Has Sweden "Struck Oil"?

Exchange Rate Implications of Large Natural Resource Discoveries

Authors

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Abstract

With the global shift towards renewable energy and sustainable development, what are considered important natural resources and the value thereof, is undergoing a change, particularly as new technologies develop. The effects of natural resources on macroeconomic factors have been debated for centuries, and while some countries have sustainably managed their natural resources, empirical evidence shows that positive effects should not be taken for granted. By using a staggered difference-in-difference methodology, this research aims to continue the discussion of economic consequences from valuable natural resource discoveries by specifically investigating anticipatory exchange rate effects from large oil and gas discoveries. While allowing limited conclusions to be drawn, this study hopes to contribute to further research while also highlighting caution in using staggered difference-in-difference analysis, emphasising careful control group selection when seeing heterogeneous treatment effects, and recommends revisiting past studies to uncover biases.

Keywords: Natural Resources, Exchange Rate, Exchange Rate Volatility, Minerals, Oil, Gas, Resource Curse, Dutch Disease, Macroeconomics, Sweden

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Sincerely,

Emil Dahlbom, Johan Helmstad

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1 Introduction

"There is nothing permanent except change"

- Heraclitus (Greek philosopher, c. 535 BCE-c. 475 BCE)

As the world is transitioning into a new energy paradigm where our dependence on fossil fuels such as oil, gas and coal is gradually ending and being replaced by more environmentally friendly sources, there is a shift in the valuation of many natural resources (International Energy Agency, 2022). New technology is developed and commercialised as new elements, both artificial and natural, are becoming necessary for production and further progress. With this, the world is seeing a shift around what can indicate natural resource finds that are valuable enough to affect nations on a macro-scale. The growth of the renewable energy sector is clear; OECD (2011) claims, according to reports from many organisations (UNEP, ILO, IOE and ITUC etc), that by 2030 more than 20 million jobs can potentially be created worldwide to satisfy the demands of this sector.

According to LKAB (2023), this state-owned Swedish mining company has found a large deposit of rare earth minerals in the northern region of Sweden which are essential to the manufacture of electric vehicles as well as wind turbines. As of the date of the press release on January 12, 2023 the mineral resources discovery seems to be the largest known deposit of its kind in Europe, exceeding one million tonnes of oxides (LKAB, 2023). Even if the long term economic consequences of this discovery are yet to be determined, the news of such a sizable discovery could potentially have an economic impact if markets are forward-looking.

Although the effects of high natural resource provision are considered contributory to economic growth according to classic economic theories, the actual effects of such abundance of oil, gas, minerals and other resources through the twentieth century have been ambiguous. While some countries, such as Norway, Canada, Chile and Botswana, have been able to deal with a large amount of natural resources efficiently through proficient management (OECD, 2011), other countries, such as the Netherlands, the Democratic Republic of Congo and Venezuela, have experienced significant decrease in economic growth after natural resource extraction and production (Mien and Goujon, 2022).

Claimed by OECD (2011), the economic implications of natural resources depend upon two fundamental aspects; its current flows of income, and potential future inflows of income. Only considering economic impacts from the time when natural resources are eventually extracted, while disregarding any anticipation effects and forward-looking agents from the time of discovery, would provide a limited aspect of analysing all economic implications, failing to paint a complete picture. While much of the past research, such as Mhuru, Dahlish and Geng (2022), and Arezki, Ramey and Sheng (2017), has focused on macroeconomic variables other than exchange rate and its volatility, research investigating the exchange rate effects from a discovery before extraction has started, i.e. the anticipation effects of a discovery in particular, is limited.

With the current relevance of the topic, this research makes two contributions by investigating the impacts of news about giant oil and gas discoveries, the main natural resource connected with energy for the last century into today. Firstly, this research utilises a staggered difference-in-difference methodology, applying traditional estimators such as ordinary least squares (OLS), as well as recently constructed estimators suggested as an improvement for the method by Callaway and Sant'Anna (2021), recommended by Baker, Larcker and Wang (2022). Secondly, this research investigates one part of the phenomenon known as Dutch disease (DD), namely the effect on the real exchange rate and its volatility as related to natural resource discoveries, rather than extraction. By directly investigating the anticipation exchange rate effects from discoveries, before extraction commences, this research hopes to give a refined perspective to the analysis of such.

From the results of this study, limited conclusions can be made about the direct anticipation effects on the exchange rates, although indications of an effect are evident. The main results highlight the importance of using appropriate methods in order to capture true effects by choosing control groups with caution. This research hopes to contribute to the discussion about anticipation effects from discoveries for further research, providing guidance to policy makers, as well as revisiting bias when using standard estimators for staggered difference-in-difference where heterogeneous treatment effects can occur.

The sections following include a literature review on past studies of the topic, classic economic theories, modern theories, and methodology, as well as application of modern improved methods in comparison to more commonly used ones, with the aim to contribute to the understanding of the potential implications of natural resource anticipation effects.

2 Literature review

2.1 Natural Resources, a Blessing or a Curse?

The economic implications of natural resources have been a longstanding subject of debate, and arguments advocating divergent perspectives have been presented. In order to receive a more comprehensive understanding of each side, well-founded arguments from previous research will be examined below.

2.1.1 Resource Curse

As OECD (2011) mentions, the initial debate about the resource curse (RC) hypothesis took a new path when Sachs and Warner (1995) found empirical evidence supporting the curse theory. In Sachs and Warner's (1995) analysis of 97 developing countries between 1971-1989, an inverse relationship between gross domestic product (GDP) growth and ratio of natural resources exports to GDP was found. Two aspects of Sachs and Warner's analysis are important to keep in mind. Firstly, they use natural resource *dependence*, that is the resource value in relation to GDP for a nation, in their case the exported value, as their measurement, and not the value of natural resources themselves. OECD (2011) also proposes a strong negative correlation between a high ratio of natural capital to total capital and being a nation with low income. They further explain that well-being does not decline from the extraction of, nor the value of, the natural resources themselves. Instead, when the natural resources are managed efficiently, resource dependence decreases as human and social capital increases.

Secondly, Sachs and Warner's (1995) analysis is focussed on developing countries only, which provides a limited perspective rather than a complete analysis. In his article, Kronenberg (2004) confirms evidence of a resource curse amongst developing countries, even after controlling for various factors such as geographic situation and price levels. Many developing countries are also affected by factors such as corruption, war, unstable business cycles, and weak legal systems; these are, according to Robinson, Torvik and Verdier (2006), major factors influencing the impacts of natural resources. To broaden the picture, there is value in adding developed countries to the analysis as well. OECD (2011) further refers to data from World Bank (2011) studying OECD countries between 1995-2005, where the results are somewhat ambiguous. They further argue that natural resources can improve growth, although reinvestment in human and social capital such as education and health plays a major part in the final outcome. This reinforces the importance of resource management by policy makers in order to fully benefit from natural resources for sustainable growth and societal well-being (OECD, 2011).

Papyrakis and Gerlagh (2004) showed early evidence of the resource curse acting through multiple transmission channels by analysing the share of mineral production, measured as a percentage of GDP, compared to economic growth, but found some countries that have managed to avoid adverse effects. In Kronenberg's (2004) analysis, he states clear evidence for the natural resource curse, i.e. that natural resource abundance has a negative impact on economic growth. However, the author points out important factors such as corruption, level of human capital investment, as well as the Dutch disease phenomenon; where extraction of natural resources leads to imbalances in the employment market, with the manufacturing sector being crowded out, which combined with exchange rate appreciation counters any positive effects from the resources themselves.

Sharma and Mishra (2022) add support to the resource curse phenomenon by investigating resource rents; the gains from natural resources for a nation over time, as percentage of GDP, as well as resource rents per capita, in countries between 1995-2018 and finding evidence for the curse. However, they too point out the importance of institutions, corruption and governance in determining the outcome (ibid). As can be concluded from OECD's (2011) analysis, looking at natural resource measurements as a percentage of GDP might not be the most appropriate measurements for revealing causality, as there might potentially be other independent variables more suited in terms of causal analysis.

Mhuru et al. (2022) find evidence for a resource curse by investigating causal impacts of oil discovery effects on innovation, measured by number of patent applications in the US for sectors other than energy, and also patent citations, to get a measure for quality. By doing so, they manage to show causal and statistically significant empirical evidence for a resource curse as well, although using methods that have been exposed to criticism.

2.1.2 Resource Blessing

Several papers have shown empirical evidence for a resource blessing rather than a resource curse, i.e. that large resource endowments, such as oil and minerals, have a positive effect on a nation's economic growth. Alexeev and Conrad (2009) argue that the claims of a resource curse is due to misinterpretation of available data. Although institutional quality is important, the authors argue that there is a neutral relationship between natural resources and institutional quality. Instead of looking at economic growth over a period of time, they focus on GDP per capita to support this argument (ibid).

