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

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Abstract

This paper examines the tendency of resource firms to overinvest induced by the business cycle and by uncertainties. The analysis is conducted using unbalanced panel data of 596 resource companies in 32 countries between 1986 and 2017 in four resource sectors: (1) alternative energy, (2) forestry and paper, (3) mining and (4) oil and gas producers. Our results suggest that 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 business cycle significantly affects overinvestment with an alternating sign from negative to positive before and after the global financial crisis. In addition, there is a significant positive relationship between global economic and country-level governance policy uncertainties and overinvestment. Lastly, our results suggest that the joint effect of investment and overinvestment are positive for firms' future performance, especially for firms in the mining sector.

Keywords: Overinvestment, Business Cycle, Uncertainty

JEL Codes: G30, E32, G32

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1. Introduction

Investment is an inherent part of business activities. By conducting investments, firms grow their capacities to be able to produce more output; however, in economics, the general notion of optimality, which also applies in terms of investments by firms, is considered. The question is what if firms invest more than they should? Richardson (2006) defines this phenomenon as overinvestment. He proposes a relative measure by assessing the degree of the over- and underinvestment of firms using residuals from firms' investment functions. It is highly instructive to identify the sectors and countries that tend to overinvest as well as the possible causes of overinvestment. One of the aims of this paper is to do so for resource companies from 32 countries in the G20 area.

Another interesting issue related to overinvestment is to assess its effects on a firm's performance. From the macroeconomic point of view, the overinvestment phenomenon could have both positive and negative effects. When the business cycle is at the booming phase, the general price would increase and thus induce firms to invest more to increase their production capacities. At a massive scale, this would expand aggregate overinvestment in the economy, which then would further boost the economy at least in the short-term; however, the overinvestments would consume the demand well ahead of time and would eventually deteriorate the economy in the long-term. From the microeconomic point of view, an overinvestment by firms could also have both side effects. For example, Henriques and Sadorsky (2011) and Chevalier-Roignant et al. (2011) suggest that increasing investment, which could be characterized as overinvestment, is an optimal strategy for firms under high uncertainty, indicating that the overinvestment could improve a firm's performance. On the other hand, Fu (2010), Liu and Bredin (2010), and Ling et al. (2016) document that an overinvestment has a significant negative impact on the future performance of firms. Therefore, it is meaningful to empirically assess the effects of overinvestment on firms' performance. This paper explores the question for resource companies across major countries.

In 2017, the total natural resource exports from the sample countries accounted for 1,566.43 billion USD (Figure 1). 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.

[**Figure 1**]

Furthermore, **Figure 2** outlines the critical role of natural resource exports as the driver of 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.

[**Figure 2**]

The study contributes to the literature by providing a comprehensive empirical observation of the overinvestment behaviour and its relation with business cycles and uncertainties of resource companies from 32 countries in the G20 area. To this end, three analyses are conducted to clarify the characteristics of overinvestment and the effects of overinvestment on the performance of firms. More specifically, first, the overinvestment and underinvestment behaviours for each firm in the sample in each period are identified using the framework developed by Richardson (2006). Second, whether the business cycle and uncertainties play a significant role in explaining the overinvestment and underinvestment behaviours of firms is examined. Third, the effects of overinvestment on the firms' future performance is assessed.

In this study, the business cycle is considered one of the possible sources of overinvestments. A dual business cycle approach is employed, representing the business cycle both with the world business cycle and the home-country business cycle. The dual business cycle approach is effective in capturing the overall effect of the business cycle fluctuation toward companies' overinvestment behaviour. In addition, the commodity price uncertainty, global geopolitical uncertainty, and global economic policy uncertainty are considered to examine the relationship between overinvestments and uncertainties. Furthermore, a worldwide governance indicator is adopted as a proxy of the country level uncertainty.

There are several significant findings from this study. The first analysis indicates that internal firm factors play a significant role in determining firms' investment decision making, and the global financial crisis in 2008 had a significant impact on the overinvestment pattern for many countries. The second analysis shows that commodity price inflation plays a more important role in inducing firms' overinvestment than commodity price uncertainty. The home country business cycle also significantly affects overinvestment with an alternating sign from negative to positive before and after the global financial crisis, although the world business cycle has no significant relationship with overinvestment. In addition, the results suggest no significant relationship between the global geopolitical risk and overinvestment, but there is a significant positive relationship between global economic and country-level governance policy uncertainties and overinvestment. Lastly, the third analysis demonstrates that the joint effect of investment and overinvestment are positive for firms' future performance, especially for firms in the mining sector. This finding supports theoretical predictions from Henriques and Sadorsky (2011) and Chevalier-Roignant et al. (2011), who suggest that overinvesting might be an optimal strategy for firms under uncertainty.

The remainder of the paper is structured as follows. Section 2 reviews the existing literature for theoretical backgrounds related to overinvestment and the empirical literature discussing the measurement of overinvestment, its relation to uncertainties, and its relation to firms' performance. Section 3 explains the dataset, while Section 4 explains the methodologies used for this study. Section 5 presents the empirical results and discussion, especially related to the findings with current blocks of literature. Section 6 concludes the paper.

2. Literature Review

The analysis is motivated by the theoretical predictions in the works of Kydland and Prescott (1982) and Long and Plosser (1983). These works indicate the importance of timing in making an investment, which may lead to misinvestment, in the form of over- and underinvestment. Furthermore, the study is also motivated by theoretical models that outline the significant role of uncertainties in inducing misinvestment behaviours. A theoretical overview is provided, which plays a role as the paper's conceptual framework as described in section 2.1. Several works defining the concept and measurements of overinvestment are also discussed in section 2.2, while previous empirical works attempting to explain the significant role of uncertainties in stimulating over- and underinvestment are reviewed in section 2.3. Finally, in section 2.4., previous empirical works analysing the relationship of overinvestment with the future performance of firms are summarized.

