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Overinvestment and Macroeconomic Uncertainty: Evidence from Renewable and Non-Renewable Resource Firms*

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Abstract

Investment is an inherent component of business activities. This study examines the tendency of resource firms to overinvest induced by the business cycle and uncertainties. The analysis is conducted using unbalanced panel data drawn from 584 resource companies across 32 countries covering 1986 to 2017 in four resource sectors: (1) alternative energy, (2) forestry and paper, (3) mining, and (4) oil and gas producers. The results indicate that the forestry and paper sector overinvests relative to the standard investment level predicted by the investment function regardless of the sample period, while the alternative energy sector tends to underinvest. Also, many emerging economies, including Brazil, China, India, Indonesia, Russia, and South Korea, are found to have overinvested over the last three decades or so. In addition, the results suggest that commodity price inflation plays a more important role in inducing firms' overinvestment than commodity price uncertainty. It is also found that the home country's business cycle significantly affects overinvestment, with the sign alternating from negative to positive after the global financial crisis. Furthermore, the finding also shows no significant relationship between global geopolitical risk and overinvestment but a significantly positive relationship is found between global economic and country-level governance policy uncertainties and overinvestment. Lastly, the results suggest that the effect of overinvestment on firm performance after three years is positive, especially for firms in the mining sector.

Keywords: Overinvestment, Business Cycle, Uncertainty, Natural Resource Companies
JEL classification: E32, G30, G32

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1. Introduction

Investment is an inherent component of business activities. By making investments, firms grow their capacity to increase output. However, the important economic notion of optimality also applies to firm investments. What if firms invest more than they should? Richardson (2006) defines this phenomenon as overinvestment. He proposes a relative measure that assesses the degree of over- and underinvestment using residuals from firms' investment functions. Overinvestment can be considered as a result of firms' risk taking behaviour, providing higher firms' performance sometimes but putting them in trouble other times. Therefore, if many firms in a sector or country overinvests, there may be too much risk for the sector or country. Thus, it is useful to identify the sectors and countries that tend to overinvest, as well as the possible causes of this overinvestment. This study identifies overinvestment and its causes among resource companies from 32 G20-area countries.

Furthermore, it is also useful to assess how overinvestment affects firm performance. From the macroeconomic point of view, overinvestment could have both positive and negative effects. When the business cycle is in a booming phase, general prices increase and thus induce firms to invest more to increase their production capacities (Kiyotaki, 2011). On a massive scale, this can expand aggregate overinvestment in the economy, which would further boost the economy, at least in the short term. However, the overinvestment would have an adverse inter-temporal impact and damage the economy in the long term. Firm overinvestment could also have both negative and positive side effects from the microeconomic point of view. For example, Kulatilaka and Perotti (1998), Weeds (1999), Chevalier-Roignant et al. (2011), and Henriques and Sadorsky (2011) suggest that increasing investment, which could be characterized as overinvestment, is a favourable strategy for firms under high uncertainty, as the overinvestment could improve their performance. On the other hand, Fu (2010), Liu and Bredin (2010), and Ling et al. (2016) argue that overinvesting has a significantly negative impact on the future performance of firms. Therefore, it is worthwhile empirically assessing the effects of overinvestment on firm performance, which this study performs for resource companies across a number of major countries.

In 2017, the total natural resource exports from the sample countries accounted for 1,566.43 billion USD. Russia and the United States are the world leaders in the export of natural resources, followed by other G20 countries, such as Australia, Saudi Arabia, Canada, and Brazil. Furthermore, the natural resource exports play the critical role in driving many leading economies. Natural resource exports accounted for more than 50% of exports for Saudi Arabia, Russia, and Australia. For many other countries, natural resource exports accounted for more than 20% of their total exports (Brazil, Greece, Indonesia, Canada, South Africa, and Cyprus). Although the role of the resource sector in the overall economy (as a percentage of total value-added and total employment) might be decreasing, natural resource exports still play a vital role in maintaining macroeconomic performance for these countries, primarily through the export channel. These facts emphasize the importance of analysing overinvestment in the resource sector, providing a solid reason to focus on the sector.

This study contributes to the literature by providing a comprehensive empirical exploration of overinvestment behaviour and its relation with business cycles and macroeconomic uncertainties among resource companies from 32 G20-area countries. Three analyses are conducted to clarify the characteristics of overinvestment and their effects on firm performance. First, this study examines overinvestment and underinvestment behaviour among the sample firms in each period using the framework developed by Richardson (2006). Second, this study examines whether business cycles and macroeconomic uncertainties play a significant role in explaining overinvestment behaviour. Third, this study examines how overinvestment affects firm performance.

This study considers the business cycle as a possible source of overinvestment. Specifically, this study employs a dual business cycle approach by considering the world business cycle and the home-country business cycle. This dual approach is effective in capturing the overall effect of business cycle fluctuations on companies' overinvestment behaviour. In addition, commodity price uncertainty, global geopolitical uncertainty, and global economic policy uncertainty are considered in order to examine the relationship between overinvestment and uncertainty. Furthermore, a worldwide governance indicator is adopted as a proxy for country-level uncertainty.

This study offers several significant findings. The first analysis indicates that internal firm factors play a significant role in determining firms' investment decision making and that the 2008 global financial crisis had a significant impact on overinvestment patterns in many countries. This result is also confirmed statistically by comparing estimated parameters from the investment function between before and after 2008. Also, the results suggest that the forestry and paper sector overinvests relative to the standard investment level predicted by the investment function regardless of the sample period, while the alternative energy sector tends to underinvest. Furthermore, many emerging economies, including Brazil, China, India, Indonesia, Russia, and South Korea, are found to overinvest over the last three decades or so. The second analysis shows that commodity price inflation plays a more important role in inducing firms' overinvestment than commodity price uncertainty does. The home country business cycle also significantly affects overinvestment, with signs alternating from negative to positive before and after the global financial crisis, while the world business cycle has no significant relationship with overinvestment. The finding also shows no significant relationship between global geopolitical risk and overinvestment but finds a significantly positive relationship between global economic and country-level governance policy uncertainties and overinvestment. Finally, the third analysis demonstrates that the effect of overinvestment on firm performance is positive, especially for firms in the mining sector. This finding supports Kulatilaka and Perotti (1998), Weeds (1999), Chevalier-Roignant et al. (2011), and Henriques and Sadorsky (2011), who suggest that overinvesting might be a favourable strategy for firms facing uncertainty.

The remainder of the paper is structured as follows. Section 2 reviews the literature and provides theoretical background on overinvestment and discusses the empirical literature on the measurement of overinvestment and its relation to uncertainty and firm performance. Section 3 explains the study's dataset, while Section 4 explains the study's methodology. Section 5 presents the study's empirical results and discusses them, focusing on their relevance to the literature. Finally, Section 6 concludes the paper.

2. Literature Review

The fundamental motivation for this study flows from Kydland and Prescott (1982) and Long and Plosser (1983), who highlight the importance of timing for investments; poor timing can lead to misinvestment, in the form of over- or underinvestment. This study is also motivated by theoretical models that outline the significant role of uncertainty in inducing misinvestment behaviours. Section 2.1 provides a theoretical overview of these issues and establishes the study's conceptual framework. Section 2.2 discusses several works defining the concept and measurements of overinvestment. Section 2.3 reviews previous empirical works attempting to explain the significant role of uncertainties in stimulating over- and underinvestment. Finally, Section 2.4 summarizes previous empirical works analysing the relationship between overinvestment and firm performance.

2.1. Theoretical Overview

In their seminal paper, Kydland and Prescott (1982) discuss the importance of time lag in the creation of new productive capital, which requires more than one period to be produced. Moreover, Long and Plosser (1983) mention the role of preference in determining the business cycle, defined as a joint movement of a wide range of aggregate economic variables. Based on these two important works, it could be argued that investment in one period is largely determined by the current preference. However, as an investment requires more than one period to be completed, preferences could change by the time the investment is completed, creating a mismatch. The possibility of a preference change over time is a source of uncertainty. As preferences are associated with the business cycle, it could be argued that the business cycle can be perceived as a form of uncertainty.

Theoretically, Abel (1983) and Abel and Eberly (1994) argue that the optimal level of investment is a positive function of Tobin's Q. Thus, it could be inferred that a higher Q represents higher investment opportunities for firms. In addition to that, they introduce the concept of "marginal Q." This concept states that the optimal investment level can be achieved when the marginal adjustment cost equates the marginal value of installed capital. Conceptually, the optimal condition can be achieved when the marginal Q and average Q are equal. Based on this framework, several studies, such as Lang et al. (1991), Degryse and de Jong (2006) and Pellicani and Kalatzis (2019), employ the Q index as a proxy for firm investment opportunities. However, as Richardson (2006) argues, the Q alone is not enough to capture a firm's growth opportunities comprehensively. He argues that a measure based on the residual framework might be a better approach, as such a residual measure can incorporate the information in both market prices and firm assets, as revealed via book value and current earnings. Therefore, this study employs the framework of Richardson (2006) to measure overinvestment.

Firms' investment decision making has been a central topic in the economics and finance literature. Fazzari et al. (1988) are one of the first to document how financial factors become a significant determinant of investment decision making. They emphasize the importance of financial constraints using their model, proxied with a dividend payout ratio, in determining the investment behaviour of the firm.

Furthermore, Bebchuk and Stole (1993) discuss how uncertainty, in the form of imperfect information and short-term managerial objectives, may boost firms' overinvestment (or underinvestment) tendencies. Their model predicts that overinvestment occurs when the market observes the number of opportunities for investment but lacks complete information regarding productivity, while underinvestment occurs when the market lacks complete information regarding the number of opportunities for investment. Lorenzoni (2008) presents a theoretical model of how uncertainty may cause an inefficient credit boom. He outlines the importance of financial friction in the form of revenue shocks, which may cause a firm to make inefficient investments and thus inefficient leverage decisions.

Glover and Levine (2015) provide dual theoretical predictions of how uncertainty can affect firms' investments. On the one hand, uncertainty may increase investment. Profits can increase at an increasing rate if firms have a positive and convex relationship between profit and cost or demand (i.e. if cost or demand increase). Furthermore, uncertainty may positively increase investment if firms have the ability to reverse their investments. This condition causes higher uncertainty increases the marginal utility of capital and thus investments. This positive relationship is outlined by Oi (1961), Hartman (1972), and Abel (1983). On the other hand, some theoretical models predict a negative relationship between uncertainty and investment. The basis of this prediction is the presence of irreversibility, which may cause firms to delay investments when uncertainty is high. This negative relationship is supported by Bernanke (1983), Brennan and Schwartz (1985), McDonald and Siegel (1986), Pindyck (1988), and Dixit and Pindyck (1994). Thus, there are dual effects of uncertainty on investment depending on the assumptions of the framework. However, Glover and Levine (2015) also point out that most empirical works find a negative relationship between uncertainty and investment.

2.2. Overinvestment: Concept and Measurement

Attempts to explain firms' overinvestment behaviours can be traced to Fazzari et al. (1988), who outline the role of financial constraint proxied by a dividend payout as a cause of overinvestment. Firms with a low payout ratio are identified as financially unconstrained and as thus having a higher tendency to overinvest. Their model is supported by the empirical finding that firms with a low payout ratio have higher investment-cashflow sensitivity. Fazzari et al. (1988) is followed by other studies, such as Bond and Meghir (1994), Chapman et al. (1996), Whited and Wu (2006), Almeida and Campello (2007), Carpenter and Guariglia (2008), and Wang et al. (2016), who use various proxies of financial constraint.

