermore, the study conducted by Olumuyiwa (2012) in Nigeria from 1985 to 2010 found a similar outcome that capital has a positive impact on economic growth.

The coefficient of the unemployment rate variable is statistically insignificant at all three significant levels indicated in Table 5. The results suggest that the unemployment rate variable is not a significant determinant of GDP per capita. The outcome is not logical because there has been empirical evidence emanating from other studies proving that the unemployment rate is a significant determinant of GDP. For example, the study by Meidani (2015), found that the unemployment rate is statistically significant in influencing GDP in the long run. This author used Auto-regressive Distribution Lag (ARDL) and focused on the period from 1971 to 2006. Furthermore, Okun's Law (1962), also found an inverse relationship between unemployment rate and output (GDP). The study by Wang and Le (2018), also found that the unemployment rate significantly affects economic growth.

The coefficient of the interest rate variable is statistically significant at the 5% significant level as indicated in Table 5. The results suggest that the interest rate variable is a significant determinant of GDP per capita. A positive relationship exists between the interest rate and GDP per capita growth rate. This means that a unit increase in interest rates would lead to an increase in the GDP per capita by 0.49%. The outcome is aligned with the outcome of the study by Amzi (2013), which found that

there is a significant impact of interest rates on GDP. The study by Ayodeji, Osifalujo, and Taiwo (2022) stated that in theory, higher interest rates are expected to attract more foreign direct investment because foreign investors put their resources where there is a promise of higher returns. An increase in foreign direct investment is essential for growing the GDP in an economy.

The coefficient of the inflation rate variable is statistically insignificant at all three significant levels indicated in Table 5. The results suggest that the inflation rate variable is not a significant determinant of GDP per capita. The outcome is not expected because there has been empirical evidence emanating from other studies proving that the inflation rate is a significant determinant of GDP. For example, the study by Amzi (2013), found that there is a significant impact of inflation on GDP. Furthermore, an increase in inflation is generally expected to have a negative and significant effect on economic growth.

4.6. Research objective 3: To investigate whether there is a causal relationship between coal funding and renewable energy output.

In addressing objective three, the study started by testing the correlation between funding for coal-fired power plants and renewable energy output. Afterward, the study did a causality test.

4.6.1. Presentation of correlation results

Table 7: Correlation results

Correlation Probability	Funding for Coal-fired power plants	Renewable energy output
Funding for Coal-fired power plants	1.0000	
Renewable energy output	0.1626 (0.1954)	1.0000

Note: *, **, and, *** indicate significance at 10%, 5% and, 1% levels respectively.

Source: Author's computations

4.6.1.1. Analysis of correlation results

A correlation of 0 indicates that there is a non-linear relationship, whilst a correlation of 1 indicates a perfect positive linear relationship and a correlation of -1 means that there is a negative linear relationship. According to the results in Table 7, the p-value suggests that there exists an insignificant relationship between Funding for Coal-fired power plants and Renewable energy output. In addition to the insignificance of the relationship, it is also clear that the correlation coefficient is very weak. Thus, there is no linear association between the two variables in question. However, the relationship might be non-linear if it exists, but assessing this is beyond the scope of

this study. About a possible nexus between coal funding and renewable output, this study investigates possible causality, and the results are shown in Table 8.

4.6.2. Causality analysis

Table 8: Causality between coal funding and renewable output

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob
Renewable energy output does not homogeneously cause coal funding	3.1654	0.0712	0.9432
Coal funding does not homogeneously cause renewable energy output	8.1463	2.2146	0.0268

Note: *, **, and, *** indicate significance at 10%, 5% and, 1% levels respectively.