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. Aligned with this, 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 would be considerably determined by the current preference at the time; however, as the investment requires more than one period to be completed, there is a possibility of changes in preference at the time when the investment is completed. Thus, there will be a mismatch. The possibility of a preference changing over time becomes the source of uncertainty. As the preference itself is associated with the business cycle, it could then be argued that the business cycle can be perceived as a form of uncertainty.

Investment decision making by firms has been a central topic in economics and finance literature. Fazzari et al. (1988) are one of the first to document how financial factors become a significant determinant of firm investment decision making. They emphasize the importance of financial constraint using their model proxied with a dividend payout ratio in determining the investment behaviour of the firm. In line with this, Jensen (1986) and Stulz (1990) argue that there is a significant conflict of interest between shareholders and corporate managers in investment decision making. Shareholders may prefer to receive a higher dividend payout, while managers would prefer to use the free cash flow to make more investments for the firm because this would give managers more control and incentives. This agency problem between shareholders and managers would result in overinvestment when free cash flow within the firm is high and underinvestment when free cash flow is low.

Furthermore, Bebchuk and Stole (1993) discuss how uncertainty—in the form of imperfect information and short-term managerial objectives—may boost the overinvestment (or underinvestment) tendency for firms. Their model predicts that when the market observes the number of opportunities for investment but does not have complete information regarding productivity, overinvestment occurs. When the market does not have complete information regarding the number of opportunities for investment, underinvestment occurs. Lorenzoni (2008) presents a theoretical model of how uncertainty may cause an inefficient credit boom,[1] and he outlines the importance of financial frictions in the form of revenue shocks, which may cause a firm to make inefficient investments and thus inefficient leverage decisions.

Glover and Levine (2015) document dual theoretical predictions of how uncertainty can affect firms' investments. On the one hand, uncertainty may increase investment due to the positive and convex relationship between cost and profit, which can be accompanied by the presence of reversibility in investments. This condition causes higher uncertainty and increases the marginal utility of capital and thus investments. On the other hand, some theoretical models predict a negative relationship between uncertainty and overinvestment. The basis of this prediction is the presence of irreversibility, which may cause firms to delay investments when uncertainty is high. 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.

[1] Lorenzoni (2008) refers to an inefficient credit boom as the presence of externality arising from the combination of the limited commitment of financial contracts and the asset pricing mechanism, which is based on the spot market.

2.2. Overinvestment: Concept and Measurement

The attempt to explain firm investment behaviours can be traced to the work of Fazzari et al. (1988), which outlines 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 firms and thus have more tendency to overinvest. Their model is also supported by empirical evidence, where they observe that firms with a low payout ratio have higher investment-cashflow sensitivity. The logic behind this is aligned with the agency problem concept discussed by Jensen (1986) and Stulz (1990), where managers of firms tend to have more power by having more investments under their control rather than by distributing the cash as dividends to shareholders. The work of 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), with 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 activities conducted by a firm in an amount that exceeds the level the firm should invest given its ability to invest and the availability of opportunity. This definition can be identified as 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 term *overinvestment* refers to the residual of the regression representing a firm's investment function in which the positive value represents overinvestment, while the negative value represents underinvestment. Richardson (2006) employs this framework to examine the overinvestment phenomenon with 58,053 firm-year observations from the US Compustat companies' data for non-financial firms in the period of 1988-2002. The result shows that the average firms overinvest 20% of its available free cash flow; however, Bergtresser (2006) criticizes this framework as the framework is based on the residual of the model, which results in a zero-mean characteristic and balanced observations of overinvestment and underinvestment. Nevertheless, this framework is still among the most popular measures because it is straightforward and easy to compute as it only requires balance sheet information. This framework is adopted for this study for these reasons. Furthermore, this framework is adopted by other studies, such as Wei et al. (2019), Guariglia and Yang (2016), and Zhang and Su (2015).

Some literature suggests the use of Tobin's Q index as a proxy of firm investment opportunity. This attempt is introduced by Lang et al. (1991) and is implemented in other studies, such as Degryse and

De Jong (2006) and Pellicani and Kalatzis (2019). In this paper, investment opportunity is represented by a ratio of the book-to-market value of equity, which resembles the Tobin's Q index.

2.3. Overinvestment and Uncertainty

Many studies have contributed to the literature regarding how uncertainty plays a vital role in explaining the tendency of overinvestment. These studies can be divided into two groups. First, there are internal firm uncertainty factors. Chakraborty et al. (1999) show that CEO income uncertainty lowers the tendency of overinvestment. They argue that because CEO compensation is tied to firm performance, the CEO will be cautious in taking a risk, which results in less capital investment. This framework provides a slightly different insight with the model presented by Jensen (1986) and Stulz (1990), where the agency problem would instead lead to the overinvestment phenomenon; however, Chakraborty et al.'s (1999) model is still a good reference to determine how the internal firm uncertainty factor could affect the investment behaviour of a firm.

Second, there are external firm uncertainty factors. Proost and van der Lo (2010) develop a theoretical model to identify the role of demand uncertainty in overinvestment and underinvestment for the 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 under high uncertainty circumstances. Chevalier-Roignant et al. (2011) develop a model of strategic investment under high uncertainty and competition. Their model indicates that an overinvesting action would be favourable under many conditions—even under increased volatility. This logic is based on their observation that the net effect of uncertainty is ambiguous. Another model by Heikkinen and Pietola (2009) suggests that uncertainty would increase the tendency of overinvestment. Wang et al. (2016) conduct an empirical examination of how inflation uncertainty could lower the tendency of overinvestment. Liu (2013) identifies the vital role of policy uncertainty, which contributes to overinvestment in wind power capacity in China. Meanwhile, Ahuja and Novelli (2017) argue that increased uncertainty would lead to research and development (R&D) overinvestment within a firm due to the complexity of investment decision making, especially in large companies with many divisions.