Richardson (2006) introduces an accounting-based framework to measure the overinvestment phenomenon. He defines overinvestment as a form of investment at an amount that exceeds the normal or expected level given the firm's characteristics and economic conditions. This definition can be considered an accounting-based definition of overinvestment because, in this framework, overinvestment is measured based on firm-specific variables, such as value, leverage, cash availability, and age. The framework estimates the investment function of all firms in the dataset in a panel setting, which generates an estimated parameter for each explanatory variable. From these parameters, the fitted values are then constructed to represent the ideal amount of new investment for each firm. The residual from this estimation is defined as the misinvestment, or, specifically, the unexplained part of the firms' investment. The positive value of this residual represents overinvestment, while the negative value represents underinvestment. One major reason why this study chooses the framework of Richardson (2006) is that it is among the most popular measures due to its straightforward and easy-to-compute characteristics; it requires only balance sheet information. Many studies adopt this framework for overinvestment analysis, such as Zhang and Su (2015), Guariglia and Yang (2016), Wei et al. (2019), and Yu et al. (2020).

In their framework, Richardson (2006) employ the 'new investment' spent by the firm as the dependent variable (I_{NEW}). This variable is calculated as the current year's total investment expenditure subtracted by the total investment required to maintain existing assets. Thus, in this framework, the dependent variable is expressed as the amount of new investment, instead of the total investment stock inside the firm. The rationale for this choice is that the analysis of overinvestment focuses on how a firm decides upon a new investment within a certain business environment. Considering that the business environment is dynamic, change in investment is considered better able to capture firm behaviour than total investment stock. Empirically, Richardson (2006) employs this framework to examine the overinvestment phenomenon using 58,053 firm-year observations drawn from Compustat data on non-financial firms covering 1988 to 2002. The result shows that the average firm overinvests 20% of its available free cash flow. However, Bergstresser (2006) criticizes this framework for being based on the residual of the model, which results in a zero-mean characteristic and balanced observations of overinvestment and underinvestment.

2.3. Overinvestment and Uncertainty

Many studies have contributed to the literature on how firms' external uncertainty plays a vital role in explaining the overinvestment tendency. Proost and Van Der Loo (2010) develop a theoretical model to identify the role of demand uncertainty in overinvestment and underinvestment for transport infrastructure. They find that an overinvesting action is costly in the presence of demand uncertainty. Henriques and Sadorsky (2011) empirically examine the effect of oil price uncertainty on strategic investment. Although their approach does not directly analyse the relationship between oil price uncertainty and the overinvestment phenomenon, their results suggest a U-shaped relationship between oil price volatility and firm-level investment. In other words, when oil price uncertainty is high, firms should increase investments, which can be characterized as overinvestment, suggesting that overinvestment could be beneficial for firms in high-uncertainty circumstances.

Dixit and Pindyck (1994) provide a very rigorous discussion about investment under uncertainty, which emphasizes the role of irreversibility, uncertainty, and timing in investment decision making. This concept motivates many empirical works, such as Bloom (2009) and Sha et al. (2020), to examine the investment decision making process. However, the empirical works conducted by these studies are only focused on firms in a specific country. Bloom (2009) implements the analysis using US firms data, meanwhile Sha et al. (2020) focus on Chinese firms' data. Furthermore, these studies focus on investment decision-making and do not specifically discuss the dynamics of over- and underinvestment. These two facts distinguish their study with the analysis conducted in this study.

Chevalier-Roignant et al. (2011) provide a comprehensive literature review on firms' strategic investment and conclude that overinvesting seems favourable amid increased uncertainty. Their review include models developed by Kulatilaka and Perotti (1998) and Weeds (1999). Weeds (1999) argues that economic and technological uncertainty might induce a firm to invest in technology that they will leave unexploited, known as the 'sleeping patent,' in order to retain their position as a dominant firm and block new entrants. Meanwhile, Kulatilaka and Perotti (1998), motivated by Dixit (1980) and in line with Spence (1979), develop a model of strategic investment under high uncertainty and competition. Their model indicates that an overinvesting action is favourable under many conditions, even under increased volatility. This conclusion is based on their argument that increased uncertainty provides more opportunity rather than just simply higher risk. One important thing to note from these studies is that they focus on strategic aspects such as industry structure and the market share where firms operate. Those factors are, therefore, important for overinvestment analysis. However, those factors are most feasible to be analyzed when estimation focuses on firms in a specific country or region. To this extent, this study, which focuses on resource companies from around the world, can hardly accommodate these strategic aspects to the analysis. Yet, the insights provided by this literature regarding the positive relationship pattern between uncertainty and overinvestment are very crucial for the analysis conducted in this study.

Another model by Heikkinen and Pietola (2009) suggests that uncertainty increases the overinvestment tendency. Wang et al. (2016) empirically examine how inflation uncertainty can lower the tendency to overinvest. Liu (2013) identifies the vital role of policy uncertainty, which contributes to overinvestment in wind power capacity in China. Ahuja and Novelli (2017) argue that increased uncertainty can lead to research and development (R&D) overinvestment in a firm due to the complexity of investment decision making, especially in large companies with many divisions.

Yoon and Ratti (2011) show that energy prices play a vital role in determining firm investment stability. Drakos and Goulas (2006) outline the positive response of investment toward uncertainty. By contrast, Acharya and Sadath (2016) and Caballero (1991) find a negative relationship between energy price uncertainty and firm investments. Ma (2016) argues that there is no significant effect of GDP uncertainty on investment. Ghosal and Loungani (2000) and Gulen and Ion (2016) also report a negative investment-uncertainty relationship.

Based on these studies, it could be argued that the relationship between uncertainty and investment is indeterminate, although some studies, such as Kulatilaka and Perotti (1998), Weeds (1999), Chevalier-Roignant et al. (2011), and Henriques and Sadorsky (2011) suggest that overinvestment might be a favourable strategy for firms amid uncertainty. This study contributes to this strand of literature by empirically examining how economic and non-economic macro uncertainties affect resource companies' tendency to overinvest.

2.4. Overinvestment and Performance

Several studies investigate the relationship between overinvestment and firm performance. For example, Kulatilaka and Perotti (1998), Weeds (1999), Chevalier-Roignant et al.

(2011), and Henriques and Sadorsky (2011) suggest that, amid high uncertainty, increasing investments, which could be characterized as overinvestment, might improve firm performance. On the other hand, Fu (2010) examines the relationship between overinvestment and the operating performance of seasoned equity offering companies (SEOs) and shows that overinvestment is significant in explaining firms' poor performance. Likewise, Liu and Bredin (2010) investigate the role of institutional investors in inducing firms' overinvestment and examine how overinvestment might affect corporate performance. They report a significantly negative relation between overinvestment and corporate performance. Moreover, Ling et al. (2016) examine the relationship between political connections and overinvestment and explore how both factors influence firm performance. They find that firms with political connections have a higher tendency to overinvest and that this condition lowers firm performance. Thus, it could be argued that overinvestment has a mixed relationship with firm performance.

3. Data

This study examines the overinvestment phenomenon at the firm level. A firm is categorized as overinvesting if its investment level is considered to be higher than its predicted level from the firm's investment function, which is estimated in a panel setting. The proxy of investment is calculated as the difference of total capital divided by the average of total assets, following the framework of Richardson (2006). The analysis uses 7,984 firm-year observations drawn from 584 natural resource companies from 32 countries in the G20 area.[3] The dataset is unbalanced, and the regression analysis covers the 32 years spanning 1986 to 2017. The analysis are limited to companies with at least 10 years of observations without a gap. Detailed information regarding the number of observations and companies for each sector is provided in Table 1.

[Table 1]

There are four resource sectors in the analysis, which follow the Worldscope Datastream classification: (1) alternative energy,[4] (2) forestry and paper, (3) mining, and (4) oil and gas producers. Companies in these four sectors are grouped into two broad classifications based on their resource characteristics: renewable and non-renewable. The renewable group is comprised of alternative energy and forestry and paper companies. The non-renewable group is comprised of mining and oil and gas production companies. Nevertheless, it is acknowledged that some companies in the dataset might involve in more than one business

[3]There are more than 20 countries in the G20 because the European Union (EU) is counted as one member, except for some of the EU's most industrialized countries (Germany, France and Italy), which are also present alone. Observations from firms in the European Union are included to accommodate this situation. If Hong Kong is counted as a single country, the dataset comprises 33 countries.

[4]The alternative energy sector comprises firms which are either (1) manufacturers of renewable energy equipment such as wind turbines and solar panels; or (2) producers of biofuels. Thus, most firms in this sector are manufacturing firms.

activities, which may include both renewable and non-renewable businesses. The Worldscope Datastream classifies each company based on their primary business activity, and therefore this study follows that classification to group them into renewable and non-renewable. This study acknowledges this condition as a caveat of the dataset.

On the one hand, conducting an analysis in a cross-country setting makes the dataset prone to the cross-country heteroscedasticity problem. On the other hand, one of the main characteristics of resource companies is they operate across countries to expand and to pursue the resources they are seeking. This is particularly true of non-renewable companies, which dominate the dataset. Therefore, the analysis is conducted in a cross-country setting with country-level macroeconomic variables used as controls.

The balance sheet data of the sample companies are acquired from Worldscope Datastream. Seven main variables are employed in this study: (1) total assets, (2) total capital,[5] (3) total shareholders' equity, (4) total debt, (5) cash, (6) market capitalization, and (7) operating income.[6] Firm age is proxied by the current year subtracted by the first year in the data available from the Worldscope database. The data are in annual frequency, primarily based on the end-of-year balance sheet position. All companies are publicly listed and are limited to companies categorized as major, primary quote, and active based on the Worldscope classification. The data are acquired in the local currency in which the firm is listed. Most firm-level variables are normalized with the average of total assets or are transformed into a logarithmic scale.

The dataset also includes macroeconomic data, at both the world and country levels. At the world level, commodity price data—specifically, the Goldman Sachs Commodity Index (GSCI)—is applied. This commodity price index is one of the most popular commodity indexes in the financial market. The GSCI is based on future contracts, which represent current market expectations of future conditions. The index is in daily frequency, and the annual average of the daily data is used as the proxy for the commodity price cycle. The index also proxies for price uncertainty, using the annual standard deviation of the daily GSCI. This study also employs the global Geopolitical Risk index ($GEOPOL$) from Caldara and Iacoviello (2018) and the Global Economic Policy Uncertainty index ($GEPU$) from Davis (2016) as proxies of global uncertainty. A higher $GEOPOL$ and $GEPU$ indicates higher uncertainty. Data for $GEOPOL$ and $GEPU$ are provided and updated monthly by the authors on the associated websites.[7]

At the country level, the study uses GDP growth, inflation rate, and the Worldwide Governance Indicators (WGI) of the World Bank. The WGI index plays a vital role as a

[5] Specifically, total capital represents total investment in the company, which is calculated as the sum of common equity, preferred stock, minority interest, long-term debt, non-equity reserves, and deferred tax liability in untaxed reserves.

[6] The following are codes for each variable acquired from Worldscope Datastream: (1) total assets - WC02999, (2) total capital - WC03998, (3) total shareholders' equity - WC03995, (4) total debt - WC03255, (5) cash - WC02003, (6) market capitalization - WC08001, and (7) operating income - WC01250.

[7] Data for $GEOPOL$ are provided by Caldara and Iacoviello (2018) on https://www.matteoiacoviello.com/gpr.htm. Data for $GEPU$ are provided by Davis (2016) on https://www.policyuncertainty.com/global_monthly.html.

proxy for country-level uncertainty. The study uses the average of six categories: (1) voice and accountability, (2) political stability and the absence of violence/terrorism, (3) government effectiveness, (4) regulatory quality, (5) the rule of law, and (6) control of corruption. The WGI ranges from -2.5 to 2.5, where a higher value indicates better governance. This value is inverted by multiplying -1 to take the opposite, with a higher value indicating poor governance, for ease of analysis.

As shown by the GSCI index, there is a strong indication of a structural break in the commodity price in 2008 (see Figure 1). This indication is also confirmed by the supremum Wald test conducted to track structural break with an unknown break date as in Casini and Perron (2019). The test is implemented to daily GSCI data based on the 2^{nd} order autoregressive ($AR(2)$) model and suggests a structural break on July 7, 2008.[8] The result is reported in Table 2. Based on this stylized fact, the analysis is conducted for three periods: (1) the full period of 1986-2017; (2) before 2008, including 1986 to 2007; and (3) after 2008, including 2009 to 2017. The year 2008 is excluded in the sub-period analysis because it is the exact year when the anomaly and structural break occurred.