Brunnschweiler and Bulte (2008) question many researchers' interpretation of resources, claiming that investigating resource dependence could be a faulty proxy for the matter. Brunnschweiler and Bulte (2008) further claim that resource dependence does not affect growth, although resource abundance in its simplest form has a positive effect on economic growth, as well as on institutional quality. As Toews and Vezina (2022) provide a more specific case with investigating resource discoveries' effect on Foreign Direct Investments (FDI) in Mozambique, they present further evidence of a resource blessing on economic growth, as they argue FDI can be considered a decent measurement for a factor of growth. Additionally they argue the discoveries have had a positive impact on employment.

2.1.3 Ambiguous Evidence

As can be concluded from past research, the economic impacts of natural resources are ambiguous, and not yet fully understood. While Papyrakis and Gerlagh (2004), Lashitew and Werker (2020), Sharma and Mishra (2022) conclude ambiguous results, they all highlight the major part that institutions play. Papyrakis (2017) summarises what have been the major lessons learned over the past decades, including the eight most debated and influential articles to provide a wider perspective. The author highlights the importance of using correct methodology and measurements, as well as including other macroeconomic and societal factors, both on a global and on country specific levels for the analysis of natural resources. According to Papyrakis (2017), the subject is dependent on numerous major factors, hence why the impacts can by no means be assumed to be binary. He also provides a modest perspective, claiming that there is still much to learn on the subject, arguing for the need of a social psychological perspective for investigating biases that affect resource management, not the least those affecting policy makers.

This claim is supported by OECD's (2011) take on the resource curse, as they claim the causal implications of the curse are divided amongst different studies while also pointing out resource management as the major factor deciding whether a nation will have a positive or negative impact from natural resources. OECD (2011) argues that we should not consider natural resources a curse per se, and instead learn from mistakes in order to benefit from the obvious potential on economic growth factors that natural resources can provide. Myhre and Holmes (2022) provides Norway as a stand-out example, and gives a lot of credit to the policy makers of Norway for their well-managed sovereign wealth fund (SWF), highlighting the importance of reinvesting the capital obtained from natural resources into sectors other than energy. Ackah (2021) realistically points out the struggles with creating and maintaining a SWF that less developed economies can face, due to governance structures and high interest rates. Even if Saudi Arabia is another example of a successful SWF (Public Investment Fund, Saudi Arabia, 2023) that has resulted in a booming economy, all economies do not have the macroeconomic and political preconditions that would allow them to manage resource abundance as efficiently (Ackah 2021).

The main point from the before-mentioned research should therefore be considered to be the importance of quality governmental institutions to manage the natural resources. Corruption, government effectiveness, rule of law, and legal aspects seem to be the main determinant factors, together with other macroeconomic variables, such as exchange rate impacts. Therefore the purpose of this research is to dig deeper into such exchange rate effects.

2.2 Anticipation aspect

Papyrakis and Parcero (2022) add to the subject a social and psychological perspective by investigating the effects on economic behaviour in Kazakhstan after news about mineral discoveries. The study finds empirical evidence for a positive correlation between exposure to news and expectations about future income, which in turn affect current consumption. In addition, as mentioned by Arezki et al. (2017), there is a significant delay between the discovery and the extraction of hidden natural resources, i.e. between the news of a find and when it should theoretically start having a real effect on GDP. As assumed by classical economic theory, before a nation's economy has had any real impacts, rational individuals and firms should not act on potential future income shocks. However, releasing the assumption of perfect rational individuals acting in accordance with classic micro- and macro theories, perception about future income is one of the factors affecting current consumption (Gottfries, 2013). Arezki et al. (2017) provide empirical evidence that consumption is instantly increased based on a future anticipated income shock such as the news about a giant oil discovery and provides evidence for effects on macroeconomic variables such as GDP, current account, savings, investments and more, even before extraction has started.

Engel and West (2005) have found empirical support for exchange rate appreciation stemming from a positive change in future income expectations. In terms of policy implementation, Papyrakis and Parcero (2022) highlight the importance of realistic communication about the potential impacts of a discovery, in order to constrain inflated and unrealistic expectations about the extent of future income. Papyrakis and Parcero (2022) recommend regular information campaigns about the resource significance, communicated through different channels, in order to reach the general public, containing comprehensive and transparent information in order to remove potential biases (ibid). The authors also point out the importance of citizens' trust in politicians and policymakers to get long-term balanced and sensible reactions to this kind of news. Here, the authors provide Kazakhstan as one example of empirical evidence where the reaction from the population went contrary to the government's intentions after receiving information about a discovery. As this research aims to provide a cross-country analysis investigating the anticipation effects on exchange rates impacted by large natural resource discoveries, it hopes to find evidence for whether news about natural resource findings, such as the one by LKAB, could have an effect on the Swedish currency, even before extraction of the resources has started.

3 Theory

3.1 Adam Smith - The Wealth of Nations

From as far back as economic theory goes, Adam Smith, the "Father of Economics" in *The Wealth of Nations* (1776) argues the fundamental impact of natural resource abundance on economic growth.

Smith (1776) discusses the role of natural resources on economic development and recognizes that natural resources, such as land, minerals, coal, and forests, are valuable inputs for production and contribute to a nation's wealth. However, he also emphasises that the value of natural resources is not solely determined by their availability for the nation, but also by their productive use and management. Furthermore, he claims that the ability to exploit natural resources efficiently is dependent on the nation's technological advancements, as well as its level of human capital. According to Smith's (1776) observations, nations with well developed infrastructure and knowledge are able to fully harvest, produce and manage the resources in a more beneficial way. Smith (1776) argues that human labour, capital, and entrepreneurship are equally important factors in creating wealth, and that the efficient utilisation of natural resources through productive labour and investment is crucial to obtain economic growth.

Even if he emphasises the critical role that managing resources plays, he claims that natural resource presence per se has a positive economic impact on a nation; countries with natural resource abundance perform better economically, compared to countries that lack similar levels of resources. This claim was something that was agreed later on by Thomas Malthus in his "Essay on the Principle of Population" in 1798.

3.2 Resource Curse and The Dutch Disease Phenomenon

The precise definition of resource curse used by OECD (2011), and used in this research, is the counterintuitive phenomenon where natural resource abundance is associated with negative outcomes such as poor governance, irrational resource exploitation and poor development outcomes. OECD (2011) have explicitly stated the main possible channels for the curse that is either political or economical, namely:

- Greed in pursuit of resource rents and corruption
- Crowding-out effects on the manufacturing sector and lack of investment in human capital
- Unsustainable depletion of non-renewable resources
- Volatile business cycles where fluctuation slows growth

- Appreciation of exchange rate leading to poor performance in export-dependent sectors - “Dutch disease” phenomenon

In addition, OECD (2011) claims that volatility in exchange rate due to natural resources extraction could potentially create large fluctuations in the business cycles, which lead to unstable economic growth and thereby create further barriers and difficulties for the economy as a whole. The effects on exchange rate and its volatility lead us into what is called the Dutch disease.

According to OECD (2011), Dutch disease in its simplest form is the phenomenon where a natural resource boom generates an appreciation of the domestic exchange rate, which affects other export dependent industries enough to cause the economy as a whole to slow down. The term originates in the event that played out in the Netherlands where offshore natural gas discoveries caused an appreciation of the Dutch real exchange rate, large enough to harm the nation’s economy (Corden 1984).

Mien and Guojon (2022) further tell us about the term’s origin in an article in the magazine The Economist 1977. They explain the counterintuitive phenomenon that occurred when the Netherlands started gas extraction during the 1960s, as well as pointing to other countries that have experienced the same since. Mien and Guojon (2022) describe the original model as where the event of a sudden resource abundance generates increased expenditure, appreciating the domestic currency and thereby creating difficulties in other sectors, not the least in export dependent ones. As there has been an increase in published papers over the recent years on the subject, Mien and Guojon (2022) also emphasise the importance of comprehending the difference between resource curse (RC) and Dutch disease (DD), as DD is one possible explanatory factor for a nation experiencing RC. In addition, the authors argue that DD is part of international trade economics and RC part of development economics and even political sciences. Therefore, the authors argue that DD is something that could potentially lead to RC.