Source: Author's computations

4.6.2.1. Interpretation and discussion of causality results

For performing the causality test, the Dumitrescu-Hurlin Panel Causality test was deployed. The null hypothesis is that there exists no causal relationship among the variables. The alternative hypothesis is that there exists a causal relationship. According to the results in Table 8, the null hypothesis that renewable energy output does not cause coal funding is not rejected as the p-value is greater than 0.05. The null hypothesis that coal funding does not cause renewable energy output is rejected as the p-value is less than 0.05. This means that there is a unidirectional causal relationship between coal-fired power plant funding and renewable energy output whereby changes in coal-fired power plant funding cause changes in renewable energy output, but the reverse is not true according to this study. It is plausible that when coal funding increases or decreases, it will cause a change in the funding that is committed towards renewable energy sources and, hence, affect the renewable output. Several countries tend to have an annual budget directed toward energy; how it works is that the higher the proportion allocated to non-renewable energy, the smaller the proportion allocated toward renewable energy. This is evidenced by the findings by Oil Change International (2022) which tracked an average total of USD 144 billion in international public finance for fossil fuels and renewables between the period 2016 to 2018 and found that only 16.5% was allocated to cleaner energy.

4.7. Conclusion

This chapter sought to answer the three objectives of the research. Furthermore, it attempted to elaborate on the possible reasons for the outcome of every regression result. The key findings from this chapter are unearthing the factors that statistically influence the funding for coal-fired power plants, how funding for coal-fired power plants affects economic growth, and investigating the causal relationship between funding for coal-fired power plants and renewable energy output.

CHAPTER 5: CONCLUSION AND SUMMARY

5.1. Introduction

This study is motivated by the fact that there is a global shift of focus from coal-based energy sources to renewable sources. While there tends to be a shift of attention from non-renewable to renewable sources of power as part of strategic goals in the global world, funding for power plants has not necessarily declined in many economies. Hence, this study seeks to investigate factors that determine funding for coal-fired power plants. Specifically, the first objective of this research paper was to investigate the determinants of coal-fired power plant funding. The second objective focused on the economic impact of changes in funding for coal-fired power station projects, and the third objective analysed the causality between coal funding and renewable energy output. In investigating objectives 1 and 2, the panel ordinary least square regression method was used. In investigating objective 3, the causality test was performed using the Dumitrescu-Hurlin Panel Causality test. Section 5.2 summarises the results of the study, Section 5.3 presents the implications drawn from the results, Section 5.4 reveals the limitations of this study, and Section 5.5 specifies areas for future research.

5.2. Summary of the findings

Regarding the determinants of coal funding (research objective one), the results show that interest rate, unemployment rate, access to electricity, GDP per capita growth, and inflation have a significant influence on funding for coal-fired power plants. However, financial depth and emissions do not have a significant influence on funding for coal-fired power plants.

In terms of the economic impact of changes in funding for coal-fired power station projects (research objective two), the study found that funding for coal-fired power plants has a significant influence on economic growth.

Furthermore, regarding whether there is a causal relationship between funding for coal-fired power plants and renewable energy output (research objective 3), the study found that there is a unidirectional causality flowing from funding for coal-fired power plants to renewable energy output. The next section presents the implications of the study.

5.3. Implications and Recommendations

5.3.1. Implication and Recommendations to investors

This study found that there is a negative relationship between funding for coal-fired power plants and economic growth. It means that when the GDP per capita growth rate increases, funding for coal-fired power plants tends to decrease. This finding implies that investors in coal-fired power plants to consider diversifying their investment portfolio to other alternative energy sources which may experience increasing funding as an economy grows. Kuang (2021) stated that the renewable energy industry is expected to flourish, and this will attract a variety of investors because of the commitment to create a climate-resilient economy. Hence, investors may benefit if they invest in cleaner energy.