[Figure 1]

[Table 2]

It is fully acknowledged that some, if not most, of the companies in the observation operate in a multinational setting, and most are export-oriented. Therefore, the home country's business cycle should not be the only proxy used for the business cycle. This study also employs the global business cycle, represented by global annual GDP growth. This dual business cycle approach is effective in capturing the overall effect of business cycle fluctuation on companies' investment behaviours.

The dataset initially contained outliers reflecting extreme economic phenomena, such as Brazilian hyperinflation in the early 1990s, which could affect the dataset's overall statistical distribution. Some companies also had extreme balance sheet profiles, such as extreme negative equity, which could distort the overall statistical properties of the dataset. Thus, these outliers were eliminated. The elimination process was conducted in two steps. Firstly, outliers were eliminated, especially on leverage (LEV) and inflation ($INFL$) data, as these two variables were identified as being the most prone to the outlier problem. The dataset was trimmed one percent in the upper and lower percentile based on these two variables. Secondly, after the outliers were removed, companies were limited to which have at least 10 years of observations without a gap. Descriptive statistics of the final dataset and the correlations between variables are presented in Tables 3 and 4.

[Table 3]

[Table 4]

[8]The lag 2 is chosen based on Akaike Information Criterion (AIC) and Hannan–Quinn Information Criterion (HQIC).

4. Methodology

4.1. Overinvestment

Overinvestment is proxied by the positive residuals of the firm investment function, based on the firm's specific variables. The specification used to measure overinvestment was developed by Richardson (2006) and has been implemented in several studies, such as Zhang and Su (2015), Guariglia and Yang (2016), Wei et al. (2019), and Yu et al. (2020). The equation for the firm investment function is as follows:

$$\begin{aligned} INVT_{i,t} = \beta_0 + \beta_1 V/P_{i,t-1} + \beta_2 LEV_{i,t-1} + \beta_3 CASH_{i,t-1} + \beta_4 SIZE_{i,t-1} \\ + \beta_5 RTRN_{i,t-1} + \beta_6 INVT_{i,t-1} + \beta_7 AGE_{i,t-1} + \Sigma YRID + \Sigma FRID + \mu_{i,t} \end{aligned} \tag{1}$$

where the subscript $i = 1, 2, ..., i$ denotes firm in the sample, meanwhile t denotes year. The term $INVT$ reflects the investment of the firm i at time t, calculated as the change in total capital divided by the average of total assets. This term is similar to the new investment variable used by Richardson (2006). The term V/P is a proxy of a firm's growth opportunity, which is the ratio between the firm's book value of shareholders' equity divided by market capitalization. The term LEV reflects the leverage ratio, calculated as total debt divided by the average of total assets. The term $CASH$ is the firm's total cash divided by the average of total assets. The term $SIZE$ is the log-transformation of total assets. The term $RTRN$ is the firm's annual return, calculated as the annual growth of the firm's market capitalization. The term AGE is firm age, calculated as the current year subtracted by the first year for which data are available in the Worldscope database, as indicated by the 'History/Hist' column in the firm's profile. The term $YRID$ is the year fixed effect dummy. The term $FRID$ is the firms' fixed effect dummy. The error term μ in this equation is a proxy for firm misinvestment; a positive value indicates overinvestment, while a negative value indicates underinvestment. Equation (1) is estimated using the panel fixed-effect ordinary least squares (OLS) with clustered error specification, where the firm is the cluster. All regressors are one-year lagged to avoid the endogeneity problem, following Richardson (2006). As there are 21 panels for each analysis, there are 21 μ in this study, specifically $\mu^{m,n}$, where $m = 1, ..., 3$ denotes estimation period, meanwhile $n = 1, ..., 7$ denotes sample set (see Table 9).

Furthermore, this study also conducts joint and separate Chow tests to check parameters stability from estimation (1).[9] The test is conducted by estimating joint equations and multiplying each independent variable with dummy indexes referring to before and after 2008, excluding the year 2008. After that, joint and separate F tests are implemented to see whether parameters from before 2008 are statistically different with parameters from after 2008. If they are statistically different, thus it could be inferred that a structural break happened. The joint F test is conducted to see whether parameters from each estimation before 2008 are jointly and statistically different from its counterpart after 2008. Meanwhile, the separate F test is aimed to see the stability of each parameter between before and after 2008.

[9]For more details please see (Greene, 2018, pp. 191).

4.2. Overinvestment and Uncertainty

In the second analysis, this study examines the effect of macroeconomic variables and uncertainty on firms' tendency to overinvest. The term misinvestment (μ) from the error term in equation (1) is transformed into a dummy of overinvestment, $OVIT$, as follows:

$$OVIT_{i,t} = \begin{cases} 1 & if \quad \mu_{i,t} > 0 \\ 0 & if \quad \mu_{i,t} < 0 \end{cases} \tag{2}$$

where the subscript $i = 1, 2, ..., i$ denotes firm in the sample, meanwhile t denotes year. Since there are 21 misinvestment ($\mu^{m,n}$) variables, thus there are also 21 overinvestment dummy variables ($OVIT^{m,n}$). The estimation equation for the second analysis is the panel probit model given as follows:

$$\begin{aligned} Prob(OVIT_{i,t} = 1) = \Phi\Big(&\beta_0 + \beta_1 OVIT_{i,t-1} + \beta_2 \sigma COMM_{i,t-1} + \beta_3 \Delta COMM_{i,t-1} \\ &+ \beta_4 WGDP_{i,t-1} + \beta_5 HGDP_{i,t-1} + \beta_6 GEOPOL_{i,t-1} + \beta_7 GEPU_{i,t-1} \\ &+ \beta_8 WGI_{i,t-1} + \beta_9 INFL_{i,t-1} + \Sigma YRID + \Sigma FRID\Big), \end{aligned} \tag{3}$$

where Φ is the cumulative distribution function of the standard normal distribution. The term $\sigma COMM$ is the annual standard deviation of the daily GSCI Index, which proxies for commodity price uncertainty. The term $\Delta COMM$ is the annual inflation of the commodity price. The term $WGDP$ reflects global GDP growth, while the term $HGDP$ is GDP growth in the home country. The term $GEOPOL$ is the log-transformed Geopolitical Risk Index, while the term $GEPU$ is the log-transformed Global Economic Policy Uncertainty index. The term WGI reflects the inverted country-level Worldwide Governance Indicators. The term $INFL$ is the annual home country inflation rate. The term $\Sigma YRID$ is a year indicator, meanwhile The term $\Sigma FRID$ is a firm indicator. The estimation is conducted with a panel probit model. To accommodate the firm fixed effects, clustered error specification is used, where the firm is the cluster.

The choice of explanatory variables in this analysis is motivated by previous studies, which outline the relationship of many macroeconomic factors with investment or overinvestment. The choice of commodity variables ($\sigma COMM$ and $\Delta COMM$) is based on Caballero (1991), Henriques and Sadorsky (2011), Yoon and Ratti (2011), and Acharya and Sadath (2016). Economic conditions, represented by $WGDP$ and $HGDP$, are considered to have a significant role in determining overinvestment, following Weeds (1999), Proost and Van Der Loo (2010), and Ma (2016). The choice of $GEOPOL$, $GEPU$, and WGI is motivated by Liu (2013) who shows the crucial role of policy uncertainty in causing overinvestment, as well as Yu et al. (2020). Finally, the choice of $INFL$ is based on Wang et al. (2016).

4.3. Overinvestment and Performance

In the third analysis, this study measures the influence of firm overinvestment on future performance. The framework of Fu (2010) is adopted for this analysis. Operating income divided by the average of assets, ROA, is employed as the dependent variable because this type of ROA represents income from real business activities conducted by a company rather than from investing or financing activities.

Three-year lags are implemented for the investment variables ($INVT$, $OVIT$, and $INVT * OVIT$) in this analysis due to the time lag between the disbursement of money for investments and the moment when the investment begins to operate. The three-year lags are used as a benchmark following Topp et al. (2008), who outline that the average construction time for mining (including oil and gas) projects is 2.1 years. The average construction time for new mining developments is 2.4 years, and the average time required for mine expansion is 1.7 years. A one-year lag is implemented for other firm-level control variables.

The estimation equation for performance is as follows:

$$\begin{aligned} ROA_{i,t} = \beta_0 &+ \beta_1 INVT_{i,t-1} + \beta_2 OVIT_{i,t-1} + \beta_3 INVT_{i,t-1} * OVIT_{i,t-1} \\ &+ \beta_4 INVT_{i,t-2} + \beta_5 OVIT_{i,t-2} + \beta_6 INVT_{i,t-2} * OVIT_{i,t-2} \\ &+ \beta_7 INVT_{i,t-3} + \beta_8 OVIT_{i,t-3} + \beta_9 INVT_{i,t-3} * OVIT_{i,t-3} + \beta_{10} V/A_{i,t-1} \\ &+ \beta_{11} ROA_{i,t-1} + \beta_{12} SIZE_{i,t-1} + \Sigma YRID + \Sigma FRID + e_{i,t} \end{aligned} \tag{4}$$

where the subscript $i = 1, 2, ..., i$ denotes firm in the sample, meanwhile t denotes year. The term ROA represents company performance, as represented by operating income divided by average assets. The term $INVT$ is company investment, represented by the change in a firm's total capital divided by average total assets. The term $OVIT$ is the overinvestment dummy, and the term $INVT * OVIT$ is an interaction term for company investment and overinvestment. The term V/A represents firms' market capitalization divided by average assets, and the term $SIZE$ is the log-transformation of a firm's total assets. The term e is an error term. The estimation is conducted with panel fixed-effect OLS, with the fixed effect applied at the firm level.

5. Empirical Results

This section presents the empirical results. For each analysis, estimations are conducted using the full dataset and at a disaggregated level by sector for the three sample periods: the full period, before 2008, and after 2008. For ease of presentation, the results of the year and firm fixed effects are excluded.

5.1. Overinvestment

The first analysis is based on a firm's investment function (1). The dependent variable of this regression is $INVT$, and all regressors are firm-specific variables following specifications from Richardson (2006). The equation is estimated using panel fixed-effect OLS, with the year and firm fixed effects. This means that each analysis is regressed in a panel setting, following Richardson (2006) and many other studies that also implement the same framework. One major difference is that Richardson (2006) implements the fixed effects at the industry level because his analysis focuses on companies in one country with multiple sectors. By contrast, this study focuses on companies from many countries with different characteristics. Therefore, this study implements the fixed effects at the firm level. This means that all companies are regressed in one fixed effects panel. They have exactly the same set of parameters, but each firm has a specific effect that comes from the firm-level fixed effects. Therefore, the residuals (the misinvestments) for each firm are comparable with those of other firms and can be aggregated. The estimation results are presented in Tables 5-7.

[Table 5]

[Table 6]

[Table 7]

As can be seen from the tables, the coefficient on V/P is significant and stable with a negative sign for most regressions, suggesting that overvalued firms have a tendency to invest more. The coefficient on LEV is estimated to be highly significantly negative for several panels in the post-2008 period. The negative sign indicates that firms tend to invest less once they have already leveraged. This finding is logical because leveraging is a major option for firms to finance investments. These results are fairly consistent with those of Richardson (2006).

The coefficient on $CASH$ is found to be significantly positive in the post-2008 period only for the forestry and paper panel. Thus, in contrast to those in Richardson (2006), these results show that cash level is not a major determinant of firms' investments before 2008. In addition, the significantly positive estimates after 2008 might suggest that firms with more cash are more aggressive and invest more after the global financial crisis, especially for forestry and paper firms.

The coefficient on $SIZE$ is found to be significantly negative for all panels and periods, indicating that large firms have lower investment rates. Meanwhile, the coefficient on $RTRN$ is estimated to be significantly positive for most of the cases. At least from the market point of view, $RTRN$ could be considered a proxy for overall firm performance, meaning that the better a firm has performed in the previous year, the higher its tendency to invest.