Corden and Near (1982) were the first to create a model for the DD phenomenon, providing a solid ground for further studies of the subject. According to Corden and Near (1982) the phenomenon can be split into a resource movement effect and a spending effect. The resource movement effect explains that a boom in one sector increases the marginal product of labour in that sector, attracting skilled labour from other sectors, which results in a real growth effect on the economy as a whole (ibid). If the sector requires limited labour resources there will instead be a major inflow of capital into the economy, creating a spending effect which in turn generates an appreciative effect on the domestic currency (ibid). Corden and Near (1982) complement the above effects with a Rybczynski effect: when a nation increases its endowment of a factor of production, the production of the good that uses the abundant factor of production will increase more than any other good. For example, if a nation experiences an increase in its natural capital, it will receive comparative advantages in the related industries, and labour intensive industries will not benefit as much.

3.3 International Finance Theory

Mien and Guojon (2022), OECD (2011), and other literature, suggest that sensible monetary and fiscal policies are crucial in managing exogenous shocks like changes in natural resource endowment and extraction effectively. It is worth noting that this thesis aims to examine the potential effects on the exchange rate resulting from news about natural resource discoveries, rather than discussing what would entail efficient policies to apply in response to such a shock.

3.3.1 National Income Identity and Real Money Demand

The national income identity (NII), as defined by Krugman (2018), is given by the equation:

$$Y = C + I + G + X - M$$

Where Y represents GDP, C represents consumption, I represents investment, G represents government spending, X represents exports and M represents imports. Assuming that all other variables remain constant, an increase in the supply of a globally demanded natural resource, such as a giant oil or mineral discovery, will result in an increase in exports, leading to an expansion of the GDP.

In the long run, again keeping everything else constant, a permanent income shock caused by an increase in natural resources will trigger an increase in the money demand due to the transaction motive, i.e. the need for money for transactions. As prices increase, the precautionary motive, i.e. the need for money to protect against unexpected events, will also come into play and increase the demand for money as prices rise. This increase in real money demand will lead to a rise in interest rates, making it more costly to hold and borrow money.

3.3.2 Interest Parity: The Basic Equilibrium Condition

As described by Krugman (2018) the uncovered interest parity condition (UIPC) suggests:

$$R^* - R = \left(\frac{E^e - E}{E}\right)$$

In the above equation, R represents the domestic interest rate, R^* the foreign interest rate, E^e the expected exchange rate one period from today, usually a year, and E represents the current exchange rate. This equation states that the only reason for there to be a difference between expected exchange rate and current rate has to be discrepancies between the different nations' interest rates for the law of one return (LOOR) to hold. The law of one return states that there are no arbitrage opportunities to be gained in international monetary markets with free capital flows, as it would open up opportunities such as carry trade. Therefore, according to Krugman (2018), the condition states that the only factors influencing exchange rates are domestic and foreign interest rates, as well as expectations. This theory includes some very strong assumptions, which is why Krugman (2018) continues the discussion with other factors influencing the exchange rates. Under certain circumstances, there could be different risk and liquidity aspects in the currencies, creating discrepancies and apparent arbitrage opportunities, although not without considerable risk involved. Potential political risks in a currency could be due to factors like corruption, investment climate, rule of law, legal/court system, and war (ibid). Empirical evidence shows that during periods with increased risk, such as the finance crisis, the Russian invasion of Ukraine etc, money flows towards safer harbours, i.e the larger currencies (IMF, n.d.). Krugman (2018) illustrates the relationship between GDP and exchange rate graphically, using the monetary model of exchange (MME) which posits that P = Ms/L(R,Y). Both models combined suggest that in the long run, a currency will appreciate due to a permanent increase in GDP, as for example the result from an increase in exports of natural resources.

According to Krugman (2018), there is another condition, namely relative purchasing power parity (RPPP) where π is domestic inflation, π^* foreign inflation, and the equation follows:

$$\left(\frac{E^e - E}{E}\right) = \pi^e - \pi^e *$$

Price levels are a significant determinant of exchange rates, as explained by Krugman (2018). According to the theory, when domestic prices rise, the domestic currency should depreciate, all else equal. The intuition behind this claim is the fact that a rise in price levels results in a decrease in the quantity of goods and services that can be purchased with the same amount of money. Since markets are forward-looking, disparities between expected inflation rates among different countries can result in differences between expected and current exchange rates, leading to losses or gains in real monetary value. Krugman (2018) further elaborates that exchange rates are a relative price of two assets, and the principles of asset pricing dictate that an asset's price depends on the rate of return it can offer. Consequently, a decrease in a currency's value will lead to depreciation of the currency.

Krugman (2018) claims that the international markets are forward looking, stating that an expected future appreciation, i.e. an increase in the expected exchange rate (E^e), will therefore automatically increase the current exchange rate (E). As a result, signalling effects from policymakers in fiscal and monetary policies, as well as a possible future exogenous shock such an upcoming income shock could possibly have an impact on expected future exchange rates, and consequently exchange rates today. Therefore, changes in the expected future level of exchange rates can significantly impact present-day exchange rates, with anticipated increases leading to corresponding increases in current exchange rates, assuming that interest rates, risk and liquidity remain unchanged (Krugman, 2018).

4 Data

In this section, the data used in this study will be the focus, whereby the sources of data, selection of variables presented and reasoning behind dependent, independent and control variables will be argued.

Table 1: Variable list of available data

Variable name	Measure	Years available	Type of variable	Source
Real effective exchange rate (REER)	Real effective exchange rate index (2010=100)	1980-2021	Dependent variable	World Bank Database
FX Volatility	Std. dev of difference in log monthly average of daily exchange rate	1994-2021	Dependent variable	IMF
Giant Oil Discoveries	500 million barrels of oil equivalent (MMBOE) or more	1960-2012	Independent variable	Horn (2011) Via Arezki et al. (2017)

4.1 Independent variable

Mhuru et al. (2022) use a staggered difference-in-difference methodology when trying to find empirical evidence for the natural resource curse by investigating the effects from giant oil discoveries on innovation. The definition of a giant oil discovery, used by Mhuru et al. (2022), Arezki et al. (2017), and Toews and Vezina, among others, is one measured at 500 million barrels of oil equivalent or more; together such discoveries account for over 40% of the world's oil and gas reserves. There is a wide range of literature arguing the validity of using such giant oil discoveries for investigating the effects of natural resources, mainly for three reasons.

Firstly, the fact that these oil discoveries are specific to a certain country, as well as being of large enough size to have a significant impact on the nation's economy, representing on average 9% of the specific country's GDP, makes it a significant income shock (Arezki et al. 2017).

Secondly, Arezki et al. (2017) mention that some might argue discoveries cannot be considered fully random if the nation has had oil discoveries in the past or if it is already a large oil producing nation. However, even if the search for oil is not random per se, Mhuru et al. (2022) argue that the timing of an actual discovery is random, unpredictable, unexpected and therefore exogenous. Lei and Michaels (2014) reinforce their argument, claiming that the chance of making a giant oil discovery of such magnitude is about 5% for a country in a given year. In addition, Toews and Vezina (2022) claim that there is no relationship between exploration and discovery, supported by a probability of a giant discovery conditional on exploration drilling of about 2%. The authors mention an example where Lundin Petroleum in 2010 found the largest oil discovery of the year, and largest ever in Norway, only three metres away from where Elf Aquitaine drilled unsuccessfully in 1971 (ibid). Furthermore, at the time of discovery, the full potential size and value of that discovery, and therefore whether it can be considered giant, is unpredictable (Arezki et al. 2017). With this, Mhuru et al. (2022), along with the other articles mentioned above, claim that the macroeconomic outcome following a giant oil discovery can be considered random.

Thirdly, Arezki et al. (2017) estimate the delay between discovery and extraction to be between four to six years; more specifically, that the average delay between discovery and extraction is 5.4 years. This can be separated into offshore delay being on average 6.7 years and onshore delay being on average 4.6 years. This further strengthens the argument that a discovery should initially be treated as a news shock, as any effect on GDP and other economic parameters before extraction is only based on anticipation and expectations about the future at the stage of discovery (Toews and Vezina 2022). Based on that claim, this research will investigate the effects five years after a discovery. For the purpose of the aim of this analysis, it is worth keeping in mind that the expected delay from the discovery in Sweden to extraction is about 10-15 years (LKAB, 2023).

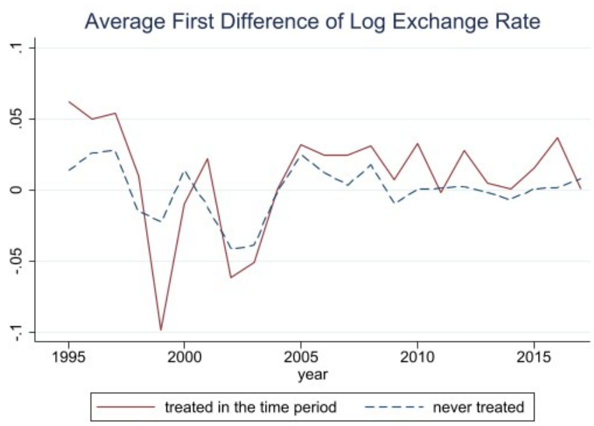
For this study, the base for the data gathered is information on giant oil discoveries, acquired from Arezki et al. (2017), originating from Horn (2011), in order to investigate causality. The original dataset includes 217 nations' giant oil and gas discoveries, measured as 500 million barrels or more oil equivalent, between 1960-2012, as mentioned in chapter 3. This is an extension of the 197 nations acknowledged by the UN.