Another study by Yoon and Ratti (2011) shows that energy price has a vital role in determining firm investment stability. Drakos and Goulas (2006) outline the positive response of investment toward uncertainty. In contrast, Acharya and Sadath (2016) and Caballero (1991) document a negative relationship between energy price uncertainty and firms' investments. Meanwhile, Ma (2016) argues there is no significant effect between GDP uncertainty on investment. Ghosal and Loungani (1999) and Gulen and Ion (2016) also report a negative investment-uncertainty relationship.

Based on the literature, it could be argued that the relationship between uncertainty and investment is indeterminate, although some theoretical models, such as in Henriques and Sadorsky (2011) and Chevalier-Roignant et al. (2011), suggest that overinvestment might be an optimal strategy for firms under uncertainty. This study thus contributes to this strand of literature by providing an empirical examination of how economic and non-economic uncertainties affect resource companies' tendency to overinvest.

2.4. Overinvestment and Performance

There are also several studies investigating the relationship between overinvestment and firms' performance. For example, Henriques and Sadorsky (2011) and Chevalier-Roignant et al. (2011) demonstrate a U-shaped relationship between uncertainty and firms' optimal investments, suggesting that under high uncertainty, increasing investments, which could be characterized as overinvestment, might improve firms' performance. On the other hand, Fu (2010) examines a relationship between overinvestment and the operating performance of seasoned equity offering companies (SEOs) and shows that overinvestment has a strong influence in explaining firms' poor performance in the future. Aligned with this, Liu and Bredin (2010) investigate the role of institutional investors in inducing overinvestment by firms and how overinvestment might affect corporate performance. They report a significant negative relation between overinvestment and corporate performance. Moreover, Ling et al. (2016) examine the relationship between political connections and overinvestment as well as how both factors influence firm performance. They document that firms with political connections have a higher tendency to overinvest, and this condition would lower firms' performance. Based on the literature, it could be argued that overinvestment has a negative 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. The proxy of investment is calculated as the difference of total capital divided by the average of total assets, following the framework from Richardson (2006). The analysis is comprised of a total of 8,165 firm-year observations from 596 natural resource companies from 32 countries in the G20 area.[2] The dataset is unbalanced with a time period span for 32 years during the 1986-2017 period. The dataset is limited to companies with at least 10 years of observations without a gap. The 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,[3] (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 the mining and oil and gas producer companies.

On the one hand, conducting an analysis in a cross-country context makes the dataset prone to the cross-country heteroscedasticity problem. On the other hand, one of the main characteristics of resource companies is to have operations across countries to expand and to pursue the location of the resources. This notion particularly applies to the non-renewable companies, which dominate the dataset. Therefore, the analysis is conducted in a cross-country setting with country-level macroeconomic variables as the control.

The balance sheet data of the sample companies are acquired from Worldscope Datastream. There are seven main variables employed in this study: (1) total assets – WC02999, (2) total capital – WC03998,[4] (3) total shareholders' equity – WC03995, (4) total debt – WC03255, (5) cash – WC02003,

[2] There is a total of more than 20 countries in the G20 area because the European Union is counted as one member. We include observations from firms in the European Union area to accommodate this. Hong Kong (special administrative region/SAR) is counted as a single market/region. Thus, our dataset is comprised of 32 countries and 1 market/region.

[3] The alternative energy sector is comprised of firms that are (1) manufacturers of renewable energy equipment, such as wind turbines and solar panels, or (2) producers of biofuels and biomass. Thus, firms in this sector are mainly manufacturing firms.

[4] More specifically, total capital represents the 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) market capitalization – WC08001, and (7) operating income – WC01250. The age of companies is proxied by the current year subtracted by the first year of the data available from the Worldscope database. The data are in annual frequency, primarily based on the end of the year balance sheet position. All companies are publicly listed companies 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 of which the firm is listed. Most firm-level variables are normalized with the average of the total assets or are transformed into a logarithmic scale.

The dataset is also comprised of macroeconomic data, both at the world level and the country level. 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. Furthermore, GSCI is based on future contracts, which represent market expectation at the current time toward future conditions. The index is in daily frequency, and the annual average of the daily data is used as the proxy of the commodity price cycle. The index also plays a role as the proxy of price uncertainty. For this purpose, the annual standard deviation of the daily GSCI is used. The global Geopolitical Risk index ($GEOPOL$) from Caldara and Iacoviello (2018) is also employed. The Global Economic Policy Uncertainty index ($GEPU$) from Davis (2016) is also used. A higher GEOPOL and GEPU refer to a higher uncertainty.

At the country level, GDP growth, inflation rate, and the Worldwide Governance Indicators (WGI) from the World Bank are employed. The WGI index plays a vital role as a proxy of the country level uncertainty. The average of six categories is used: (1) voice and accountability, (2) political stability and absence of violence/terrorism, (3) government effectiveness, (4) regulatory quality, (5) the rule of law, and (6) control of corruption. The WGI has a range from -2.5 to 2.5, where a higher value refers to better governance. This value is inverted by multiplying -1 so that a higher value refers to poor governance to ease the analysis.

As shown by the GSCI index, there is a strong indication of a structural break in the commodity price in 2008 (Figure 3). Based on this stylized fact, the analysis is conducted for three periods: (1) the full period, 1986-2017, (2) before 2008, including the year 1986-2007, and (3) after 2008 from 2009-2017. The year 2008 is excluded in the sub-period analysis because it is the exact year when the anomaly—and the structural break—most likely occurred.

[**Figure 3**]

It is fully acknowledged that some, if not most, companies in the observation operate in a multi-national setting. Most are export-oriented. Therefore, the home country business cycle should not be the only proxy for the business cycle. Thus, the world business cycle, represented by the world's annual GDP growth, is also employed. This dual business cycle approach is fruitful in capturing the overall effect of the business cycle fluctuation on companies' investment behaviours.