5.3.2. Implication and Recommendations to governments/ policymakers

Policymakers need to align energy policies with economic development as well as environmental sustainability goals. Furthermore, as the results show as the economy grows, a shift away from coal funding is observed, and this implies that policymakers need to promote cleaner energy sources through incentives as well as implementing stringent policies that are pro-environmental sustainability. According to Kuang (2021), new investment opportunities will arise in the clean energy industry, hence, there is a need for policymakers to formulate effective pro-clean energy policies. However, in doing so, policymakers need to consider the recommendation of the study by Kuang (2021) which recommends that policymakers need to consider the uneven attractiveness of each clean energy sector when formulating policies that are aimed at encouraging investment in clean energy. The study further found that there exists a unidirectional causal relationship flowing from funding for coal-fired power plants to renewable energy output. This may imply that policymakers may be making decisions concerning funding for coal-fired power plants in line with those decisions made to achieve sustainability through renewable energy. It is possible that when policymakers decide to increase funding for coal plants, a sacrifice is made on the side of renewable energy. Unfortunately, on the reverse, clean energy decisions may be made without any influence of non-renewable funding. Thus, the promotion of renewable energy output may necessarily occur without effectively reducing the unclean, unsustainable non-renewable energy.

5.3.3. Implication and Recommendations to coal-producing companies

Coal-producing companies may need to consider diversifying their investment to cleaner energy sources as the results of this study show that as the funding for coal-fired power plants increases, the economy declines. During the time of economic growth, coal-producing companies may suffer due to changes in market dynamics, hence, they need to diversify their portfolio into cleaner energy sources. The study by Kuang (2021) stated that new investment opportunities are created by the expansion of the clean energy industry. This suggests that coal-producing companies may benefit from the investment opportunities created as a result of diversifying their investments.

5.3.4. Implication and Recommendations to researchers/ scholars

The findings of this research contribute to the academic literature relating to the funding of coal-fired power plants. Future scholars and researchers may focus on what forces drive the funding of coal-fired power plants to decrease as economic growth increases. This study has found results that may channel researchers and scholars toward understanding the interplay between funding for coal-fired power plants and other factors.

5.4. Limitations

The following limitations were encountered by the study:

For South Africa, the data relating to the funding for coal-fired power plants from domestic financiers could not be found, hence, only data from international financiers was used. The outcomes of this study are limited to South Africa, India, Indonesia, South Korea, and Vietnam.

5.5. Possible areas for future research

Future studies may consider including many countries and expanding the period. More so, different research approaches such as qualitative research may be adopted to get in-depth information regarding the factors that influence coal funding from a group of experts.

REFERENCES

Adedoyin, F. F., Gumede, M. I., Bekun, F. V., Etokakpan, M. U., & Balsalobre-Lorente, D. (2020). Modeling coal rent, economic growth, and CO2 emissions: does regulatory quality matter in BRICS economies? *Science of the Total Environment*, 710, 136284.

Azmi, F. (2013). An empirical analysis of the relationship between GDP and unemployment, interest rate, and government spending. *Interest Rate and Government Spending* (June 10, 2013).

Ayodeji, I. N., Osifalujo, B. B., & Taiwo, O. K. (2022). Interest Rate And Foreign Direct Investment In Sub-Sahara African Countries: The Comparison Between Asymmetric And Symmetric Effects (Ardl And Nardl Approach). *International Journal of Economics, Social Science, Entrepreneurship and Technology (IJESET)*, 1(3), 186-200.

BankTrack (2018). “Coal plant developers: 2018 research analysis”, https://www.banktrack.org/campaign/coal_plant_developers_2018_research_analysis#
—

Bartlett, C. D. (2011). The High Cost of Cheap Coal; Why Can't We Move to Renewable Energy?

Best, R. (2017). Switching towards coal or renewable energy? The effects of financial capital on energy transitions. *Energy Economics*, 63, 75-83.

Bilgen, S. E. L. Ç. U. K. (2014). Structure and environmental impact of global energy consumption. *Renewable and Sustainable Energy Reviews*, 38, 890-902.

Blondeel, M., Van de Graaf, T., & Haesebrouck, T. (2020). Moving beyond coal: Exploring and explaining the Powering Past Coal Alliance. *Energy Research and Social Science*, 59 (September 2019), 101304. <https://doi.org/10.1016/j.erss.2019.101304> Elsevier.