4.2 Dependent variables

To match the discovery data, yearly cross-country data from the World Bank (WDI, n.d.) has been collected with real effective exchange rate to 2015 (USD). The dataset from WDI includes 217 nations between 1980-2021, with 208 nations also included in the discovery set. As mentioned by Engel and West (2005), expected future higher GDP can lead to an exchange rate appreciation. This research aims to investigate the exchange rate effects of news of a discovery, before the start of extraction, to capture the anticipation effects of future income expectations. The measure observed for this investigation is the first difference of the logarithm of real effective exchange rate. Using the first difference of the logarithm allows for investigating relative changes, and consequently growth rates as a percentage and also deals with omitted variables. By investigating the real effective exchange rate (REER), the inflation rate is captured, as argued by Ma and Sun (2010). This is an important factor in determining the nominal exchange rate, also stated in the RPPP condition by Krugman (2018). As inflation and interest are highly correlated, according to Krugman (2018), this study hopes to capture the interest rate as well, assumed in the UIPC condition.

In addition, daily exchange rate against USD for 52 currencies from 1994-2021 from IMF (n.d.) are used to devise a measure of foreign exchange (FX) volatility for the currency, calculated by taking the standard deviation of the first differences of the logarithmic monthly averages for the exchange rates. This measure gives an indication of the spread of the movement in currency exchange rates over each year. Even if Clark et al. (2004) argue that the most appropriate measurement for exchange rate volatility is undetermined, this research follows Dai, Li and Xu (2023), Lin, Shi and Ye (2018), among others, using the above mentioned measurement. European Central Bank (2007) explains that the data available from IMF starts as late as 1994 due to the fact that an extensive amount of data before that period consists of former transition economies and therefore a lot of exchange rate data was very unstable before 1994.

Figure 1: Average first difference of log exchange rate.
Figure 2: Average exchange rate volatility.



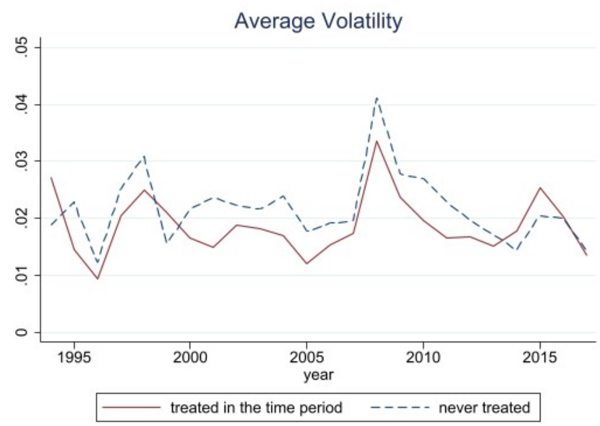


Figure 1 and 2 present the average of the first difference of log exchange rates and volatility, where the average of the group that is treated, i.e has a discovery, during the time period and the average of the group that is not treated in the time period follow the same trend. However, there are some discrepancies in both directions, which can be considered reasonable as identical fluctuations would be impossible.

4.3 Control variables

Following Harding et al. (2020) and Arezki et al. (2017), a year fixed effect is used to capture global shocks and fluctuations, and a country fixed effect is used to capture time-invariant differences between countries. As mentioned in chapter 2, including institutional quality when investigating the outcome of natural resource discoveries is crucial. This research accounts for institutional quality in our heterogeneity analysis by dividing the sample into subgroups, based on the nation's corruption status. By doing so, this study hopes to capture other political instability aspects, such as investment climate, rule of law and legal/court system, as these variables are highly correlated with each other (The World Bank n.d.). In addition, this study also hopes to capture the risk factor affecting a currency's exchange rate, as expressed by Krugman (2018). As the data available for a corruption measure is incomplete over the years and show too much heterogeneity for sensible interpolation to be made when not available, this study has created a dummy variable for subsamples, indicating countries with significant corruption in their earliest measure as reported by Worldwide Governance Indicators (n.d.). The earliest measure available from this source is from 1996, and while available for 91.8% of the countries in that year, even these countries have incomplete data for the years following. It should be noted here, there are some countries that have changed their corruption status over the years in the study; further studies could take this into account and create a more nuanced measure.

4.4 Data adjustments

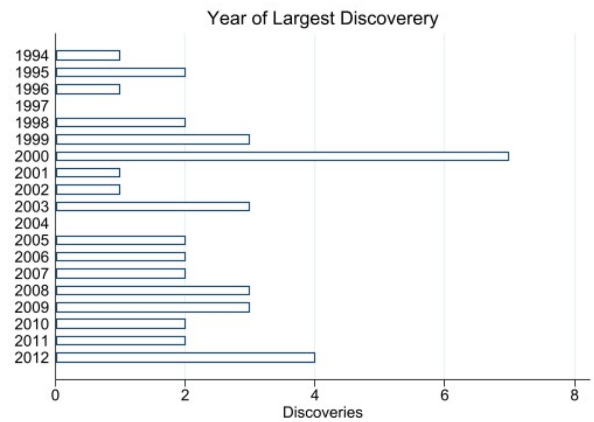
Since all real exchange rate and exchange rate volatility data is compared to USD in this study, including the exchange rates effects on USD itself does not make sense. There are also further valid reasons for excluding the USA from the investigations. The United States has a long history as an oil producing nation, drilling for oil was introduced in Pennsylvania in 1859, and the USA furthermore holds a special status as the world's largest economy and being home to the world's most important reserve currency. These factors mean that any expected effects from oil discoveries would be too small to cause a news shock. This is also confirmed by investigating the net present value (NPV) of discoveries in proportion to GDP, where the US has by far the smallest expected impact from any of their oil discoveries. From these arguments, this study has decided to exclude the USA and any other countries using USD as primary currency from our data for further conclusions. Although most other countries in the dataset using USD are small island nations, it is worth mentioning even countries like El Salvador and Ecuador had to be excluded.

The implementation of the Euro (EUR) on 1 January 2002 also creates difficulties for investigating this time period, therefore countries that have adopted the Euro in the investigated years have been excluded as well. Fortunately, the only country with a giant oil discovery in the period and using the Euro is Italy, although a decent amount of countries from the control group had to be excluded. Furthermore, Brazil reduced its nominal currency by 1:2750 in the middle of 1994, Poland reduced its currency by 1:10000 in 1995, both of which have been accounted for.

In addition, as this study investigates the effect of a news shock from a giant oil discovery, it needs to consider what can be deemed a shock. More specifically, the question is whether consecutive giant oil strikes should each be considered a shock. Arezki et al. (2017) use a variable to control for prior discoveries, in their case, creating a conditional giant oil discovery variable requiring a three year window with no previous giant oil discovery.

Because the anticipation effects from news shocks are investigated, this study will only take into account the largest discovery in the dataset for each country over the years 1994-2012 when running regressions, as this research argues that the largest giant discovery has the highest probability to cause a news shock in the time period. The largest discovery is found by comparing a net present value (NPV) measure, constructed by Arezki et al. (2017), taking the economic value as a percentage of GDP into account. The range of years selected to be included in this study is due to exchange rate data availability being limited before 1994 and giant oil discovery data availability being limited to 2012. Economic data is included for a period of 5 years after 2012, up until 2017, in order to analyse post treatment effects of all years in the time period. By doing so, we would not capture effects from any largest discoveries happening in the years 2013-2017.

Figure 3: Distribution of the year of the largest giant discoveries over the time period.
Figure 4: Illustration of number of countries in treated and not treated groups over time.



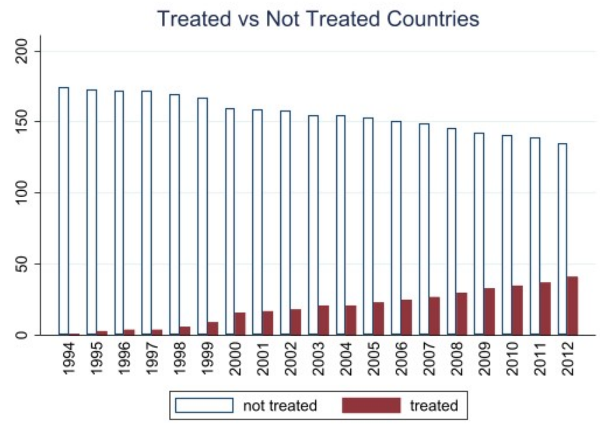


Figure 3 shows that even though this research is only considering the largest giant oil discovery in the time span, there are still countries making their largest discovery over the whole time span. Figure 4 shows the accumulated distribution of countries that have had their largest discovery in the time period, compared to the ones that have not had a giant discovery in this time period.