The dataset initially contained some outliers, which portrays some extreme economic phenomena, such as the Brazilian hyperinflation in the early 1990s, which could deviate the dataset's overall statistical distribution. There were also some companies with extreme balance sheet profiles, such as extreme negative equity, which may alternate the overall statistical properties of the dataset. Thus, these outliers were eliminated. The focus of the cleaning process is mostly the leverage (LEV) and inflation ($INFL$) data, as these two variables are detected to be the most prone to the outlier problem. Descriptive statistics of the final dataset and correlations between variables are outlined in Table 2 and 3.

[**Table *2***]

4. Methodology

The aim of the analysis is to provide a comprehensive examination of the overinvestment of resource firms as well as how business cycles and uncertainties play significant roles in overinvestment. To this end, three series of analyses are conducted. The aim of the first analysis is to acquire overinvestment information for each firm across the time period. The analysis is conducted with a regression of firms' investments on firm-level variables, following the design from Richardson (2006). The residuals of this investment function become the proxy of overinvestment. A positive value indicates the overinvestment phenomenon. In contrast, a negative value indicates the underinvestment phenomenon. The second analysis focuses on how to explain the overinvestment phenomenon of the companies. The way macroeconomic variables and uncertainties are able to explain the overinvestment behaviour of resource companies is analysed. The third analysis investigates how overinvestment indicates the future performance of a firm. In this analysis, the aim is to explain whether the overinvestment action taken by the companies can alter the operating performance of the companies in the future.

For each analysis, regressions are run for three sample periods, as discussed in the previous section: (1) the full period, 1986-2017, (2) before 2008, including the year 1986-2007, and (3) after 2008 from 2009-2017. Also, the analyses are conducted with the full dataset, and then the dataset is divided into the renewable and non-renewable sectors. Each of the four sectors are also analysed. Therefore, for each sample period, there are seven estimation panels: (1) full dataset, comprised of all four sample sectors, (2) renewable sectors – comprised of the alternative energy and forestry and paper sectors, (3) non-renewable sectors, comprised of the mining and oil and gas producers sectors, (4) alternative energy, (5) forestry and paper, (6) mining, and (7) oil and gas.

4.1. Overinvestment

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

$$INVT_t = \beta_0 + \beta_1 V/P_{t-1} + \beta_2 LEV_{t-1} + \beta_3 CASH_{t-1} + \beta_4 SIZE_{t-1} + \beta_5 RTRN_{t-1} + \beta_6 INVT_{t-1} + \beta_7 AGE_{t-1} + \sum YRID + \mu_t \quad (1)$$

The term $INVT$ is the investment of the firm at time t, which is calculated as $\frac{Capital_t - Capital_{t-1}}{\overline{Asset}}$, or the difference in the change in total capital divided by the average of total assets. 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 the market capitalization. The term LEV refers to 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 firms' annual return, calculated as the annual growth of firms' market capitalization. The term AGE is the age of the firm, calculated as the current year subtracted by the first year the data are available in the Worldscope database, as stated by the 'History/Hist' column in the firm's profile. The term $YRID$ refers to the year fixed effect dummy. The error term μ in this equation is a proxy of a misinvestment of a firm. The positive value of μ refers to overinvestment, while the negative value refers to underinvestment. Equation (1) is estimated using the 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, as outlined by Richardson (2006). As there is a total of 21 panels for each analysis, there are 21 time series of μ.

4.2. Overinvestment and Uncertainty

Most overinvestment studies examine how financial constraint or free cash flow can explain the tendency of overinvestment. Instead, in the second analysis of the study, the role of macroeconomic variables and uncertainties in a firm's tendency to overinvest is examined. The term misinvestment –

μ from the error term in equation (1) is transformed into a dummy of overinvestment, $OVIT$, as follows:

$$OVIT_t = \begin{cases} 1 & \text{if } \mu_t > 0 \\ 0 & \text{if } \mu_t < 0 \end{cases} \quad (2)$$

The estimation equation for the second analysis is the Probit model given as follows:

$$Prob(OVIT_t = 1) = \Phi(\beta_0 + \beta_1 OVIT_{t-1} + \beta_2 \sigma COMM_{t-1} + \beta_3 \Delta COMM_{t-1} + \beta_4 WGDP_{t-1} + \beta_5 HGDP_{t-1} + \beta_6 GEOPOL_{t-1} + \beta_7 GEPU_{t-1} + \beta_8 WGI_{t-1} + +\beta_9 INFL_{t-1} + \sum YRID) \quad (3)$$

where Φ is the cumulative distribution function of the normal distribution. The term $\sigma COMM$ is the annual standard deviation of the daily GSCI Index, which is the proxy for commodity price uncertainty. The term $WGDP$ stands for the world GDP growth, while the term $HGDP$ is the home country GDP growth. 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 is the inverted country-level Worldwide Governance Indicators. The term $INFL$ is the annual home country inflation rate. Meanwhile, the term $\sum YRID$ is year indicator. The estimation is conducted with a panel Probit model. To accommodate the firm fixed-effect, clustered error specification is used, where the firm is the cluster.

4.3. Overinvestment and Performance

In the third analysis, the influence of the overinvestment of a firm on future performance is measured. The framework from Fu (2010) is adopted for this analysis. Operating ROA is the dependent variable because this type of ROA represents income from real business activities conducted by a company—not 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 the new investment begins. The three years are used as a benchmark following Topp et al. (2008), who outline that the average construction time for mining (including oil and gas) projects overall is 2.1 years. The average construction time for new mining developments is 2.4 years and 1.7 years for mine expansion. A one-year lag is implemented for other firm-level control variables.