Böhringer, C., Keller, A., & Van der Werf, E. (2013). Are green hopes too rosy? Employment and welfare impacts of renewable energy promotion. *Energy Economics*, 36, 277-285.

Bugge, J., Kjær, S., & Blum, R. (2006). High-efficiency coal-fired power plants development and perspectives. *Energy*, 31(10-11), 1437-1445.

Burke, P.J., 2013. The national-level energy ladder and its carbon implications. *Environ. Dev. Econ.* 18 (4), 484–503.

Bryman, A. (2012). *Social Research Methods*. Oxford: Oxford University Press.

Brys, G., Hubert, M., & Struyf, A. (2004). A robustification of the Jarque-Bera test of normality. In *COMPSTAT 2004 Symposium, Section: Robustness*.

Chen, H., & Schmidt, J. (2017). Power shift: shifting G20 international public finance from coal to renewables. *Natural Resources Defense Council*.

Clark, A., Benoit, P., & Walters, J. (2023). Government shareholders, wasted resources and climate ambitions: why is China still building new coal-fired power plants? *Climate Policy*, 23(1), 25-40.

De Coninck, H., Stephens, J. C., & Metz, B. (2009). Global learning on carbon capture and storage: A call for strong international cooperation on CCS demonstration. *Energy Policy*, 37(6), 2161-2165.

Diluiso, F., Walk, P., Manych, N., Cerutti, N., Chipiga, V., Workman, A., ... & Minx, J. C. (2021). Coal transitions—part 1: a systematic map and review of case study learnings from regional, national, and local coal phase-out experiences. *Environmental Research Letters*, 16(11), 113003.

Dumitrescu, E. I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic modeling*, 29(4), 1450-1460.

Ditta, A., & Hassan, A. (2017). Nexus of economic misery, interest rate, exchange rate, and foreign direct investment in Pakistan. *Bulletin of Business and Economics (BBE)*, 6(1), 35-44.

Do, T. N., & Burke, P. J. (2023). Phasing out coal power in a developing country context: Insights from Vietnam. *Energy Policy*, 176, 113512.

Dong, K. Y., Sun, R. J., Li, H., & Jiang, H. D. (2017). A review of China's energy consumption structure and outlook based on a long-range energy alternatives modeling tool. *Petroleum Science*, 14(1), 214-227.

Economic welfare impacts from renewable energy consumption: The China experience. *Renewable and sustainable energy Reviews*, 15(9), 5120-5128.

Edianto, A., Trencher, G., & Matsubae, K. (2022). Why do some countries receive more international financing for coal-fired power plants than renewables? Influencing factors in 23 countries. *Energy for Sustainable Development*, 66, 177-188.

ENEA (2019). "Current Report No: 24/2019,
<https://investors.enea.pl/en/pr/446564/terms-andconditions-of-a-national-bond-issue-of-enea-s-a>.

EU, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Off. J. Eur. Union L 140 (16).

European Environment Agency. (2023, June 2). Share of energy consumption from renewable sources in Europe (8th EAP). Site. <https://www.eea.europa.eu/ims/share-of-energy-consumption-from>.

Fang, Y. (2011). Economic welfare impacts from renewable energy consumption: The China experience. *Renewable and sustainable energy Reviews*, 15(9), 5120-5128.9. Fang, Y. (2011).

Faroh, A., & Shen, H. (2015). Impact of interest rates on foreign direct investment: Case study Sierra Leone economy. *International Journal of Business Management and Economic Research*, 6(1), 124-132.

G7, 2021. G7 Climate and Environment Ministers' Meeting Communiqué. London, United Kingdom. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/988551/g7-climate-environment-com-munique.pdf.

Gao, X., Davidson, M., Busby, J., Shearer, C., & Eisenman, J. (2021). The Challenges of Coal Phaseout: Coal Plant Development and Foreign Finance in Indonesia and Vietnam. *Global environmental politics*, 21(4), 110-133.

Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. *Res. Policy* 36, 399–417. <https://doi.org/10.1016/J.RESPOL.2007.01.003>.

Global Coal Project Finance Tracker, Global Energy Monitor, October 2023 release.

Hansen BE, Seshadri A (2014). Uncovering the Relationship between Real Interest Rates and Economic Growth, Working Papers wp303, University of Michigan, Michigan Retirement Research Center.

Harswari, M. H. A. B. N., & Hamza, S. M. (2017). The impact of interest rate on economic development: A study on Asian countries. *International Journal of Accounting & Business Management*, 5(1), 180-188.

Hetti, R. K., Karunathilake, H., Chhipi-Shrestha, G., Sadiq, R., & Hewage, K. (2020). Prospects of integrating carbon capturing into community-scale energy systems. *Renewable and Sustainable Energy Reviews*, 133, 110193.

IRENA and CPI (2023), *Global landscape of renewable energy finance*, 2023, International Renewable Energy Agency, Abu Dhabi.

Jin, T., & Kim, J. (2018). Coal consumption and economic growth: panel cointegration and causality evidence from OECD and non-OECD countries. *Sustainability*, 10(3), 660.

Khan, G. S., & Mitra, P. (2014). A Causal Linkage between FDI Inflows with Select Macroeconomic Variables in India – An Econometric Analysis. *IOSR Journal of Economics and Finance*, 5(5), 2321-5933.

Hellenicshippingnews (2022, October 25). *South Africa's coal exports to the EU up 582.7% during 2022*. Hellenic Shipping News Worldwide. <https://www.hellenicshippingnews.com/south-africas-coal-export-to-the-eu-up-582-7-during-2022/>.

IEA (2022), *Coal in Net Zero Transitions*, IEA, Paris <https://www.iea.org/reports/coal-in-net-zero-transitions>, License: CC BY 4.0.

IEA (2023), *World Energy Investment 2023*, IEA, Paris <https://www.iea.org/reports/world-energy-investment-2023>, License: CC BY 4.0.

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogenous panels. *Journal of Econometrics*, 115, 53-74.

Imran, M., Mughal, K. S., Salman, A., & Makarevic, N. (2015). Unemployment and economic growth of developing Asian countries: A panel data analysis. *European journal of economic studies*, (3), 147-160.

IPCC (2018). “Global Warming of 1.5 °C”, available at: <https://www.ipcc.ch/sr15/>.

Jevons, W S. (1866). *The Coal Question: an inquiry concerning the progress of the nation, and the probable exhaustion of our coal-mines*. Second revised edition, London: Macmillan. Available: <http://www.econlib.org/library/YPDBooks/Jevons/jvnCQ1.html> (accessed 18 June 2023).

Kong, B., & Gallagher, K. P. (2021). The new coal champion of the world: The political economy of Chinese overseas development finance for coal-fired power plants. *Energy Policy*, 155, 112334.

Korkmaz, Ö. (2022). Do oil, coal, and natural gas consumption and rents impact economic growth? An empirical analysis of the Russian Federation. *Resources Policy*, 77, 102739.

Kuang, W. (2021). Which clean energy sectors are attractive? A portfolio diversification perspective. *Energy Economics*, 104, 105644.

Kuo, G. (2019). *When Fossil Fuels Run Out, What Then?* MAHB Stanford University. https://mahb.stanford.edu/library-item/fossil-fuels-run/#disqus_thread

Kurniawan, R., et al. (2020). Understanding the multi-faceted drivers of increasing coal consumption in Indonesia. *Energies*, 13(14), 3660. <https://doi.org/10.3390/en13143660>.

Lauber, V., Jacobsson, S., (2015). Lessons from Germany's Energiewende. In: Fager-berg, J., Laestadius, S., Martin, B.R. (Eds.), *The Triple Challenge for Europe: Economic Development, Climate Change, and Governance*. Oxford University. Press, Oxford (UK), pp. 173–203.