4.5 Descriptive statistics

In order to give an overview over the variables' statistics, table 2 in Appendix A describes summary statistics from the 78 countries between 1994-2017. Appendix B provides a detailed list over the specific countries used in the exchange rate analysis. As FX volatility data is more limited, the 42 countries with such data used in the exchange rate volatility analysis are mentioned in appendix C.

5 Methodology

5.1 Model specification

In order to investigate the effects from giant natural discoveries on exchange rate parameters, this thesis uses an adjusted form of difference-in-difference. The regular difference-in-difference method is used to investigate the effects of a treatment by comparing a treatment group to a control group before and after the treatment. Argued by Goodman-Bacon (2021), difference-in-difference (DiD) is the most common and effective method to investigate causal inference, dating all the way back to Snow's (1855) analysis of a London cholera outbreak. Investigating the average effect on the treated and comparing to the average of a control group, causal inference can be drawn by calculating an average treatment effect on the treated (ATT). A generalised version of DiD has been created, to account for a situation where different observations receive the treatment at different time points, named staggered DiD.

This thesis uses an staggered difference-in-difference (SDiD) model as follows:

$$\Delta E_{j,t} or\ v_{j,t} = \sum_{\tau=-5}^{-2} (\beta_{\tau}\delta_{\tau,j,t}) + \sum_{\tau=0}^{5} (\beta_{\tau}\delta_{\tau,j,t}) + \gamma_{t} + \eta_{j} + \varepsilon_{j,t} \quad (1)$$

Here $\Delta E_{j,t}$ represents the first differences in logs of real exchange against the USD for country j in year t, and $v_{j,t}$ the volatility measure for country j in year t, $\delta_{\tau,j,t}$ is a dummy variable that takes the value of 1 if a giant oil discovery strike have occurred in country j in year t - τ. Each β_{τ} represent the lag coefficient of the strike variables $\delta_{\tau,j,t}$ for the period five years before and after the strike, with the year before strike chosen as the reference year. γ_{t} represents time fixed effects, η_{j} represents country fixed effects and $\varepsilon_{j,t}$ represents the error term.

As argued in chapter four, a five year event window after a discovery is chosen in order to capture anticipation effects before extraction, which is the aim of this study. In order to create symmetry, an equal event window is chosen for the time period before a discovery, aligning with studies such as Mhuru et al. (2022) and Baker et al. (2022).

5.1.1 Acknowledging problems with staggered difference-in-difference

Over the last 20 years or so, many papers have created estimates for their staggered difference-in-difference models by applying standard regression methods, most often OLS. However, as Baker et al. (2022) explain, recent econometric studies suggest that the regression estimates with standard methods do not always provide valid causal estimates. Baker et al. (2022) and Goodman-Bacon (2021) highlight a “bad comparison” problem; when treatment effects display heterogeneity or where the effects can develop over time, the treatment effect can obtain the opposite sign of the true treatment effect even if the parallel trend assumption holds, making studies not as robust as first thought.

Baker et al. (2022) also highlight the importance of choosing the most appropriate way of interpreting the control groups. If a unit was once treated, and in the next period is not treated, it will be included in the control group of the post-treated period when using standard regression methods. In order for that assumption to hold, the potential effects on exchange rate from discoveries need to be fixed and immediate, not creating spillover effects on following years, which is a very unrealistic assumption as exchange rate effects from giant oil discoveries would likely be long lasting and develop over time, including from time of discovery to when extraction draws close. Therefore, it is of great value separating different control groups by using one of the three estimators suggested by the authors to reduce the risk of comparing the treated groups to inappropriate control groups (Baker et al. 2022).

5.1.2 Correcting for problem with staggered difference-in-difference

Baker et al. (2022) suggest three different estimators for correcting the biases, originating from Callaway and Sant'Anna (2021), Sun and Abraham (2021), and Gormley and Matsa (2011). This analysis is using the method proposed by Callaway and Sant'Anna (2021) that, while considered to be the most complex and hard to implement, is the method argued by Baker et al. (2022) to be more flexible and robust than the others.

Callaway and Sant'Anna (2021) suggest an estimator to use when there is a variation in treatment timing, as well as heterogeneous treatment effects. As Callaway and Sant'Anna (2021) mentions, regular staggered DiD compares all cohorts with each other, as long as there is variation in the treatment status, and does not care about interpreting appropriate treatment and comparison groups. The authors propose a transparent way of dealing with setups of multiple time periods. Instead of using all units not treated in a certain time period, Callaway and Sant'Anna (2021) highlight the importance of using only never-treated, i.e units that are never exposed to treatment effects, and optionally including not-yet-treated, i.e units that are eventually treated, but only used as control at timepoints before they are exposed to treatment effects, as appropriate control groups.

For the purpose of this study, the choice has been made to include not-yet-treated into the control groups when using Callaway and Sant'Annas (CS) method. This can be done due to discoveries, as mentioned previously, being nearly impossible to predict and therefore should not be causing any anticipatory effects before a discovery is made. With this, out of the 78 countries used in this study, only 21 countries experienced some kind of giant oil discovery over the time period, leaving at least 57 countries that can be used as a control group over the whole period.

6 Results

The results from the four regressions are separated into four sections; regressions using standard OLS for the effect from giant oil discoveries on the first difference of log real effective exchange rate (REER) changes and the FX volatility measure used, along with the CS method applied to each regression.

The table and graphs below should be interpreted as the average treatment effects on respective dependent variables. For the graphs, the zero value on the x-axis is the year of the largest giant oil discovery of 500 million barrels and more for a nation, with the average treatment effects on the y-axis with an event window of five years before and after the discovery in order to capture any anticipation from the news shock effects, prior to extraction. The confidence interval in the graphs is at 95%.

Table 3: Regression results. (ATT Exchange Rate and Exchange Rate Volatility, *** p<0.01, ** p<0.05, * p<0.1). Statistics in parentheses present the standard errors.

Dependent variable	First differences of logs of Exchange Rate		Volatility	
Event window	**(1) OLS**	**(2) CS**	**(3) OLS**	**(4) CS**
-5	0.0514*	0.0010	0.0069*	0.0049
	(0.0311)	(0.0263)	(0.0041)	(0.0042)
-4	0.0831***	0.0377	0.0020	-0.0010
	(0.0300)	(0.0236)	(0.0042)	(0.0023)
-3	0.0652**	-0.0211	0.0040	-0.0053
	(0.0296)	(0.0180)	(0.0041)	(0.0030)
-2	0.0628**	-0.0012	0.0020	0.0029*
	(0.0295)	(0.0178)	(0.0041)	(0.0027)
-1		-0.0674		0.0007
	(reference)	(0.0768)	(reference)	(0.0026)
τ = 0	0.0817***	0.0872	0.0009	-0.0005
	(0.0295)	(0.0718)	(0.0040)	(0.0020)
+1	0.0420	0.0549	0.0040	0.0045*
	(0.0293)	(0.0802)	(0.0040)	(0.0026)
+2	0.0189	0.0265	0.0024	0.0040
	(0.0293)	(0.0810)	(0.0040)	(0.0051)
+3	0.0894***	0.0960	0.0019	0.0032
	(0.0294)	(0.0688)	(0.0040)	(0.0064)
+4	0.0747	0.0766	0.0007	0.0011
	(0.0294)	(0.0719)	(0.0039)	(0.0029)
+5	0.0550	0.0597	0.0002	0.0014
	(0.0293)	(0.0789)	(0.0039)	(0.0027)
N	1529	1767	641	391
Groups	78	78	42	42

6.1 The effect of Giant Oil Discoveries on the change in REER

Figure 5: Average effects of oil discovery on first difference in log exchange rate - OLS (1)