[Table 8]

Furthermore, joint and separate Chow tests are conducted to compare estimated parameters from Table 6 and Table 7. This test aims to see whether parameters from before and after 2008 estimations are statistically different. The joint Chow test focuses on the joint stability of the parameters between before and after 2008. Meanwhile, the separate Chow test focuses on the stability of each parameter. To conduct this test, each estimation in Table 6 is merged with it's counterpart in Table 7 and jointly estimated as one equation, with each variable is indexed with a dummy indicating the period of before and after 2008 ($b2008$ and $a2008$). The results of both joint and separate tests are presented in Table 8. Based on the value of the F test, it can be seen whether parameters from before 2008 are statistically different after 2008. The joint test results show that parameters from all panels are jointly different between before and after 2008 based on the F value, strongly suggesting a structural break in all estimations.

Results for separate Chow tests suggest that many coefficients are not stable, especially for non-renewable companies (Table 8). Specifically, the coefficient on the variable $INVT$ is not stable for the alternative energy, forestry paper, and mining panels. The coefficient on V/P is not stable for the full sample, non-renewable, and mining; meanwhile, the coefficient on LEV is not stable in the full sample, non-renewable, and oil and gas panels. The coefficient on $CASH$ is found stable for all panels; meanwhile, for $SIZE$, the coefficient is only found stable for the alternative energy panel. Lastly, the coefficient on $RTRN$ is found not stable for the alternative energy and mining panels; meanwhile, the coefficient on AGE is found not stable for the renewable, alternative energy, and oil and gas panels. In general, these results outline that the stability of each parameter between before and after 2008 varies significantly based on the sub-sample. Therefore, the results from the full sample estimation, although they are correct, are not sufficient to describe the overall characteristics of the firms in the sample. This fact shows the importance of dividing the analysis into several sub-samples. In addition, the results also suggest a strong indication of a major structural break for non-renewable companies, as shown by the number of non-stable coefficients for the mining and oil and gas panels.

[Table 9]

The residuals, or the variable misinvestment (μ), are obtained in each estimation in the first analysis. The variable μ describes the degree of firm over- and underinvestment compared to its predicted value from the investment function. There are 21 misinvestment variables, μ, from the 21 panels of the analysis (see Table 9). Each μ is indexed as $\mu^{m,n}$ where $m = 1, ..., 3$ refers to period and $n = 1, ..., 7$ refers to sample set. For ease of presentation, only the results of $\mu^{1,1}$, which are residuals from the full period-full sample estimation, are presented. A statistical description of $\mu^{1,1}$ by sector is presented in Table 10. The more positive the value of $\mu^{1,1}$, the higher the overinvestment; the more negative the value of $\mu^{1,1}$, the greater the underinvestment. Specifically, in Table 10, $\mu^{1,1}$ are divided into sectors and time periods to show the pattern variations. Furthermore, over- and underinvestment levels are classified into three categories based on the mean value of $\mu^{1,1}$:

$$Degree\ of\ misinvestment = \begin{cases} overinvestment & if & mean \geq 0.05 & \rightarrow & dark\ gray\ shade \\ neutral & if & -0.05 < mean < 0.05 & \rightarrow & white\ shade \\ underinvestment & if & mean \leq -0.05 & \rightarrow & light\ gray\ shade \end{cases} \quad (5)$$

As can be seen in Table 10, regardless of the sample period, the alternative energy sector underinvests relative to the standard investment level predicted by the investment function (1). This result could suggest that renewable energy development may be underdeveloped compared to the conventional energy sector because the oil and gas production sector is classified as neutral in the results.

[Table 10]

By contrast, Table 10 demonstrates that the forestry and paper sector overinvests regardless of the sample period, suggesting that the forestry and paper sector generally has an investment rate higher than the standard investment level predicted by the investment function (1). This sector is comprised mostly of forestry and paper mill companies. The high investment rate in this sector might provide insight into the demand growth for paper products. However, on the upstream side of this industry, a higher investment rate might be seen to indicate a higher rate of conversion from natural to industrial forest.

The mining sector has an underinvestment pattern in the full period. However, an interesting pattern change for this sector occurs from neutral before 2008 to underinvesting after 2008. The results indicate that a structural break occurs in the investment pattern in the mining sector before and after the 2008 financial crisis. Investment in this sector is observed to be highly conservative after the crisis.

For the oil and gas producer sector, the investment pattern is stable in the neutral position for all three sample periods, indicating the stability of the proper investment rate in this sector.

Furthermore, $\mu^{1,1}$ is also plotted according to the market, as can be seen in Figures 2-4 and is statistically summarised by Table 11. For most markets, the misinvestment pattern remains the same before and after 2008 (Table 11). Particularly, many emerging economies, including Brazil, China, India, Indonesia, Russia, and South Korea, are found to overinvest over the last three decades or so. The exceptions are Belgium, Canada, Germany, and Poland, which changed from neutral before 2008 to underinvesting after 2008. A similar downward pattern can be observed for Finland, Portugal, and Spain, which changed from overinvesting before 2008 to neutral after 2008. For others, upward patterns can be observed, such as for Hong Kong SAR, Romania, and Turkey, where the pattern changed from neutral before 2008 to overinvesting after 2008. The change in the pattern of overinvestment for each market appears to be determined by market-specific factors, especially those related to macroeconomic conditions before and after 2008. Some markets may have experienced a long period of extensive investment before 2008, which was then corrected when the 2008 crisis occurred.

[Table 11]

[Figure 2]

[Figure 3]

[Figure 4]

This study is among the first to analyse overinvestment patterns in resource sectors using the Richardson (2006)'s method, conducted at the firm level in a cross-country setting. In the next subsection, this study examines whether macroeconomic factors and uncertainties can explain the investment patterns of the sample firms.

5.2. *Overinvestment and Uncertainty*

In the second analysis, this study analyses whether firms' overinvestment behaviour is determined by macroeconomic factors, especially the business cycle and uncertainties. The dependent variable of this estimation is $OVIT$, a dummy for overinvestment, with a value 1 if μ has a positive value and 0 otherwise. The panel probit model (3) is employed and estimated using a clustered error specification, where the firm is the cluster.

The estimation results are summarised in Tables 12-14. As can be seen, the coefficient on $\sigma COMM$, which is the proxy for commodity price uncertainty, is insignificant for all periods. By contrast, the coefficient on $\Delta COMM$ is significant in the full-period analysis for the full sample and for the renewable and non-renewable panels with positive coefficients (see Table 12). In general, it could thus be inferred that companies' overinvestment tendency is determined by the growth of commodity prices rather than uncertainty. The positive sign indicates the procyclicality of overinvestment. Explanations are provided by Kulatilaka and Perotti (1998), Weeds (1999), and Glover and Levine (2015) who point out that, theoretically, there could be a positive relationship between uncertainty and investment. Regarding the commodity price, the results of a positive relationship between $\Delta COMM$ and overinvestment are arguably consistent with their predicted sign, given a positive relationship between commodity inflation and uncertainty. This result can also be related to the findings in Chevalier-Roignant et al. (2011) and Yoon and Ratti (2011), although this result might contradict the findings in Caballero (1991) and Acharya and Sadath (2016), who find a negative relationship between energy price uncertainty and firm investment.

[Table 12]

[Table 13]

[Table 14]

The coefficient on $WGDP$, reflecting the global business cycle, is significant in the full-period analysis, especially for the forestry and paper panel, with a positive coefficient; it is significantly negative after 2008 for the renewable panel. These results show that different sectors might respond differently to the same global factor. The different coefficient signs seem to support the findings of the first analysis, which shows that the forestry and paper sector has a strong pattern of overinvestment. Thus, due to the inconsistent signs, it is fair to say that analyses of the relationship between $WGDP$ and overinvestment produce relatively weak and mixed results.

The variable $HGDP$ represents the home country's business cycle. In the full-period analysis, its coefficient is significant for the renewable panel with a positive sign and is significant for the mining sector with a negative sign. Before 2008, the coefficient on the variable is significantly negative for the full sample and for the non-renewable and oil and gas panels. After 2008, its coefficient is significantly positive for the renewable and mining panels. These are mixed results; however, some patterns can be inferred. First, the results are mixed for the full-period analysis. Second, before 2008, the relationship between $HGDP$

and overinvestment is negative. Third, after 2008, the relationship between $HGDP$ and overinvestment is positive. The change in pattern from negative to positive before and after 2008 could be caused by the global financial crisis, which also changed the behaviour of companies in the sample. Moreover, comparing the results for $WGDP$ and $HGDP$ suggests that the home country's business cycle ($HGDP$) plays a more important role in affecting the overinvestment behaviour of resource firms than $WGDP$ does. The mixed results on the relationship between the business cycle and overinvestment might be slightly different from those of Ma (2016), who finds no significant relationship between GDP uncertainty and investment.

The next variable of interest is the Geopolitical Risk Index ($GEOPOL$), which represents global geopolitical instability. The index is a scalar measure, wherein a higher value indicates higher uncertainty. For the full-period analysis, the coefficient on $GEOPOL$ is significantly positive only for the renewable and alternative energy panels. However, before 2008, its coefficient is significantly negative only for the full-sample panel. Given these results, it could be inferred that $GEOPOL$ and overinvestment do not have a significant relationship.

The variable $GEPU$ plays a vital role as a measure of global economic policy uncertainty. For the full-period analysis, the coefficient of this variable is significant for the full sample and for the renewable and forestry and paper panels with positive signs. In general, this variable is not significant for the non-renewable sectors, such as the mining and oil and gas production sectors. Therefore, it could be inferred that global economic policy uncertainty has a positive relationship with overinvestment, especially for the renewable sector.

The next variable is WGI, which is a proxy for country-level non-economic uncertainty. The inverted version of this index is applied for ease of analysis; a higher number indicates poor governance. As can be seen from Tables 12-14, the coefficient on WGI is statistically significant for all panels in all periods with positive signs. Thus, there is a clear and strong pattern wherein poor governance at the country level has a positive relationship with overinvestment.

The positive relationship of $GEPU$ and WGI with overinvestment supports the findings of many previous studies, such as Drakos and Goulas (2006), Heikkinen and Pietola (2009), Liu (2013), Glover and Levine (2015), and Ahuja and Novelli (2017). These studies find a positive relationship between uncertainty and firm overinvestment or investment. The results also support Kulatilaka and Perotti (1998), Weeds (1999), Chevalier-Roignant et al. (2011), and Henriques and Sadorsky (2011), who suggest that overinvesting might be a favourable strategy for firms facing uncertainty. However, the findings contradict Ghosal and Loungani (2000) and Gulen and Ion (2016), who report a negative investment-uncertainty relationship.

In general, the country-level control variable, inflation ($INFL$), is found to be significantly negative, especially for the full period and after 2008. These results are in line with those of Wang et al. (2016), who find that inflation uncertainty reduces overinvestment tendencies, given a positive correlation between inflation and inflation uncertainty.

5.3. Overinvestment and Performance

In the third analysis, this study examines the relationship between overinvestment and firms' future performance based on Equation (4). The framework of Fu (2010) is used to measure the effect. One- to three-year lags are employed for the investment-related variables ($INVT$, $OVIT$, and $INVT * OVIT$), following the benchmark used by Topp et al. (2008), who outline the average construction time for mining projects. The dependent variable is operating income divided by the average of assets (operating ROA), which represents the income surge from the firms' main business activities. The analysis is divided into the full sample and the sub-sample panels and the full period and sub-periods, as in the previous analyses. Equation (4) is estimated using panel fixed-effect OLS, where the fixed effect is implemented at the firm level. The estimation results are presented in Tables 15-17.

[Table 15]

[Table 16]

[Table 17]

The coefficient of $INVT_{t-2}$ and $INVT_{t-3}$ are found to be significantly negative for the full sample and for the non-renewable and mining panels in the full period and the post-2008 period. These results indicate that, in non-renewable sectors, investments will generally reduce future performance, especially after the 2008 global financial crisis.