Levin, A., Lin, C. F., & Chu C. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, 108, 1-24.

LeRoy, S. F., & Werner, J. (2014). *Principles of financial economics*. Cambridge University Press.

Li, R., & Leung, G. C. (2012). Coal consumption and economic growth in China. *Energy policy*, 40, 438-443.

Lin, B., & Bega, F. (2021). China's Belt & Road Initiative coal power cooperation: Transitioning toward low-carbon development. *Energy Policy*, 156, 112438

Loorbach, D., & Rotmans, J. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures*, 42(3), 237-246.

Lopez, L., & Weber, S. (2017). Testing for Granger causality in panel data. *The Stata Journal*, 17(4), 972-984.

Ma, X. I. N. Y. U. E., and KEVIN P. Gallagher. (2021). "Who Funds Overseas Coal Plants." The Need for Transparency and Accountability.

Meidani, A. A. N. (2015). The Dynamic Effect of Unemployment Rate on Per Capita Real GDP in Iran The Dynamic Effect of Unemployment Rate on Per Capita Real GDP in Iran, (January). <https://doi.org/10.5539/ijef.v3n5p170>.

Manych, N., Egli, F., Ohlendorf, N., Schmidt, T. S., Steffen, B., Stünzi, A., & Steckel, J. C. (2023). Pushed to finance? Assessing technology export as a motivator for coal finance abroad. *Environmental Research Letters*, 18(8), 084028.

Manych, N., Steckel, J. C., & Jakob, M. (2021). Finance-based accounting of coal emissions. *Environmental Research Letters*, 16(4), 044028.

Mathews, J. P., Miller, B. G., Song, C., Schobert, H. H., Botha, F., & Finkleman, R. B. (2013). The EBB and flow of US coal research 1970–2010 with a focus on academic institutions. *Fuel*, 105, 1-12.

Markus Wacket, Riham Alkousaa, Draft Law Shows Germany Plans to Revise Key Emissions Target for Energy Sector, Reuters, 2022. <https://www.reuters.com/business/energy/draft-law->

shows-germany-plans-revise-key-emissions-target-energysector-2022-07-05/. (Accessed 5 July 2022).

Martí-Ballester, C. P. (2019). Do European renewable energy mutual funds foster the transition to a low-carbon economy? *Renewable Energy*, 143, 1299-1309.

Noor, S., & Siddiqi, M. W. (2010). Energy consumption and economic growth in South Asian countries: a co-integrated panel analysis. *International Journal of Energy and Power Engineering*, 4(7), 1731-1736.

Okun, A. M. (1962). Potential GNP: Its measurement and significance. *American Statistical Association, Proceedings of the Business and Economics Section*, 98-103.

Ogieva, O. F., & Ogiemudia, A. O. (2019). Capital structure and firm performance in Nigeria: Is pecking order theory valid. *Amity Journal of Corporate Governance*, 4(2), 13-26.

Oil Change International. (2022). Public finance for energy database.

Olusanya, S. O. (2012). Long run relationship between energy consumption and economic growth: Evidence from Nigeria. *Journal of Humanities and Social Sciences*, 3(3), 40-51.

Prasada, I. M. Y. (2019, October). Food security in Java Island, Indonesia: Panel data of ordinary least square approach. In *IOP Conference Series: Earth and Environmental Science* (Vol. 346, No. 1, p. 012065). IOP Publishing.

RAN et al. (2019). “Banking on Climate Change 2019”, Rainforest Action Network, <https://www.ran.org/bankingonclimatechange2019/>.

Renn, O., & Marshall, J. P. (2016). Coal, nuclear and renewable energy policies in Germany: From the 1950s to the “Energiewende”. *Energy Policy*, 99, 224-232.