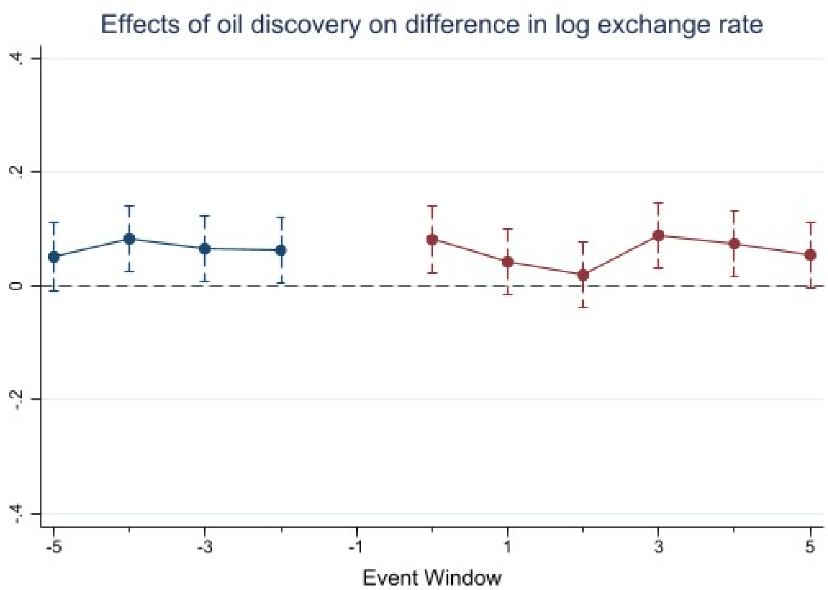
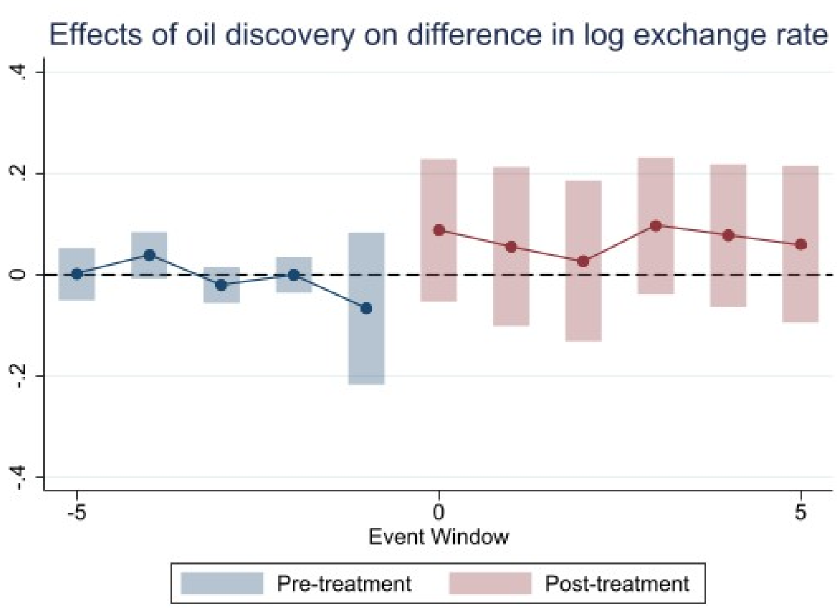


Figure 6: Average effects of oil discovery on first difference in log exchange rate - CS estimator (2)



6.2 The effect of Giant Oil Discoveries on FX volatility

Figure 7: Average effects of oil discovery on exchange rate volatility - OLS (3)

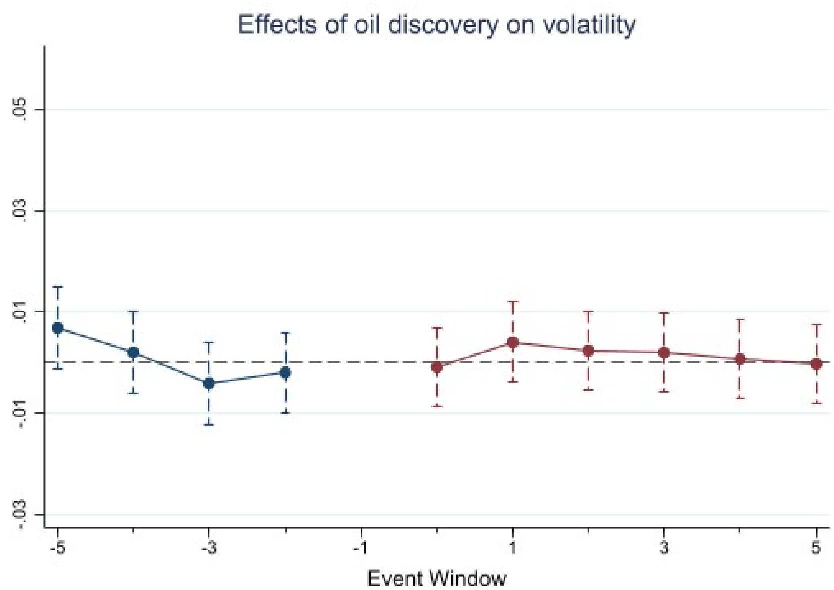
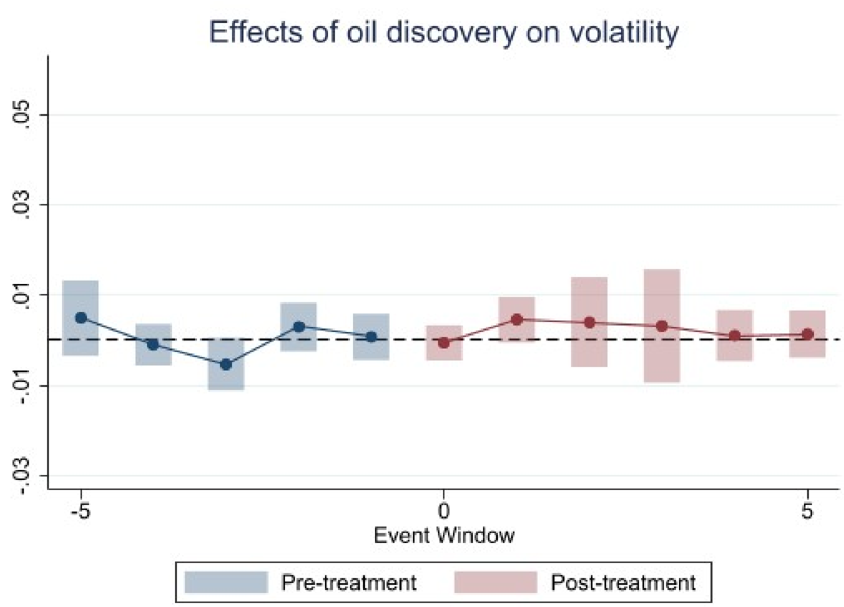


Figure 8: Average effects of oil discovery on exchange rate volatility - CS estimator (4)