The following is the estimation equation for performance:

$$ROA_t = \beta_0 + \beta_1 INVT_{t-3} + \beta_2 OVIT_{t-3} + \beta_3 INVT * OVIT_{t-3} + \beta_4 V/A_{t-1} + \beta_5 ROA_{t-1} + \beta_6 SIZE_{t-1} + \sum YRID + e_t \quad (4)$$

The term ROA represents company performance, as represented by the operating income divided by the average of the assets of a firm. The term $INVT$ is the company investment represented by the change in a firm's total capital divided by the average of total assets. The term $OVIT$ represents the overinvestment dummy, and the term $INVT * OVIT$ is an interaction term for company investment and overinvestment. The term V/A is a firm's market capitalization divided by the average of 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 fixed-effect OLS.

5. Empirical Results

The empirical results are presented in this section. For each analysis, estimations are conducted using the full dataset and a disaggregated level by sectors for the three sample periods, namely the full period, before 2008, and after 2008 periods. For ease of presentation, the results of year fixed-effects are suppressed.

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 fixed-effect OLS at the firm level. The estimation results are presented in **Table 4**.

[**Table 4**]

As can be seen from the tables, the coefficient on V/P is found to be 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 all panels in the full period, before 2008, and after 2008 periods. The negative sign indicates that firms tend to invest less once they have already leveraged. This finding is logical as leveraging is one of the main options for companies to finance investments. These results are fairly consistent with those of Richardson (2006).

The coefficient on $CASH$ is found to be insignificant in the full and before 2008 periods; however, it is found to be significantly negative in the after 2008 period for the full sample and for non-renewable, alternative energy, and mining panels. Thus, in contrast to Richardson (2006), the results show that the level of cash is not a major determinant of firms' investments before 2008. In addition, the significant negative estimates after 2008 might suggest that firms with more cash are more conservative and invest less after the global financial crisis.

The coefficient on $SIZE$ is found to be mostly insignificant, while the coefficient on $RTRN$ is estimated to be significantly negative for most of the cases. At least from the market point of view, $RTRN$ could be considered a proxy of the overall performance of a company, meaning that the better firms performed in the previous year, the lower tendency for firms to invest.

Furthermore, from each estimation in the first analysis, the residuals, or the variable misinvestment – μ, are obtained. The variable μ describes the degree of over- and underinvestment of a firm compared to its predicted value from the unvestment function. There are in total 21 misinvestment variables, μ, from the 21 panels of analysis. For ease of presentation, only the results of $\mu 1$, which are residuals from the full period–full sample estimation, are presented. The statistical description of $\mu 1$ by sector is presented in Table 7. The more positive the value of $\mu 1$, the higher the overinvestment. In contrast, the more negative the value of $\mu 1$, the more the underinvestment. The degree of the over- and underinvestment analyses is classified into three categories in the following table based on the mean value of $\mu 1$:

$$\text{Degree of misinvestment} = \begin{cases} \text{overinvest} & \text{if} \quad \text{mean} \geq 0.5 \quad \rightarrow \text{red shade} \\ \text{neutral} & \text{if} \quad -0.5 < \text{mean} < 0.5 \rightarrow \text{white shade} \\ \text{underinvest} & \text{if} \quad \text{mean} \leq -0.5 \quad \rightarrow \text{yellow shade} \end{cases} \tag{5}$$

As can be seen in Table 7, regardless of the sample periods, the alternative energy sector relatively underinvests compared to the standard investment level predicted by the investment function (1). From this result, it could be inferred that renewable energy development could be underdeveloped compared to the conventional energy sector because the oil and gas producers sector is classified into a neutral category in the results.

In contrast, Table 7 demonstrates that the forestry and paper sector are indicated to be overinvestors regardless of the sample periods, suggesting that in general, the forestry and paper sector has a higher investment rate compared to the standard investment level predicted by the investment function (1). Generally, this sector is comprised of both forestry and paper mill companies. The high investment rate in this sector might provide good insight into the demand growth for paper products; however, on the upstream side of this industry, a higher investment rate might be inferred to be a higher rate of forest conversion from a natural forest into an industrial forest.

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

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

The $\mu 1$ is also plotted by markets, as can be seen in Figure 4, and markets are classified by their degree of misinvestment in Table 8. For most markets, the pattern of misinvestment remains the same before and after 2008. Some exceptions can be seen for Belgium, Canada, Germany, and Poland, which changed from neutral before 2008 to underinvesting after 2008. A similar downward pattern can be also 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 China, 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 is determined by market-specific factors, especially 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.

[**Figure 4**]

[**Table 9**]

This is the first analysis of its kind of the investment patterns of resource-related sectors using the method implemented in this study because the analysis is conducted at the firm level in a cross-country setting. In the next subsection, whether macroeconomic factors and uncertainties can explain the investment patterns for each firm in the sample is examined.

5.2. Overinvestment and Uncertainty

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

The estimation results are summarised in Tables 9-11. As can be seen, the coefficient on $\sigma COMM$, which is the proxy for commodity price uncertainty, is found to be insignificant for all periods. In contrast, the coefficient on $\Delta COMM$ is found to be significant in the full period analysis for the full-sample and for renewable and non-renewable panels with positive coefficients (Table 9). In general, it could be inferred that companies' overinvestment tendency is determined by the growth of commodity price rather than its uncertainty. The positive sign indicates the procyclicality of overinvestment. Theoretically, the increase in uncertainty would lower the tendency of overinvesting; however, for some firms, an increase in price uncertainty would be associated with an increase in price, which boosts the tendency to overinvest. An explanation is provided by Glover and Levine (2015), who discuss that theoretically, there could be a positive relationship between uncertainty and investment. In terms of the commodity price, Our results of a positive relationship between $\Delta COMM$ and overinvestment are arguably consistent with their prediction, given a positive relationship between the commodity inflation and uncertainty. This result can also be related to findings from Chevalier-Roignant et al. (2011) and Yoon and Ratti (2011), although this result might contradict the findings from Acharya and Sadath (2016) and Caballero (1991), who document negative energy price uncertainty and firms' investment.