The coefficient on $OVIT$, the overinvestment dummy, is generally found to be not significant, although it is either positive or negative for several specific lags and sample estimations. It could thus be inferred that there is no conclusive relationship between $OVIT$ as a standalone variable and firms' future performance.

However, the results for the interaction term $INVT * OVIT$ indicate that it has a generally positive relationship with future performance, especially for the lag-three in the full sample and for the non-renewable and mining panels in the full-period and post-2008-period analysis. Any interpretation of the results for the interaction term should consider the results of the main term $INVT$, which is generally negative. Thus, $INVT$ has a generally negative relationship with future firm performance. For overinvesting firms, however, the joint effect ($INVT * OVIT$) will be positive. It could thus be inferred that overinvesting might have a positive impact on firms' future performance, especially for firms in the mining sector. These results support those of Kulatilaka and Perotti (1998), Weeds (1999), Chevalier-Roignant et al. (2011), and Henriques and Sadorsky (2011), who suggest that overinvesting might be a favourable strategy for firms facing uncertainty. On the other hand, the results contradict the findings of Fu (2010), Liu and Bredin (2010), and Ling et al. (2016), who find that overinvestment has a significantly negative impact on future performance.

It could also be inferred that the most significant relationship between the investment-related variables ($INVT$, $OVIT$, and $INVT * OVIT$) and performance exists in the lag-three. This finding highlights the importance of the time lapse between investment and performance, as outlined by Kydland and Prescott (1982). The finding also supports Topp et al. (2008), who find that the construction time for mining projects might span between 1.7 to 2.4 years. Thus, this study confirms the delayed impact of investment on firm performance.

6. Conclusion

This study has examined the tendency of resource firms to overinvest induced by the business cycle and macroeconomic uncertainties. The analysis has been conducted using unbalanced panel data drawn from 584 resource companies across 32 countries spanning 1986 to 2017 in four resource sectors: (1) alternative energy, (2) forestry and paper, (3) mining, and (4) oil and gas production. The analysis was also conducted by grouping the first two sectors as renewable, and the other two as non-renewable. This grouping has provided interesting insights into overinvestment behavior between the renewable and non-renewable firms.

Three analyses have been conducted to clarify the role the business cycle and uncertainty play in overinvestment and its effects on firm performance. First, the overinvestment and underinvestment behaviours of each firm in the sample have been investigated using the framework developed by Richardson (2006). The results indicated that internal firm factors play a significant role in determining firms' investment decision making. The results also suggested that the 2008 global financial crisis had a significant impact on overinvestment patterns in many countries. The separate Chow test results showed that many coefficients of non-renewable companies are not stable, which strongly suggested that a structural break occurred in 2008 for the mining and oil and gas sectors. Also, the results confirmed that the forestry and paper sector overinvests relative to the standard investment level predicted by the investment function regardless of the sample period, while the alternative energy sector tends to underinvest. Furthermore, many emerging economies, including Brazil, China, India, Indonesia, Russia, and South Korea, were found to overinvest over the last three decades or so.

Second, this study has examined whether the business cycle and uncertainty play a significant role in explaining firms' overinvestment behaviour. The study found a significantly positive relationship between commodity price inflation and overinvestment and found no clear relationship between commodity price uncertainty and overinvestment. In addition, the results showed that although the global business cycle has no noticeable relationship with overinvestment, the home country's business cycle significantly affects overinvestment, with signs alternating from negative to positive before and after the global financial crisis. Furthermore, the study found no significant relationship between global geopolitical risk and overinvestment but found a significantly positive relationship between global economic and country-level governance policy uncertainties and overinvestment.

Finally, the study has explored how overinvestment may affect firms' future performance. The results demonstrated that the joint effect of investment and overinvestment is positive for firm performance, especially for firms in the mining sector. These results support Kulatilaka and Perotti (1998), Weeds (1999), Chevalier-Roignant et al. (2011), and Henriques and Sadorsky (2011), who suggest that overinvesting might be a favourable strategy for firms facing uncertainty. A further extension from this study should consider the inclusion of strategic factors in the market where firms operate, such as industry structure and market share, following formal models discussed by Kulatilaka and Perotti (1998), Weeds (1999), Chevalier-Roignant et al. (2011), and Henriques and Sadorsky (2011).