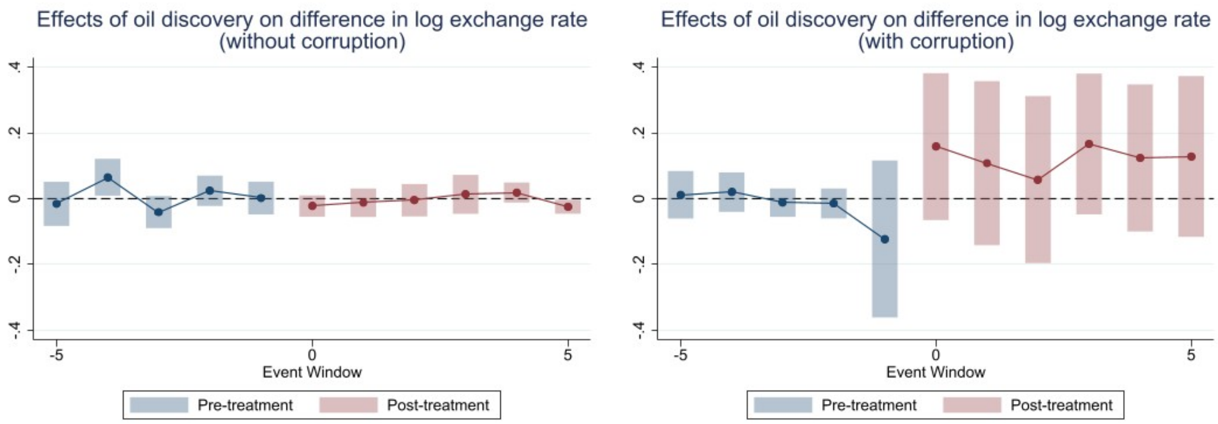


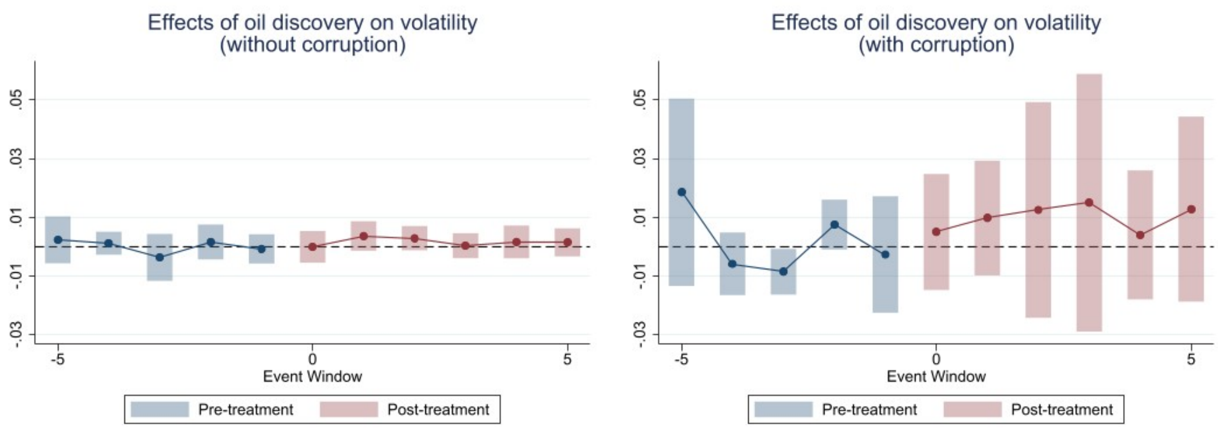
The results from table 3 and the graphs above show an instant statistically significant coefficient when using OLS, i.e for regression (1), as well as three and four years after discovery, for the first difference in logarithm of exchange rate. However, the result for two, three and four years before a discovery is statistically significant with similar coefficients as in the post-treatment period, indicating no treatment effect taking place. When using the estimator presented by Callaway and Sant'Anna (2021), the results for the same relative time point in regression (2) show statistically insignificant results as the confidence intervals are increased when different, more appropriate, control groups are being used. The post-treatment coefficients present higher values compared to the pre-treatment coefficients, indicating some kind of treatment effect, even if it is not statistically significant. All other values after a discovery are statistically insignificant in all regressions, therefore not sufficient for making any further conclusions. Further discussion about the magnitudes and their economic implications will be elaborated in section 7.

6.3 Heterogeneity analysis

In order to investigate heterogeneity, a measure for corruption is used to investigate the importance of institutional quality, as its crucial aspect was argued in chapter 2. Separating nations with a negative value (corrupted), with nations with a positive value (not corrupted), provides results below. As can be interpreted in the figures, the group without corruption unexpectedly seem to experience less of an increase in difference in log exchange rates, indicating some discrepancies between nations experiencing corruption and nations not experiencing corruption. Most likely this could possibly be to nations with corruption generally are smaller and less stable nations. However, with all values, except five years after a discovery for the group without corruption, being statistically insignificant in the post-treatment period, no further conclusion can be made.

Figure 9: Heterogeneity without corruption on difference in log exchange rate - CS estimator.
Figure 10: Heterogeneity with corruption on difference in log exchange rate - CS estimator
Figure 11: Heterogeneity without corruption on exchange rate volatility - CS estimator.
Figure 12: Heterogeneity with corruption on exchange rate volatility - CS estimator.

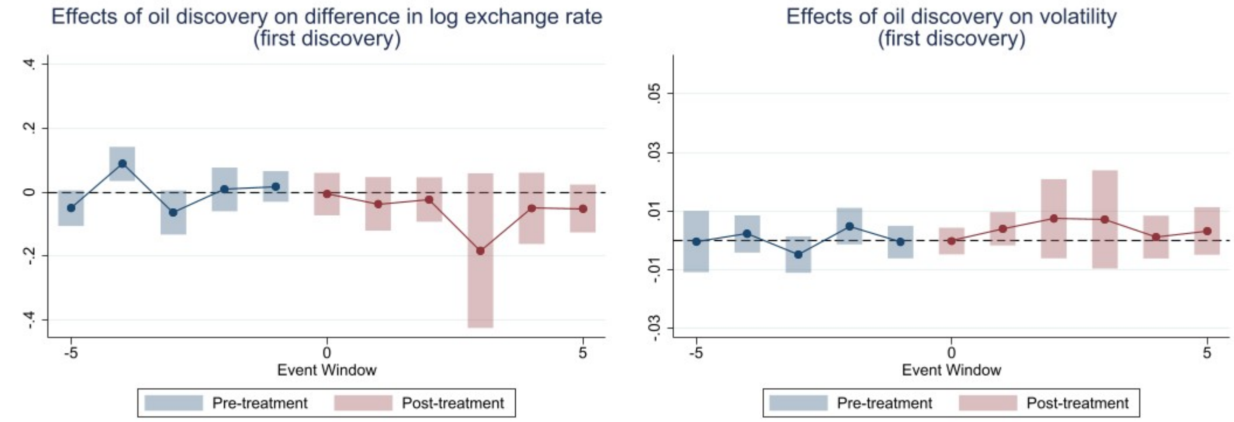




6.4 Robustness

In order to implement a robustness check and analyse our chosen selection of discovery, the first discovery per country is used as the independent variable instead of the largest discovery per country. Note also that for the first years in the time range of this study, a discovery is not considered news-shock-worthy if the nation has had a discovery in the three preceding years, including the years before 1994. Although the results are statistically insignificant, the expected signs after the treatment are less explicit than before. The conclusion to be made is that the treatment effect experiences heterogeneity, as expected, and that the size of the discovery plays an important part, rather than treating the independent variable, any discovery of 500 million barrels of oil equivalent or more, as homogenous.

Figure 13: Robustness with first discovery on difference in log exchange rate - CS estimator.
Figure 14: Robustness with first discovery on exchange rate volatility - CS estimator.



7 Discussion

7.1 Effects of Giant Natural Resource Findings on Exchange Rate

Firstly, the expected result from the first set of regressions, (1) and (2), was to see indications of an appreciation of the currencies, i.e. a positive change in exchange rate, when a news shock of possible future income flows occurred. The expected results were not confirmed in equation (1), however, they could potentially include bias due to the acknowledged problems with the method, and further conclusions need to be drawn with caution. When the Callaway and Sant'Anna estimator was used for regression (2), the expected results after a news shock like a giant oil discovery were confirmed, although statistically insignificant, possibly confirming the initial results from SDiD using regular regressors as being biassed compared to when the control group consists only of never-treated and not-yet-treated units. Even if the results are statistically insignificant, the post-treatment effect on the exchange rate varies from an appreciative effect of 3-10% per year, which can be considered economically significant as changes of such decent impact on exchange rates would definitely affect the economies.

Secondly, the expected results of the volatility in exchange rates, in equations (3) and (4), are to see increased volatility after a giant oil discovery, especially directly after the news shock. Although statistically insignificant results, regression (3) using OLS confirms the expected increase in the volatility in exchange rate three years after discovery; however, the control for bias using different control groups is in order. Using the CS estimator in equation (4), only comparing to never-treated and not-yet-treated units, indicates an increase in exchange rate volatility, although all the regression results show statistically insignificant results as well. An exchange rate volatility increase of 0.45 at highest, corresponding to 24% of average volatility for the treated group, would be considered a decent impact and economically significant, however it is statistically insignificant in the study and no further conclusions about volatility can be made at this stage.

In terms of investigating the anticipation impact on exchange rate volatility from a giant natural resource discovery such as oil or gas, both series of regressions allow no further conclusions to be drawn. This conclusion aligns with comments made by Arezki et al. (2017) in a supplementary appendix, stating that their research also was not able to draw any conclusion about the effects on exchange rates from giant oil discoveries. Most of the difficulties investigating the subject is due to lack of data, together with the general difficulties in investigating exchange rates as they are affected by exposure to many external economic factors, both real and expected, mentioned by Arezki et al. (2017). In addition, the adoption of the Euro during the time period of the study across many economies where the exchange rate data was available, led to them having to be excluded from the analysis. Hopefully, the availability of data will increase down the road, and without further major currency reforms being implemented, the interpretation of exchange rate data should be less problematic.

Although not the initial aim of this study, another conclusion can be drawn that aligns with Baker et al. (2022), Callaway and Sant'Anna (2021), Sun and Abraham (2021), and Gormley and Matsa (2011) research, based on the discrepancies between the OLS regression results and CS estimation results presented in section 6. In particular, the importance of choosing control groups with caution when using SDiD with treatment spread out over multiple time points and possibly heterogeneous treatment effects. A method, such as the one suggested by Callaway and Sant'Anna, that is clearly separating treated, not-yet-treated and never-treated units as part of its design, should be considered in such cases in order to be able to draw more accurate and reliable conclusions with minimal bias.