[**Table 9**]

The coefficient on $WGDP$, which represents the world business cycle, is significant in the full period analysis, especially for the alternative energy panel with a negative coefficient, and for the forestry and paper panels with a positive coefficient. The results show that different sectors might have different responses to the same global factor. The different coefficient signs seem to support the findings from the first analysis, which show that the alternative energy sector is relatively underinvesting compared to the other sectors (Table 7). For the forestry and paper sectors, the results of the first analysis clearly show a strong pattern of overinvestment in this sector. Thus, it is fair to say there are relatively weak and mixed results of the relationship between $WGDP$ and overinvestment.

The variable $HGDP$ represents the home country business cycle. In the full period analysis, its coefficient is significant for the renewable panel with a positive sign and for the mining sector with a negative sign. Before 2008, the coefficient on the variable is found to be significantly negative for the full sample and for non-renewable and oil and gas panels. After the 2008 analysis, its coefficient is significantly positive for the renewable and mining panels. Obviously, there are mixed results; however, some patterns can be inferred. First, for the full period analysis, there are mixed results. 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 the pattern from negative to positive after 2008 is caused by the global financial crisis, which also changes the behaviour of companies in the sample. Also, if the results for $WGDP$ and $HGDP$ are compared, it could be inferred that the home country business cycle ($HGDP$) plays a more important role in affecting the overinvestment behaviour of resource firms compared to $WGDP$. The mixed results of the relationship between the business cycle and overinvestment might be slightly different from those of Ma (2016), who documents that there is 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, where a higher value means a higher uncertainty. Log-transformation is applied to the variable. For the full period analysis, the coefficient on $GEOPOL$ is significantly positive only for the renewable panel; however, before 2008, its coefficient is significantly positive only for the full sample panel. Based on these results, it could be inferred that there is no significant pattern of a relationship between $GEOPOL$ and overinvestment.

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 renewable, 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 producers 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. As the inverted version of this index is applied for ease of analysis, the higher number refers to poor governance. As can be seen from Tables 9-11, the coefficient on WGI is statistically significant for all panels in all periods with positive signs. Thus, there is a clear and strong pattern that poor governance at the country level has a positive relationship with overinvestment.

The positive relationship of the $GEPU$ and WGI with overinvestment supports many previous studies, such as by Heikkinen and Pietola (2009), Liu (2013), Ahuja and Novelli (2017), Drakos and Goulas (2006), and Glover and Lovine (2015). They document a positive relationship between uncertainty and the overinvestment/investment of firms. The results also support theoretical predictions by Henriques and Sadorsky (2011) and Chevalier-Roignant et al. (2011), who suggest that overinvesting might be an optimal strategy for firms under uncertainty; however, the findings contradict findings from Ghousal and Loungani (2000) and Gulen and Ion (2015), 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 would lower the tendency of overinvestment, given a positive correlation between inflation and inflation uncertainty.

5.3. Overinvestment and Performance

In the third analysis, the way firms' overinvestment behaviour influences the future performance of firms based on (4) is examined. The framework from Fu (2010) is adopted to measure the effect. A three-year lag is employed for investment variables ($INVT$, $OVIT$, and $INVT * OVIT$), following the benchmark from 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 surge of income from the main business activities of the firms. The analysis is divided into the full sample and sub-sample panels, and the full period and sub-periods as the previous analyses. Equation (4) is estimated using fixed-effect OLS at the firm level. The estimation results are presented in Tables 12-14.

[**Table 12**]

The coefficient on $INVT$ is found to be significantly negative for the full sample and for non-renewable and mining panels in the full period and the after 2008 period. These results indicate that in general, for the non-renewable sectors, investments result in lower performance in the future.

The coefficient on $OVIT$, which is the dummy for overinvestment, is found to be significantly positive for the renewable panel in the full period analysis. It is also found to be significant for the alternative energy and oil and gas panels in the after 2008 analysis. Based on these results, a positive relationship between overinvestment and firms' future performance can only be found for the specific cases.

However, for the results of the interaction term $INVT * OVIT$, in general, there is a positive relationship between the interaction term and future performance, especially for the full sample and for non-renewable and mining panels in the full period and the after 2008 period. To interpret the results of the interaction term, the results of the main term $INVT$, which is negative in general, should also be acknowledged. Thus, in general, $INVT$ has a negative relationship with firms' future performance; however, if the firms are overinvesting, the joint effect ($INVT * OVIT$) will be positive. The results confirm that based on the sample, it could be inferred that overinvesting might have a positive impact on firms' future performance, especially for firms in the mining sector. The results support theoretical predictions from Henriques and Sadorsky (2010) and Chevalier-Roignant et al. (2011), who suggest that overinvesting might be an optimal strategy for firms under 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 significant negative impact on future performance.

6. Conclusion

This paper has examined the tendency of resource firms to overinvest induced by the business cycle and uncertainties. The analysis has been conducted using unbalanced panel data of 596 resource companies in 32 countries during the 1986-2017 period in four resource sectors: (1) alternative energy, (2) forestry and paper, (3) mining, and (4) oil and gas producers. The first two sectors are renewable, and the other two are non-renewable.

Three analyses have been conducted to clarify the role of the business cycle and uncertainties in overinvestments and the effects of overinvestments on the performance of firms. First, the overinvestment and underinvestment behaviours of each firm in the sample have been investigated using the framework developed by Richardson (2006). The results have indicated that internal firm factors play a significant role in determining firms' investment decision making. The results also suggest that the global financial crisis in 2008 had a significant impact on the overinvestment pattern for many countries.

Second, whether the business cycle and uncertainties play a significant role in explaining the overinvestment behaviour of firms has been examined. There is a significant positive relationship between commodity price inflation and overinvestment, while there is no clear relationship between commodity price uncertainty and overinvestment. In addition, although the world business cycle has no noticeable relationship with overinvestment, the home country business cycle significantly affects overinvestment with an alternating sign from negative to positive before and after the global financial crisis. Furthermore, the results suggest no significant relationship between the global geopolitical risk and overinvestment but a significant positive relationship between global economic and country-level governance policy uncertainties and overinvestment.