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7. Appendix: Figures

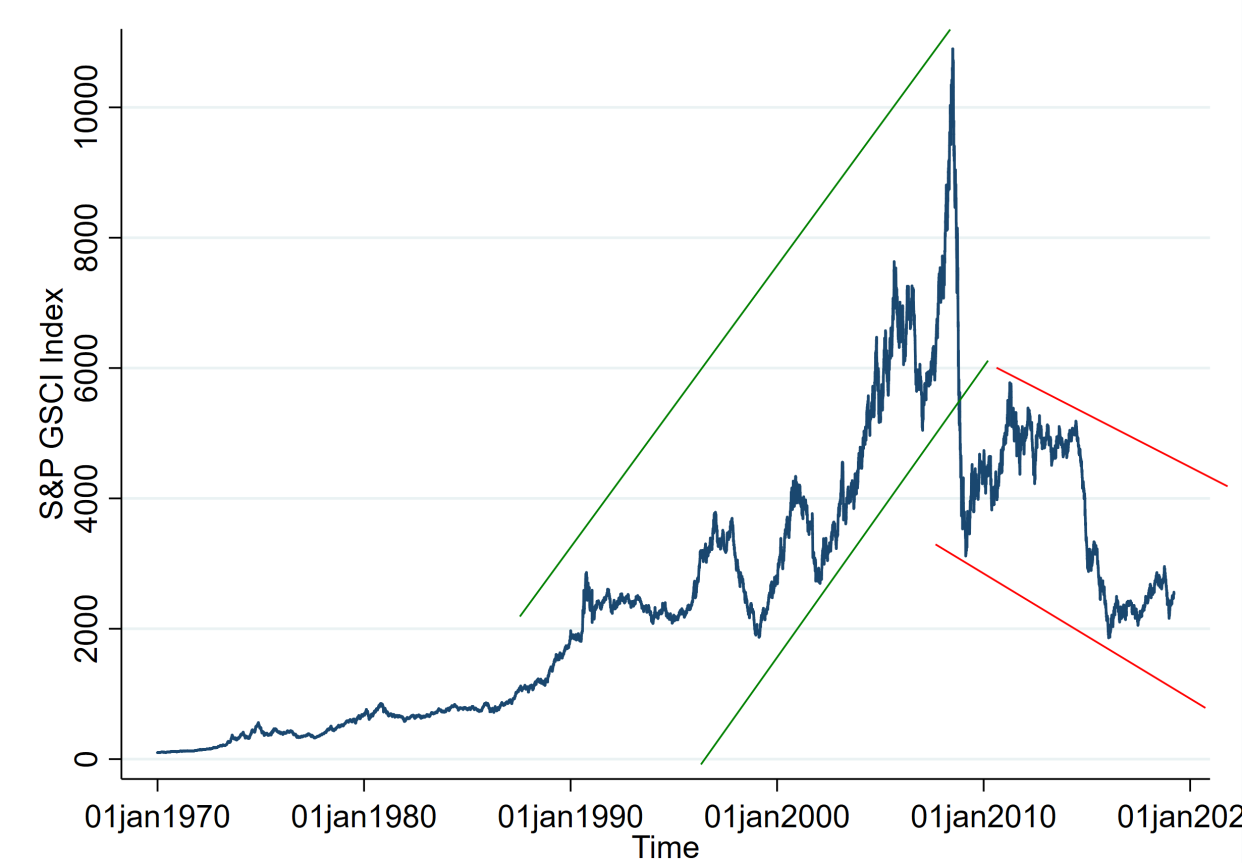

Figure 1: Goldman Sachs Commodity Index (GSCI), 1970-2019

Source: Refinitiv Datastream

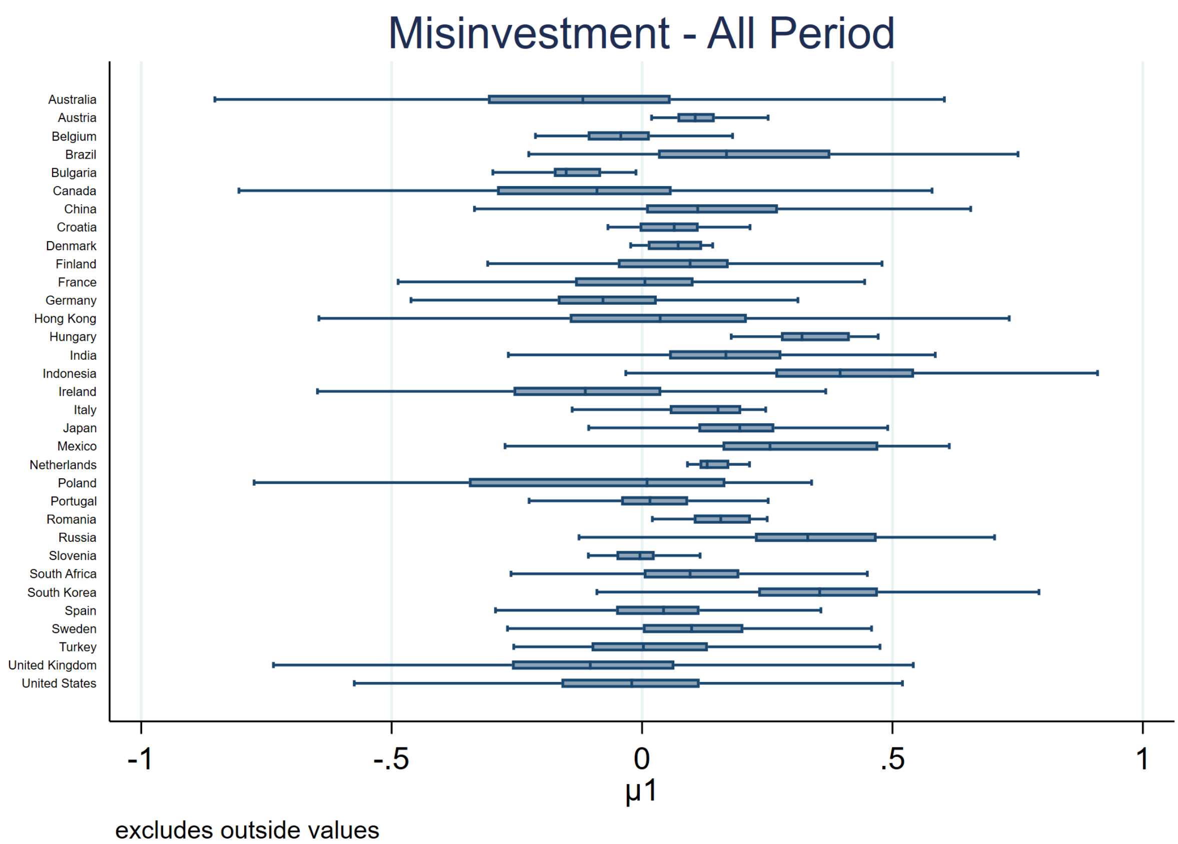

Figure 2: Misinvestment ($\mu^{1,1}$) by Country, Full Period

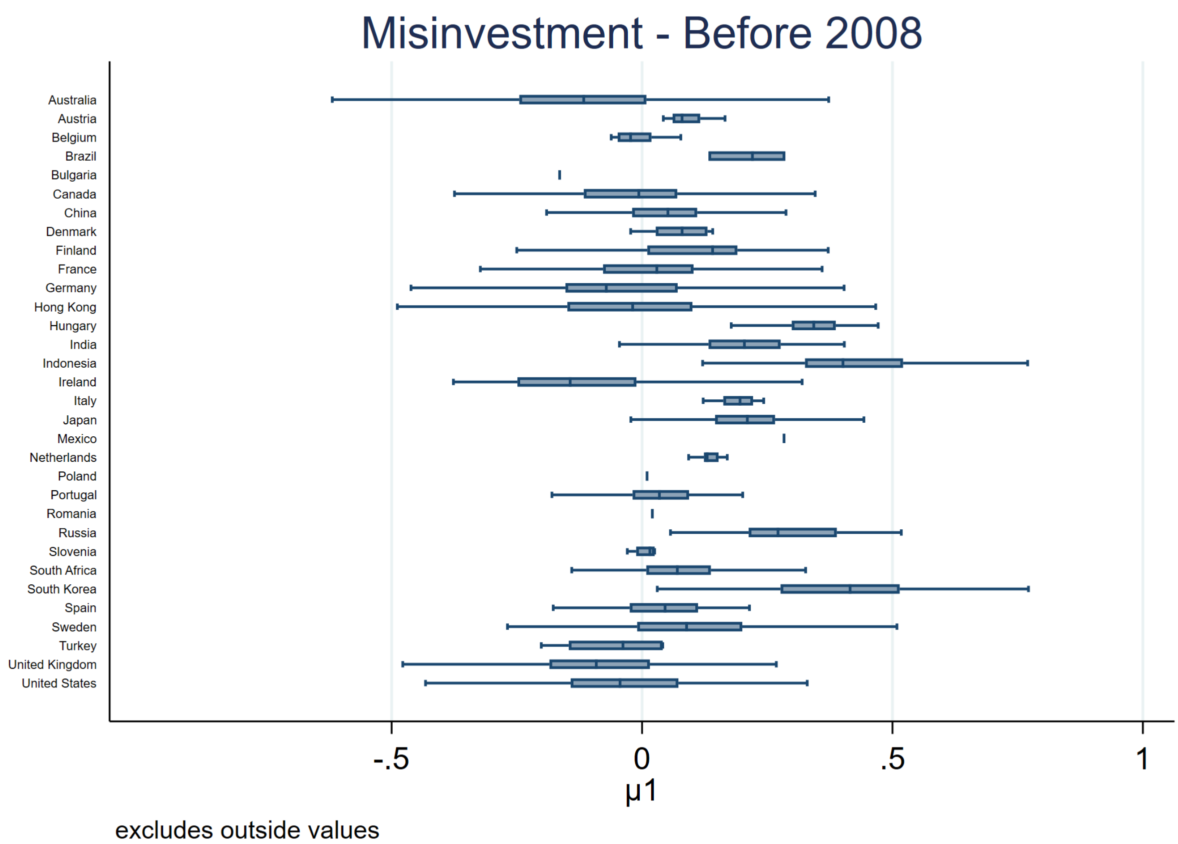

Figure 3: Misinvestment ($\mu^{1,1}$) by Country, Before 2008

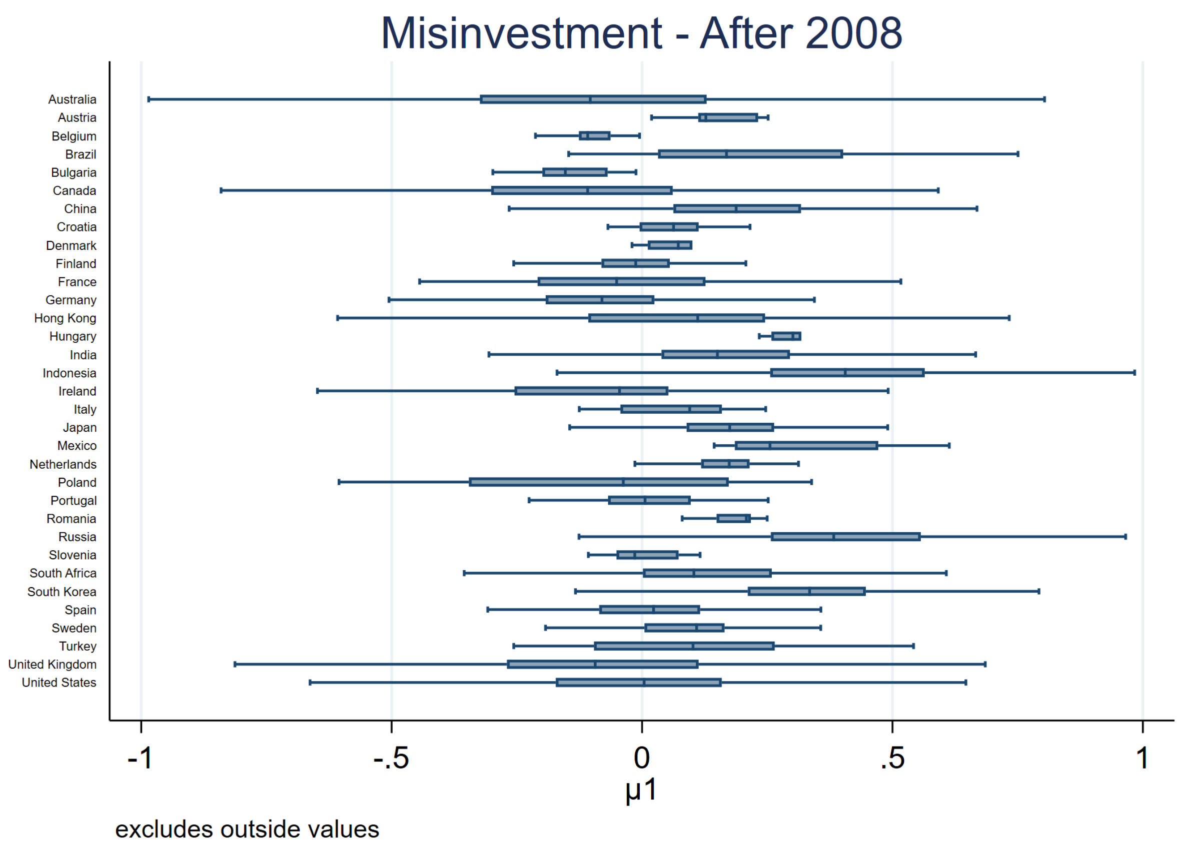

Figure 4: Misinvestment ($\mu^{1,1}$) by Country, After 2008

8. Appendix: Tables

Table 1: Coverage of Sectors

No	Sector	Number of Companies	Number of Observations
1	Alternative Energy	40	496
2	Forestry and Paper	86	1,453
3	Mining	314	4,043
4	Oil and Gas Producers	144	1,992
	Total	584	7,984

Table 2: Result of Supremum Wald Test for Structural Break of the GSCI Index

Number of observations	12,839
Full sample	02-Jan-1970 to 20-Mar-2019
Trimmed sample	23-May-1977 to 02-Nov-2011
Estimated break date	*07-Jul-2008*

H_0: *No Structural Break*

Test	Statistic	p-value
Supremum Wald	110.4044	0.0000

Table 3: Descriptive Statistics

Variables	Transformation	Obs	Mean	Std. Dev.	Min	Max	Source
$INVT$	$\frac{Capital_t - Capital_{t-1}}{Asset_t}$	7,984	0.0506	0.3335	-2.6053	2.4341	Worldscope
ROA	Operating Income / Average of Assets	7,984	0.0075	0.1535	-0.9193	0.7114	Worldscope
V/A	Market Capitalization / Average of Assets	7,984	1.0509	1.0823	0.0059	7.7618	Worldscope
V/P	Equity / Market Capitalization	7,984	1.0313	1.0050	-3.6183	7.7908	Worldscope
LEV	Total Liabilities / Total Assets	7,984	0.1946	0.2094	0.0000	2.7806	Worldscope
$CASH$	Total Cash / Total Assets	7,984	0.1036	0.1469	-0.0041	1.0000	Worldscope
$SIZE$	Natural Log of Total Assets	7,984	13.7262	3.9067	2.3026	25.3637	Worldscope
$RTRN$	Growth of Market Capitalization (%)	7,984	0.3321	1.1544	-0.9706	12.0027	Worldscope
AGE	Age - No Transformation	7,984	16.2885	9.7335	2.0000	53.0000	Worldscope
$\sigma COMM$	Natural Log of Std Dev of Goldman Sachs Commodity Index	7,984	5.7327	0.7265	3.8070	7.5786	Datastream
$\Delta COMM$	Difference of Natural Log of Goldman Sachs Commodity Index	7,984	-0.6783	22.2911	-48.2286	50.9073	Datastream
$WGDP$	Annual Growth of the World Economy	7,984	2.7784	1.4585	-1.6866	4.6170	World Bank
$HGDP$	Annual Growth of the Home Country GDP	7,978	2.8112	2.6313	-8.2690	25.1173	World Bank
$INFL$	Percentage - No Transformation	7,984	2.6448	2.2583	-4.4781	14.1108	World Bank
$GEOPOL$	Geopolitical Risk (Global) - Natural Log Transformed	7,984	4.3889	0.3805	3.5000	5.3152	Caldara and Iacoviello (2018)
$GEPU$	Economic Policy Uncertainty (Global) - Natural Log Transformed	7,498	4.7209	0.3086	4.1356	5.2376	Davis (2016)
WGI	Worldwide Governance Index (Country) - Inverted	7,570	-1.1783	0.6742	-1.9700	0.9100	World Bank

Note: Total *capital* (World Scope WC03998) represents total investment in the company; which is calculated as the sum of common equity, preferred stock, minority interest, long-term debt, non-equity reserves and deferred tax liability in untaxed reserves.

Table 4: Correlation Between Variables

Variables		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1)	$INVT$	1																
(2)	ROA	0.1793	1															
(3)	V/A	0.312	0.0107	1														
(4)	V/P	-0.0862	-0.0363	-0.392	1													
(5)	LEV	-0.0676	0.1208	-0.2259	-0.0418	1												
(6)	$CASH$	0.0316	-0.1966	0.1232	-0.1576	-0.1945	1											
(7)	$SIZE$	0.0752	0.4904	-0.0696	0.0874	0.3898	-0.2989	1										
(8)	$RTRN$	0.2277	-0.0072	0.2424	-0.2599	-0.0678	0.1522	-0.0728	1									
(9)	AGE	-0.0255	0.1767	0.0618	0.0111	0.1255	-0.1196	0.2579	-0.0905	1								
(10)	$\sigma COMM$	0.0762	-0.0186	-0.0332	-0.0462	-0.0588	0.0476	-0.0582	-0.0213	-0.1721	1							
(11)	$\Delta COMM$	0.0903	0.0656	-0.0165	-0.0811	-0.0292	0.0145	-0.0097	-0.0206	-0.0895	0.2408	1						
(12)	$WGDP$	0.0693	0.0291	0.0413	-0.0908	0.003	0.0231	0.0166	0.0532	0.013	-0.0699	0.6095	1					
(13)	$HGDP$	0.0342	0.1036	-0.0079	-0.0287	0.0771	-0.0309	0.1981	0.0073	-0.113	-0.0091	0.3057	0.4701	1				
(14)	$INFL$	0.0744	0.1599	-0.0031	0.0421	0.0581	-0.082	0.2493	0.0021	-0.117	0.2	0.2194	0.075	0.3082	1			
(15)	$GEOPOL$	-0.063	-0.0089	-0.0628	0.0376	0.0593	0.0022	0.0015	0.0108	0.1089	-0.1941	-0.0849	0.1216	0.0678	-0.1107	1		
(16)	$GEPU$	-0.0294	0.0068	0.1001	0.1374	0.0312	-0.0369	0.0366	-0.1055	0.1862	-0.5067	-0.1952	-0.2689	-0.1707	-0.0369	0.1121	1	
(17)	WGI	0.0226	0.2745	-0.0716	0.04	0.2493	-0.1515	0.5847	-0.0115	-0.0763	-0.0056	-0.0097	-0.0091	0.4529	0.581	0.0002	0.0177	1