7.2 Potential concerns and further research

Firstly, the study has used a dataset of giant oil and gas discoveries of 500 million barrels and more, from Horn (2011) accessed via Arezki et al. (2017), that contain many nations having multiple discoveries over the time period. The fact that only a single discovery, in this case the largest one, for each nation is considered news-shock-worthy might be a too strict assumption. Also, as each discovery is treated as a dummy indicator, one concern is the major heterogeneity in the size of the discoveries, supported by the robustness check. Although Arezki et al. (2017) argue each discovery of 500 million barrels is large enough to create a future economic shock, it might have been a more reasonable approach including the size of the discoveries in the regressions, which could be considered a recommendation for future research or when revisiting past studies.

Secondly, there seem to be discrepancies between the nations with corruption, compared to the nations without corruption, supported by the heterogeneity analysis. Although providing insignificant results with the binary separation between the groups, a more continuous measurement or smaller groups might have affected the results in order to make further conclusions.

Thirdly, Krugman (2018) argues for the importance of considering interest rates and risk when investigating exchange rates, something this research tries to take into account. However, he also argues the importance of the liquidity of a currency in determining exchange rates. Unfortunately this study has not been able to find any accurate measure to be able to control for such a factor, and even if it did, there would most likely be an endogeneity problem with such a control variable. In addition, the time span, for which the daily exchange rate data used to investigate the currency volatility is available, is limited. Following research could possibly gather additional data to find more robust results.

Fourthly, investigating any effects on exchange rates over the time horizon chosen in this research does not come without issues. One of the prime concerns is the introduction of the Euro in 1999 and the adoption of this new currency by many countries in 2002, along with further adoptions, which limited the data available for this research. Future research should be able to limit the time span to start after the introduction to the Euro and still have data available to include euro countries.

Fifthly, when using a difference-in-difference method it is of high importance that the impact should not have any spillover effects to neighbouring countries. One could argue there are less spillover effects by investigating exchange rates effects against the USD, rather than investigating growth effects that would most likely have substantial geographic spillover effects, or spillover effects between countries with extensive trading. However, assuming there are no spillover effects on other exchange rates is also a strong assumption as in reality the exchange rate determinants of a currency is a combination of incalculable factors. Engel and West (2005) support this argument, and highlight the difficulties with making conclusions about macroeconomic correlation to exchange rates.

Sixthly, investigating oil discoveries as the 20th century's most important natural resource for energy from a GDP perspective and extrapolating any results about its effects to all energy production resources might be inaccurate. The importance and effects of rare natural resources, such as minerals used for battery production, are yet to be determined as technology progresses in a way that cannot be predicted.

Seventhly, for the purpose of this study, due to insufficient concordant data, an assumption of no giant discoveries after 2012 had to be made in order to not limit the time period considered remarkably.

Realistically, there have most likely been nations that have been treated in the time period after 2012, something that further research could investigate, when data is accessible.

8 Conclusion

This research has investigated the effects from giant oil discoveries on exchange rate changes and exchange rate volatility in order to draw conclusions stemming from economic expectations in the years immediately following giant natural resource findings. The impact of such valuable natural resource findings on a nation's economy is not uniform. This study wanted to find whether it was possible to predict how a large resource discovery, in this case mineral in nature, would affect the Swedish economy, but no definite predictions are able to be made. Furthermore, with a longer time period before extraction, compared to oil and gas, there is a low probability of being able to identify any distinct effects on the economy. This research hopes to help the discussion about understanding the potential consequences, before extraction starts, of valuable natural resource discoveries, such as the findings in northern Sweden.

As for the effects of natural resources on macroeconomic variables, the outcome is by no means binary. Past research is ambiguous and experts agree that patterns like resource curse and Dutch disease are not yet completely understood. However, the major conclusion earlier research can agree upon is the importance of resource management by institutions and policy makers for the positive outcome of any resource discoveries.

Even if the standard staggered difference-in-difference regressions indicated some statistically significant results on the exchange rate measurements used in this research, the major conclusion to be drawn is the importance of approaching staggered difference-in-difference with caution, as can be seen in the discrepancies between the different estimation results in section 6. In particular, conducting a careful analysis in terms of control groups should not be neglected. This research has highlighted the importance of dealing with heterogeneous and long-term treatment effects by using appropriate estimators when using a staggered difference-in-difference approach with treatment at different time points. With that in mind, this research uses the one developed by Callaway and Sant'Anna. We want to point out that this has possibly been neglected in many studies from the past decades, leading to too strong assumptions being made about reality. In that sense, past studies in all fields that have been using staggered difference-in-difference models could be revisited in order to find ignored biases, both unintentional and intentional, not the least publication bias.

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Appendix A

Table 2: Descriptive statistics of the adjusted data

Variable name	Years	Obs	Median	Mean	Std. Dev	Min	Max
Nations with exchange rate data and discoveries in the time period (21)							
Giant oil discoveries[1]	1994-2012	21	1667	3097.37	3861.14	500	16333
Exchange rate change[2]	1994-2017	482	0.0097	0.0085	0.132	-1.3726	0.876
GDP[4]	1994-2017	476	284.738	791.051	1518.37	1.731	12640
Real interest rate[5]	1994-2017	356	3.8141	6.3199	13.4508	-35.314	77.617
Nations with exchange rate data and no discoveries in the time period (57)							
Exchange rate change[2]	1994-2017	1308	0.0032	0.0005	0.0859	-0.8011	0.8033
GDP[4]	1994-2017	1365	16.9011	172.338	573.260	0.3002	4553.4
Real interest rate[5]	1994-2017	2056	6.6083	6,9719	10.98	-87.853	139.96

Nations with FX volatility data and discoveries in the time period (17)							
Giant oil discoveries[1]	1994-2012	17	1667	2569.9	2600.23	500	9500
FX Volatility[3]	1994-2017	327	0.0160	0.0187	0.0170	0.000	0.1860
GDP[4]	1994-2017	404	349.696	979.221	1611.81	8.8915	12640
Real interest rate[5]	1994-2017	306	4.5577	7.8170	12.4902	-18.951	77.617
Nations with FX volatility data and no discoveries in the time period (25)							
FX Volatility[3]	1994-2017	505	0.0198	0.0217	0.0128	0.0000	0.1084
GDP[4]	1994-2017	544	137.683	399.481	859.441	0.02236	4553.5
Real interest rate[5]	1994-2017	363	4.0877	5.7674	9.4728	-18.227	93.915

[1] MMBOE. For the largest discovery larger than 500 million barrels for each country.
[2] First difference of log real effective exchange rate index (2010=100).
[3] Standard deviation of the first diff of log monthly averages of daily exchange rates.
[4] Billions. Measured as constant 2015 USD.
[5] Real interest rate (%).

Appendix B

List of 78 countries used in real exchange rate (REER) regressions

With giant oil discoveries		
Algeria	Australia	Bolivia
Brazil	Canada	China
Colombia	Denmark	Equatorial Guinea
Ghana	Israel	Malaysia
Nigeria	Norway	Pakistan
Russian Federation	Saudi Arabia	Sierra Leone
Trinidad and Tobago	United Kingdom	Venezuela

Without giant oil discoveries		
Antigua and Barbuda	Armenia	Bahamas
Bahrain, Kingdom of	Belize	Bulgaria
Burundi	Cameroon	Central African Rep.
Chile	Hong Kong	Congo, Dem. Rep.
Costa Rica	Croatia	Czech Republic
Côte d'Ivoire	Dominica	Dominican Republic
Fiji	Gabon	Gambia
Georgia	Grenada	Guyana
Hungary	Iceland	Iran
Japan	South Korea	Lesotho
Macedonia	Malawi	Mexico
Moldova	Morocco	New Zealand
Nicaragua	Papua New Guinea	Paraguay
Philippines	Poland	Romania
Samoa	Singapore	Solomon Islands
South Africa	St. Kitts and Nevis	St. Lucia
St. Vincent & Grens.	Sweden	Switzerland
Togo	Tunisia	Uganda
Ukraine	Uruguay	Zambia

Appendix C

List of 42 countries used in exchange rate volatility regressions

With giant oil discoveries

Australia	Brazil	Canada
China	Colombia	Denmark
India	Israel	Norway
Thailand	Trinidad and Tobago	United Kingdom

Without giant oil discoveries

Algeria	Botswana	Brunei Darussalam
Chile	Czech Republic	Faroe Islands
Greenland	Japan	Kiribati
South Korea	Kuwait	Liechtenstein
Malaysia	Mauritius	Mexico
Nauru	New Zealand	Peru
Philippines	Poland	Russian Federation
Saudi Arabia	Singapore	South Africa
Sweden	Switzerland	Tuvalu
United Arab Emirates	Uruguay	West Bank and Gaza