Lastly, the way overinvestment might affect firms' future performance has been investigated. The results have demonstrated that the joint effect of investment and overinvestment is positive for firms' future performance, especially for firms in the mining sector, supporting theoretical predictions from Henriques and Sadorsky (2011) and Chevalier-Roignant et al. (2011), who suggest that overinvesting might be an optimal strategy for firms under uncertainty.

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8. Appendix: Figures and Tables

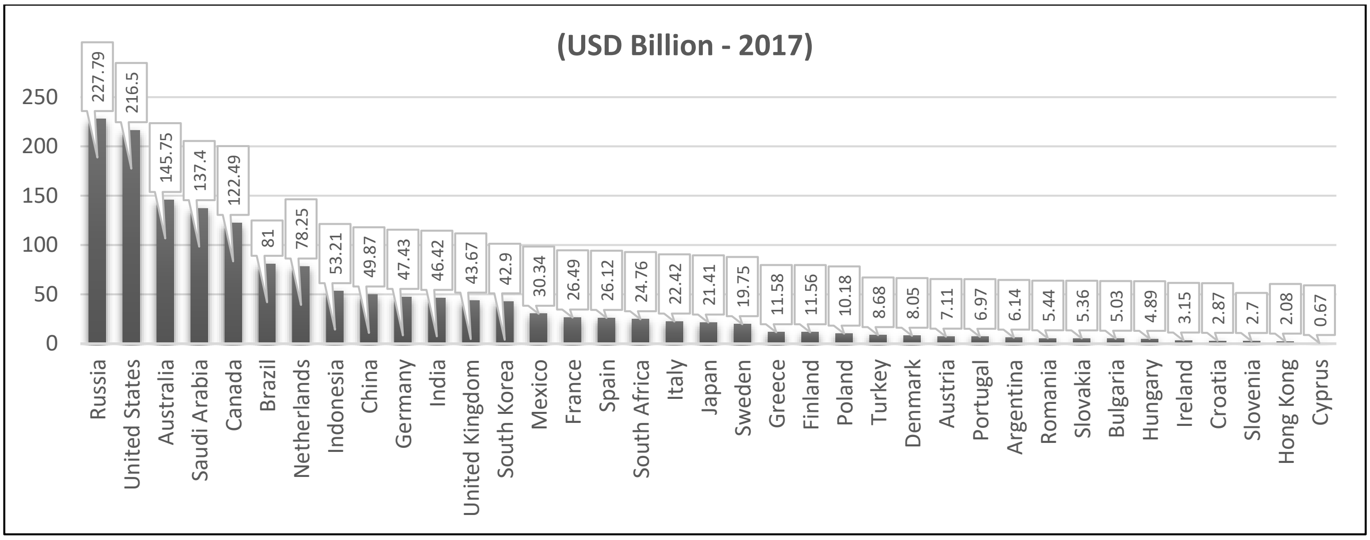

Figure 1 Natural Resource Export Value by Market in 2017

Data from 2016 for Saudi Arabia | Calculation based on exports of Crude Materials and Fuels (SITC 2 and 3)

Source: UN COMTRADE

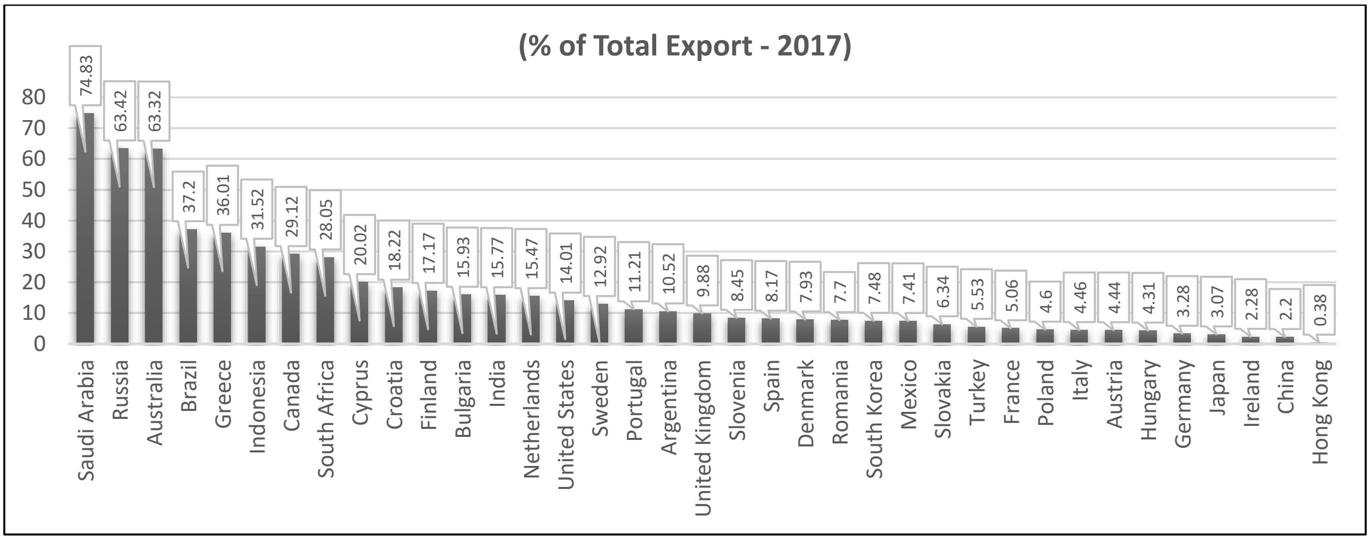

Figure 2 Natural Resource Export as a Percentage of the Total Export by Market in 2017

Data from 2016 for Saudi Arabia | Calculation based on exports of Crude Materials and Fuels (SITC 2 and 3)