Table 5: Overinvestment - Full Period

Dependent Variable = $INVT_t$

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$INVT_{t-1}$	-0.0552***	-0.0883	-0.0512**	0.0344	-0.2090**	-0.0816***	0.0234
V/P_{t-1}	-0.0778***	-0.0424***	-0.0928***	-0.0967***	-0.0279***	-0.0947***	-0.0903***
LEV_{t-1}	-0.0445	-0.0143	-0.0511	-0.2451	0.0026	-0.0717	0.0067
$CASH_{t-1}$	0.0379	0.1588	0.0135	-0.0912	0.4468**	0.0622	-0.0949
$SIZE_{t-1}$	-0.0426***	-0.0696***	-0.0431***	-0.1286***	-0.0322	-0.0358***	-0.0608***
$RTRN_{t-1}$	0.0205***	0.0282***	0.0162***	0.0121	0.0377***	0.0084	0.0341***
AGE_{t-1}	0.0031**	0.0013	0.0046**	-0.0476	-0.0012	0.003	0.0077***
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	0.6368***	1.0863***	0.6206***	2.6002**	0.5515*	0.5598***	0.8143***
Observations	7,984	1,949	6,035	496	1,453	4,043	1,992
R^2	0.0952	0.1099	0.1053	0.2383	0.1148	0.1171	0.1155

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 6: Overinvestment - Before 2008

Dependent Variable = $INVT_t$

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$INVT_{t-1}$	-0.0992	-0.0475	-0.1186	-0.1814	-0.025	-0.2830***	0.2378
V/P_{t-1}	-0.0487***	-0.0373**	-0.0548***	-0.1120**	-0.0242*	-0.0278**	-0.1315**
LEV_{t-1}	0.0908	0.0916	0.1157	-0.0215	0.0298	-0.0101	0.3333*
$CASH_{t-1}$	0.0016	0.1327	-0.0156	0.1675	0.1087	-0.0079	-0.0431
$SIZE_{t-1}$	-0.0313**	-0.0552***	-0.0406**	-0.076	-0.0431***	-0.0366*	-0.0519*
$RTRN_{t-1}$	0.0153**	0.0067	0.0165*	-0.0237	0.0234	0.0190*	0.0161
AGE_{t-1}	0.0064***	0.0016	0.0102***	0.047	-0.0001	0.0132***	0.0063**
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	0.4854***	0.8779***	0.5575**	0.7624	0.7167***	0.4722*	0.7623**
Observations	2,803	839	1,964	151	688	1,260	704
R^2	0.0913	0.1027	0.1147	0.3446	0.1092	0.1346	0.2471

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 7: Overinvestment - After 2008

Dependent Variable = $INVT_t$

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$INVT_{t-1}$	-0.0568**	-0.1569*	-0.0470*	0.0506	-0.2718***	-0.0758***	0.0192
V/P_{t-1}	-0.0804***	-0.0393***	-0.0971***	-0.0762***	-0.0204*	-0.1027***	-0.0843***
LEV_{t-1}	-0.1102**	-0.1109	-0.1284**	-0.3028*	0.0487	-0.1190**	-0.1562
$CASH_{t-1}$	0.0572	0.2199	0.0342	-0.0021	0.6969*	0.1218	-0.1802
$SIZE_{t-1}$	-0.1322***	-0.1756***	-0.1273***	-0.1567***	-0.2119***	-0.1114***	-0.1662***
$RTRN_{t-1}$	0.0112	0.0329**	0.0037	0.0176	0.0434*	-0.0073	0.0257
AGE_{t-1}	0.0068**	-0.0067	0.0122***	-0.0052	-0.0034	0.0154***	0.0081
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	1.8001***	2.9475***	1.5882***	2.2834***	3.5972***	1.2722***	2.3657***
$Observations$	4,679	1,000	3,679	311	689	2,513	1,166
R^2	0.1276	0.1519	0.1362	0.1834	0.2025	0.1524	0.137

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 8: Chow Test of Parameter Estimates in Table 6 and Table 7

$F-Test$

	Hypothesis	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
	Joint $H0$	F(8, 6427) 5.95***	F(8, 1586) 2.73***	F(8, 4800) 8.02***	F(8, 361) 3.68***	F(8, 1186) 1.99***	F(8, 3180) 7.68***	F(8, 1579) 3.86***
Separate $H0$	$INVT_{t-1,b2008} = INVT_{t-1,a2008}$	0.44	0.97	0.70	3.24*	2.77*	5.28**	2.06
	$V/P_{t-1,b2008} = V/P_{t-1,a2008}$	5.58**	0.01	4.26**	0.46	0.06	18.28***	0.81
	$LEV_{t-1,b2008} = LEV_{t-1,a2008}$	5.05**	1.29	4.90**	1.38	0.01	1.54	4.12**
	$CASH_{t-1,b2008} = CASH_{t-1,a2008}$	0.34	0.21	0.23	0.25	2.19	1.16	0.56
	$SIZE_{t-1,b2008} = SIZE_{t-1,a2008}$	24.75***	5.18**	14.00***	1.45	3.34*	8.13***	7.27***
	$RTRN_{t-1,b2008} = RTRN_{t-1,a2008}$	0.17	2.61	1.23	3.23*	0.63	3.9**	0.23
	$AGE_{t-1,b2008} = AGE_{t-1,a2008}$	1.46	3.08*	0.29	4.06**	2.59	1.04	3.79*
	$Cons_{b2008} = Cons_{a2008}$	0.81	0.00	0.70	3.77*	0.02	1.26	6.65**

Note: This table presents F value of joint and separate Chow test for coefficients from each estimation in Table 6 compared to its counterpart in Table 7. The subscript $b2008$ refers to before 2008 period, meanwhile $a2008$ refers to after 2008 period. The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 9: The 21 Misinvestment Variables

$\mu^{m,n}$	Full Sample (1)	Renewable (2)	Non-Renewable (3)	Alternative Energy (4)	Forestry and Paper (5)	Mining (6)	Oil and Gas (7)
(1) Full Period	$\mu^{1,1}$	$\mu^{1,2}$	$\mu^{1,3}$	$\mu^{1,4}$	$\mu^{1,5}$	$\mu^{1,6}$	$\mu^{1,7}$
(2) Before 2008	$\mu^{2,1}$	$\mu^{2,2}$	$\mu^{2,3}$	$\mu^{2,4}$	$\mu^{2,5}$	$\mu^{2,6}$	$\mu^{2,7}$
(3) After 2008	$\mu^{3,1}$	$\mu^{3,2}$	$\mu^{3,3}$	$\mu^{3,4}$	$\mu^{3,5}$	$\mu^{3,6}$	$\mu^{3,7}$

Note: Each μ represents misinvestment (residuals) from one investment panel analysis. It is indexed as $\mu^{m,n}$ where $m = 1, ..., 3$ refers to period and $n = 1, ..., 7$ refers to sample set.

Table 10: Overinvestment by Sector

Sectors	Full Period					Before 2008					After 2008				
	Mean	St Dev	Observations			Mean	St Dev	Observations			Mean	St Dev	Observations		
	$\mu^{1,1}$	$\mu^{1,1}$	Under	Over	Total	$\mu^{1,1}$	$\mu^{1,1}$	Under	Over	Total	$\mu^{1,1}$	$\mu^{1,1}$	Under	Over	Total
Alternative Energy	-0.06	0.31	281	215	496	-0.05	0.29	81	70	151	-0.07	0.30	183	128	311
Forestry and Paper	0.14	0.27	383	1070	1453	0.14	0.22	179	509	688	0.15	0.31	178	511	689
Mining	-0.05	0.40	2294	1749	4043	-0.03	0.27	724	536	1260	-0.06	0.45	1400	1113	2513
Oil and Gas Producers	0.02	0.35	921	1071	1992	0.02	0.24	329	375	704	0.01	0.40	537	629	1166
Total	0.00	0.37	3879	4105	7984	0.02	0.26	1313	1490	2803	-0.01	0.42	2298	2381	4679

Note: All numbers are based on variable $\mu^{1,1}$, which represents residuals from 'full sample - full period' overinvestment regression from the equation (1). The degree of over- and underinvestment analysis is classified into three categories in this table, based on mean value:

$$Degree\ of\ misinvestment = \begin{cases} overinvestment & if \quad mean \geq 0.05 \quad \rightarrow \quad dark\ gray\ shade \\ neutral & if \quad -0.05 < mean < 0.05 \quad \rightarrow \quad white\ shade \\ underinvestment & if \quad mean \leq -0.05 \quad \rightarrow \quad light\ gray\ shade \end{cases}$$

Table 11: Overinvestment by Sector

No	Country	Full Period					Before 2008					After 2008				
		Mean	St Dev	Observations			Mean	St Dev	Observations			Mean	St Dev	Observations		
		$\mu^{1,1}$	$\mu^{1,1}$	Under	Over	Total	$\mu^{1,1}$	$\mu^{1,1}$	Under	Over	Total	$\mu^{1,1}$	$\mu^{1,1}$	Under	Over	Total
1	Australia	-0.13	0.42	1190	574	1764	-0.11	0.29	467	171	638	-0.14	0.48	646	362	1008
2	Austria	0.12	0.07	0	29	29	0.11	0.07	0	19	19	0.15	0.08	0	9	9
3	Belgium	-0.03	0.09	18	9	27	-0.01	0.07	9	8	17	-0.08	0.11	8	1	9
4	Brazil	0.21	0.25	6	27	33	0.21	0.08	0	3	3	0.23	0.26	5	22	27
5	Bulgaria	-0.10	0.16	19	2	21	-0.16	0.00	1	0	1	-0.10	0.17	16	2	18
6	Canada	-0.12	0.41	828	434	1262	-0.02	0.26	148	125	273	-0.14	0.44	615	283	898
7	China	0.14	0.21	57	194	251	0.05	0.10	21	43	64	0.19	0.23	28	143	171
8	Croatia	0.06	0.09	3	7	10	0.00	0.00	0	0	0	0.06	0.09	3	6	9
9	Denmark	0.11	0.14	2	16	18	0.09	0.10	1	7	8	0.12	0.18	1	8	9
10	Finland	0.08	0.25	29	47	76	0.14	0.27	12	39	51	-0.03	0.13	14	7	21
11	France	-0.01	0.20	98	102	200	0.02	0.15	46	66	112	-0.03	0.24	46	34	80
12	Germany	-0.07	0.24	113	52	165	-0.04	0.22	42	20	62	-0.08	0.24	64	29	93
13	Hong Kong	0.05	0.39	199	245	444	-0.01	0.22	85	66	151	0.08	0.46	100	166	266
14	Hungary	0.34	0.11	0	18	18	0.34	0.09	0	8	8	0.34	0.14	0	9	9
15	India	0.17	0.24	45	260	305	0.21	0.11	3	68	71	0.15	0.27	38	172	210
16	Indonesia	0.43	0.28	5	207	212	0.45	0.22	0	62	62	0.42	0.31	5	131	136
17	Ireland	-0.10	0.22	64	28	92	-0.12	0.17	28	9	37	-0.07	0.25	31	18	49
18	Italy	0.11	0.11	7	24	31	0.19	0.04	0	11	11	0.07	0.11	6	12	18
19	Japan	0.19	0.13	29	418	447	0.20	0.11	11	247	258	0.17	0.14	16	155	171
20	Mexico	0.31	0.32	1	10	11	0.28	0.00	0	1	1	0.37	0.29	0	9	9
21	Netherlands	0.15	0.09	1	22	23	0.13	0.05	0	13	13	0.18	0.13	1	8	9
22	Poland	-0.10	0.31	10	11	21	0.01	0.00	0	1	1	-0.07	0.29	9	9	18
23	Portugal	0.03	0.14	32	44	76	0.05	0.14	13	20	33	0.02	0.14	17	21	38
24	Romania	0.16	0.07	0	11	11	0.02	0.00	0	1	1	0.18	0.06	0	9	9
25	Russia	0.35	0.23	3	79	82	0.27	0.15	1	25	26	0.41	0.26	1	47	48
26	Slovenia	0.00	0.07	7	7	14	0.01	0.03	1	3	4	0.00	0.08	5	4	9
27	South Africa	0.10	0.22	62	196	258	0.09	0.18	21	76	97	0.10	0.23	36	109	145
28	South Korea	0.35	0.19	13	258	271	0.40	0.17	1	101	102	0.32	0.20	11	142	153
29	Spain	0.04	0.20	54	80	134	0.05	0.12	23	44	67	0.02	0.26	28	33	61
30	Sweden	0.11	0.18	32	100	132	0.11	0.16	19	53	72	0.10	0.20	13	41	54
31	Turkey	0.04	0.22	19	20	39	-0.02	0.17	5	4	9	0.09	0.22	11	16	27
32	United Kingdom	-0.09	0.37	616	320	936	-0.09	0.21	203	85	288	-0.08	0.43	374	216	590
33	United States	-0.03	0.31	317	254	571	-0.04	0.25	152	91	243	-0.03	0.35	150	148	298
	Total	0.00	0.37	3879	4105	7984	0.02	0.26	1313	1490	2803	-0.01	0.42	2298	2381	4679