Roemer, K. F., & Haggerty, J. H. (2021). Coal communities and the US energy transition: A policy corridors assessment. *Energy Policy*, 151, 112112.

Rostow, W.W. 1960b. *The Stages of Economic Growth: A Non-Communist Manifesto*. Cambridge: Cambridge University Press.

Salmerón, R., García, C., & García, J. (2020). Overcoming the inconsistencies of the variance inflation factor: A redefined VIF and a test to detect statistical troubling multicollinearity. *arXiv preprint arXiv:2005.02245*.

Schücking, H. (2021). *Groundbreaking Research Reveals the Financiers of the Coal Industry*.

Singhania, M., & Gupta, A. (2011). Determinants of foreign direct investment in India. *Journal of international trade law and policy*, 10(1), 64-82.

Soylu, Ö. B., Çakmak, İ., & Okur, F. (2018). Economic growth and unemployment issue: Panel data analysis in Eastern European Countries. *Journal of International Studies*, 11(1).

Urgewald et al. (2018). “New Research Reveals the Banks and Investors Financing the Expansion of the Global Coal Plant Fleet”, <https://urgewald.org/medien/new-research-reveals-banks-and-investorsfinancing-expansion-global-coal-plant-fleet>.

Van Lerven, F. (2020). *Banking on coal: how central banks can address the financial risks and support a capital shift away from coal*.

Van Noorden, R. (2013). Europe's untamed carbon: funding and politics hobble CCS technology, seen as the best hope for cleaning up coal. *Nature*, 493(7431), 141-143.

Wang, C. N., & Le, A. L. (2018). Measuring the macroeconomic performance among developed countries and Asian developing countries: Past, present, and future. *Sustainability*, 10(10), 3664.

Wilford, L. L., & Taylor, D. (1975). The power of four tests of autocorrelation in the linear regression model. *Journal of Econometrics*, 3(1), 1-21.

Wilson, G. (2012). *Community resilience and environmental transitions*. Routledge.

Winkler, H., Tyler, E., Keen, S., & Marquard, A. (2023). Just transition transaction in South Africa: an innovative way to finance accelerated phase out of coal and fund social justice. *Journal of Sustainable Finance & Investment*, 13(3), 1228-1251.

World development indicators. Washington, D.C. : The World Bank.

Xiahou, Q., Springer, C. H., & Mendelsohn, R. (2022). The effect of foreign investment on Asian coal power plants. *Energy Economics*, 105, 105752.

Yukhananov, A., & Volcovici, V (2013). World Bank to Limit Financing of Coal-Fired Plants.

Zhang, F., Lu, J., & Chen, L. (2023). When green recovery fails to consider coal pushback: Exploring global coal rebounds, production, and policy retrenchment. *Energy Research & Social Science*, 101, 103142.

Zhao, S., & Alexandroff, A. (2019). Current and future struggles to eliminate coal. *Energy Policy*, 129, 511-520.

Zhao, Y., Liu, X., Wang, S., & Ge, Y. (2019). Energy relations between China and the countries along the Belt and Road: An analysis of the distribution of energy resources and interdependence relationships. *Renewable and Sustainable Energy Reviews*, 107, 133-144.

APPENDICES

Appendix A 1: Data information

Table A1: Applied data		
Variable	Period	Source
Funding for coal-fired power plants	2008-2020	Global Energy Monitor.
Financial depth	2008-2020	World Development Indicators
GDP per capita	2008-2020	World Development Indicators
Capital	2008-2020	World Development Indicators
Inflation rate	2008-2020	World Development Indicators
Interest rate	2008-2020	World Development Indicators
Unemployment rate	2008-2020	World Bank
Emissions	2008-2020	World Development Indicators
Trade	2008-2020	World Development Indicators
Access to electricity	2008-2020	World Development Indicators
<i>Continent:</i>	<i>List of countries</i>	
Africa	South Africa	
Asia	India	
Asia	Indonesia	
Asia	South Korea	
Asia	Vietnam	