Note: All numbers are based on variable $\mu^{1,1}$, which represents residuals from 'full sample - full period' overinvestment regression from the equation (1). The degree of over- and underinvestment analysis is classified into three categories in this table, based on mean value:

$$Degree\ of\ misinvestment = \begin{cases} overinvestment & if \quad mean \geq 0.05 & \rightarrow \quad dark\ gray\ shade \\ neutral & if \quad -0.05 < mean < 0.05 & \rightarrow \quad white\ shade \\ underinvestment & if \quad mean \leq -0.05 & \rightarrow \quad light\ gray\ shade \end{cases}$$

Table 12: Overinvestment and Uncertainty - Full Period

Dependent Variable = $OVIT_t$

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$OVIT_{t-1}$	0.3388***	0.6885***	0.3156***	-0.0323	0.5642***	0.3343***	0.3954***
$\sigma COMM_{t-1}$	0.0786	0.0433	0.0456	0.4344	0.0937	0.0226	0.147
$\Delta COMM_{t-1}$	0.0064*	0.0179**	0.0064*	0.0083	0.01	0.0068	-0.0044
$WGDP_{t-1}$	0.338	0.878	0.4777	-0.8165	1.1612*	0.3804	0.0001
$HGDP_{t-1}$	-0.0149	0.0560**	-0.0089	0.0031	0.0085	-0.0309*	0.0119
$GEOPOL_{t-1}$	-0.0141	0.7309**	-0.0128	1.1819*	0.2018	-0.0686	-0.3935
$GEPU_{t-1}$	0.5386*	1.5498**	0.3997	1.3496	1.9910**	0.3602	-0.2055
WGI_{t-1}	0.8904***	0.6104***	0.9410***	1.7925**	0.3770***	0.8727***	0.9980***
$INFL_{t-1}$	-0.0238	0.0123	-0.0436**	0.3560**	0.0181	-0.0438**	-0.0646*
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	-2.7564	-13.0767**	-2.1496	-10.3311	-14.2784*	-1.2782	3.0782
$Observations$	6,897	1,610	5,287	438	1,168	3,565	1,722
$McFadden's\ R^2$	0.1506	0.1786	0.1465	0.1533	0.2126	0.1520	0.1470

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 13: Overinvestment and Uncertainty - Before 2008

Dependent Variable = $OVIT_t$

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$OVIT_{t-1}$	0.6879***	0.5754*	0.6430***	2.0069***	0.6408**	1.0033***	0.2748
$\sigma COMM_{t-1}$	0.3909	-0.3509	0.1954	16.6477	-0.5418	0.3029	-0.2964
$\Delta COMM_{t-1}$	0.0006	0.0082	0.0035	0.0692	0.0048	0.0097	0.0037
$WGDP_{t-1}$	0.004	0.0068	0.0033	-3.4007	0.1949	-0.256	-0.0736
$HGDP_{t-1}$	-0.0608**	0.0237	-0.0817**	-0.1108	0.0191	-0.014	-0.1704**
$GEOPOL_{t-1}$	-0.4631**	0.2763	-0.3209	16.0973	0.2699	-0.134	0.0342
$GEPU_{t-1}$	1.3779	-0.5995	0.5795	-14.7382	-0.7712	-0.4121	-1.2599
WGI_{t-1}	0.8392***	1.3142**	1.0747***	0.2711	1.4293***	0.7440***	1.2880***
$INFL_{t-1}$	-0.001	0.0751	-0.0297	0.0673	0.0072	-0.0115	0.0279
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	-5.357	4.3038	-0.9371	-100.374	5.7512	1.8812	9.2069
$Observations$	1,859	535	1,324	110	421	856	468
$McFadden's\ R^2$	0.3462	0.3391	0.3438	0.3009	0.4118	0.3579	0.3096

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 14: Overinvestment and Uncertainty - After 2008

Dependent Variable = $OVIT_t$

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$OVIT_{t-1}$	0.5171***	2.7718***	0.4196***	0.1778	3.3716***	0.4650***	0.7655***
$\sigma COMM_{t-1}$	0.1124	-0.0303	-0.0178	-0.0943	-0.0928	-0.0342	0.0789
$\Delta COMM_{t-1}$	0.0029	0.0141*	-0.005	-0.0083	0.0016	-0.0006	-0.0086
$WGDP_{t-1}$	-0.0083	-0.2421*	0.0591	0.0619	-0.1283	-0.0109	0.0958
$HGDP_{t-1}$	0.01	0.0709**	0.0123	0.0507	0.0371	0.0519**	0.0285
$GEOPOL_{t-1}$	0.0283	0.2459	0.0054	-0.1504	0.2468	0.1472	-0.35
$GEPU_{t-1}$	0.2238	0.2202	0.1433	-0.5074	-0.7225	0.0958	0.0665
WGI_{t-1}	1.7368***	0.3155***	1.6508***	1.2086*	0.2697*	1.3869***	1.5090***
$INFL_{t-1}$	-0.0680**	-0.0869***	-0.044	0.1006	-0.0851**	-0.0105	-0.0879
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	0.215	-2.2048	1.1566	4.5333	1.9214	0.5882	1.9806
$Observations$	4,109	880	3,229	272	608	2,203	1,026
$McFadden's\ R^2$	0.1515	0.1666	0.1609	0.1065	0.3096	0.1719	0.1405

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 15: Overinvestment and Performance - Full Period

Dependent Variable = ROA_t

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$INVT_{t-1}$	-0.0163	-0.0388*	-0.0179	-0.0586	0.0001	-0.0171	-0.0289**
$OVIT_{t-1}$	0.0031	0.0089	0.0012	0.0219	0.002	-0.0017	-0.0053
$INVT_{t-1} * OVIT_{t-1}$	0.0111	0.0328	0.0178	0.0481	-0.007	0.0217	0.0376*
$INVT_{t-2}$	-0.0277***	-0.0068	-0.0277***	-0.043	-0.0062	-0.0315***	-0.0056
$OVIT_{t-2}$	0.0066	0.0018	0.0032	0.0328*	0.0019	-0.0049	0.0087
$INVT_{t-2} * OVIT_{t-2}$	0.0207	0.022	0.0222	0.0376	0.0232	0.0395**	-0.0171
$INVT_{t-3}$	-0.0350***	-0.0341	-0.0383***	-0.0414	-0.0176	-0.0436***	-0.0246
$OVIT_{t-3}$	0.0018	0.0097*	0.0024	0.004	0.0001	0.0058	-0.0024
$INVT_{t-3} * OVIT_{t-3}$	0.0373***	0.0358	0.0408***	0.0651	0.0116	0.0543***	0.0058
V/A_{t-1}	0.0071**	0.0102	0.0043	0.0102	0.0201**	0.0029	0.0063
ROA_{t-1}	0.3936***	0.3053***	0.3955***	0.2535***	0.3015***	0.3619***	0.4729***
$SIZE_{t-1}$	-0.0078**	-0.0268***	-0.0064*	-0.0587***	-0.0147	-0.0098**	0.0062
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	0.0725*	0.4247***	0.011	0.7211***	0.2732*	0.0383	-0.1102
$Observations$	6,202	1,553	4,649	376	1,177	3,089	1,560
R^2	0.1865	0.1616	0.2044	0.2281	0.1879	0.1829	0.352

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 16: Overinvestment and Performance - Before 2008

Dependent Variable = ROA_t

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$INVT_{t-1}$	0.0633*	0.0351	0.0826	-0.0993**	0.0625	0.0201	0.1050*
$OVIT_{t-1}$	0.0049	0.0063	-0.0062	0.0605**	0.0156	0.0038	-0.0224**
$INVT_{t-1} * OVIT_{t-1}$	-0.1041**	-0.0506	-0.105	0.0806	-0.1034**	-0.0802	0.0037
$INVT_{t-2}$	0.0113	0.0106	0.0189	-0.1607***	-0.0449	0.0096	0.0691
$OVIT_{t-2}$	-0.005	-0.0217	-0.0039	0.0281	-0.0091	0.0283**	0.0007
$INVT_{t-2} * OVIT_{t-2}$	0.0385	0.0371	0.0417	0.3889**	0.075	-0.0653	-0.1535
$INVT_{t-3}$	-0.0921	-0.0242	-0.1157	-0.1455**	-0.019	-0.2054	-0.0903
$OVIT_{t-3}$	0.003	-0.0103	0.0011	-0.006	0.0021	0.0161	-0.0067
$INVT_{t-3} * OVIT_{t-3}$	0.1116	0.0435	0.1305	0.3105	0.0135	0.2412	0.099
V/A_{t-1}	0.0291***	0.0536***	0.0158	0.0722***	0.0454*	0.0159	0.0196
ROA_{t-1}	0.2168*	0.1737***	0.1818	-0.1848	0.2438***	-0.0009	0.6002***
$SIZE_{t-1}$	-0.0065	-0.0417***	-0.0016	-0.0848**	-0.0365*	-0.0063	0.001
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	0.0854	0.6495***	-0.0026	0.9325*	0.5871**	0.0115	-0.0085
Observations	1,655	559	1,096	82	477	671	425
R^2	0.1943	0.2241	0.2509	0.6475	0.2253	0.1913	0.6571

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.

Table 17: Overinvestment and Performance - After 2008

Dependent Variable = ROA_t

Variables	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry and Paper	Mining	Oil and Gas
$INVT_{t-1}$	-0.0087	-0.0147	-0.0141	-0.0093	-0.0312	-0.0209	-0.0084
$OVIT_{t-1}$	-0.0146	-0.0163	-0.0102	-0.0014	0.0339*	-0.0092	-0.0173
$INVT_{t-1} * OVIT_{t-1}$	0.0167	0.0506	0.0151	0.0451	0.0348	0.021	0.0313
$INVT_{t-2}$	-0.0221**	-0.0076	-0.0284**	-0.0036	0.0079	-0.0375**	0.0132
$OVIT_{t-2}$	0.0135	0.016	0.0094	0.0373*	0.0096	-0.0016	-0.0043
$INVT_{t-2} * OVIT_{t-2}$	0.0082	0.0555	0.01	-0.0648	0.0063	0.0299	-0.0143
$INVT_{t-3}$	-0.0318***	-0.0431	-0.0299***	0.0274	-0.0199	-0.0337**	-0.0186
$OVIT_{t-3}$	0.0083	-0.0037	-0.0096	0.0295	-0.0009	-0.0069	0.0206
$INVT_{t-3} * OVIT_{t-3}$	0.0256*	0.0794*	0.0310*	-0.1346	0.0399	0.0406**	-0.0039
V/A_{t-1}	0.0049	0.0004	0.0036	-0.0088	0.0145	0.0014	0.0063
ROA_{t-1}	0.2600***	0.0832	0.2701***	0.0187	0.1359	0.2459***	0.3104***
$SIZE_{t-1}$	-0.0353***	-0.0664***	-0.0304***	-0.0843***	-0.0233	-0.0296***	-0.0298**
$YRID$	YES	YES	YES	YES	YES	YES	YES
$FRID$	YES	YES	YES	YES	YES	YES	YES
$Cons$	0.4875***	1.0498***	0.4154***	1.0604***	0.4012	0.3774***	0.4646***
Observations	2,993	649	2,344	199	450	1,593	751
R^2	0.1344	0.1388	0.1456	0.249	0.1232	0.1356	0.3096

Note: The significance level is shown by ***, **, *, to denote respectively 1%, 5%, and 10% significance level.