Source: UN COMTRADE

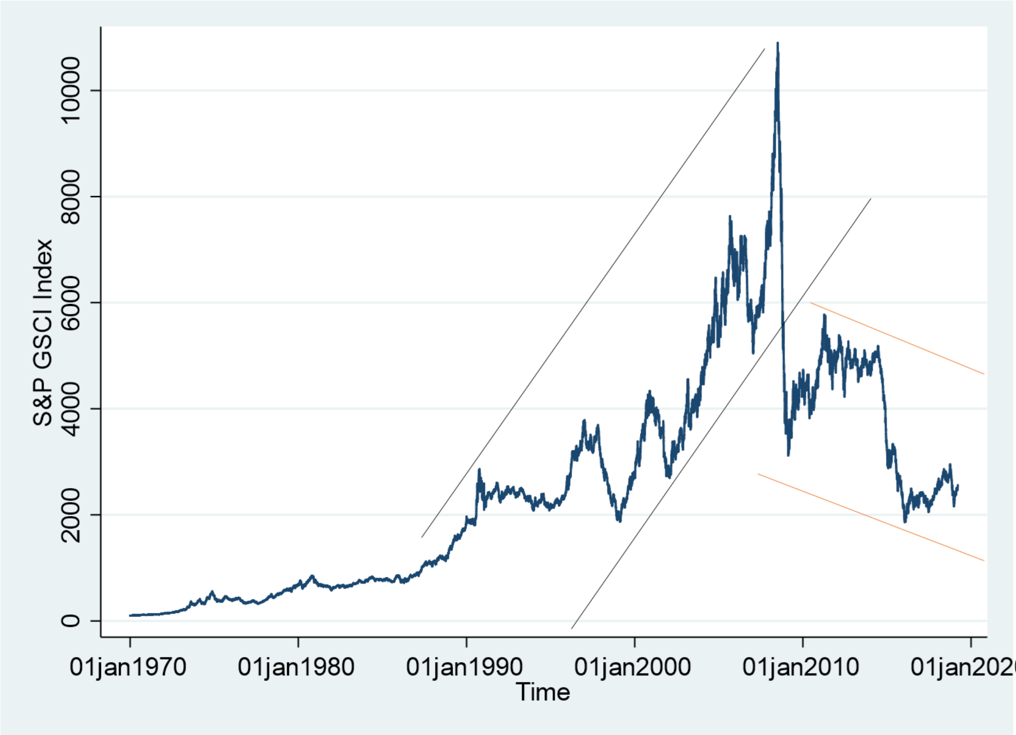

Figure 3 Goldman Sachs Commodity Index, 1970-2019

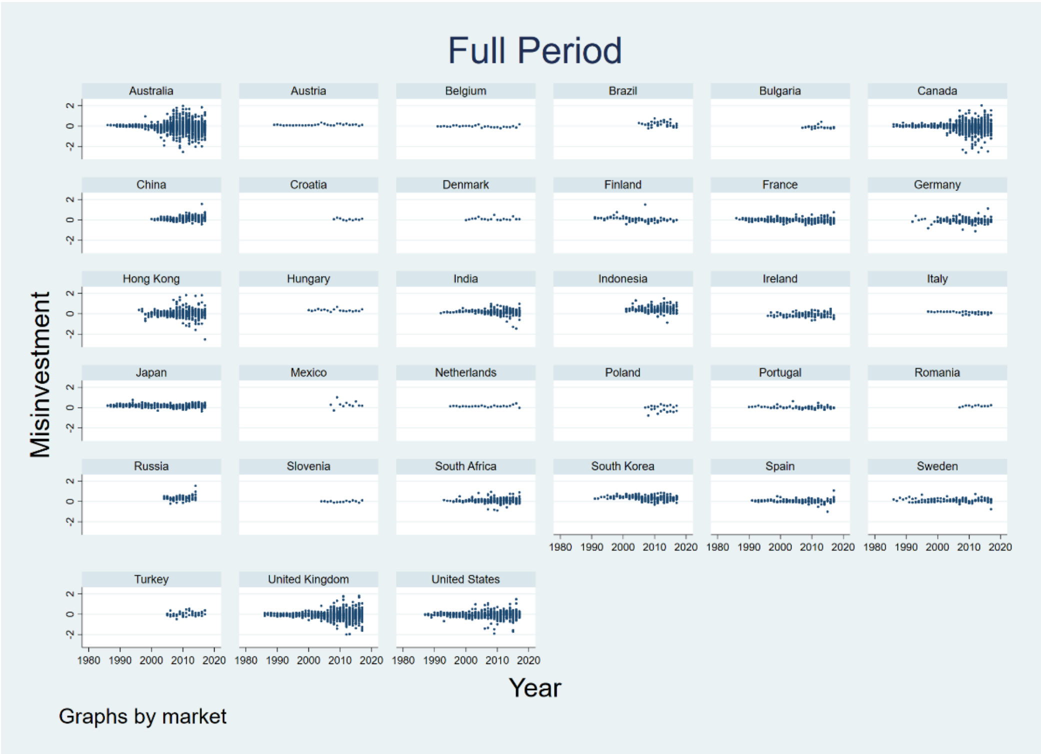

Figure 4 Misinvestment by Country, Full Period

Figure 5 Misinvestment by Country, Before 2008

Figure 6 Misinvestment by Country, After 2008

9. Appendix: Tables

Table 1 Coverage of Sectors

No	Sector	Number of Companies	Number of Observations
1	Alternative Energy	48	595
2	Forestry and Paper	87	1,462
3	Mining	316	4,093
4	Oil and Gas Producers	145	2,015
	Total	**596**	**8,165**

Table 2 Descriptive Statistics of the Dataset

Variable	Transformation	Obs	Mean	Std. Dev.	Min	Max	Source
$INVT$	$\frac{Capital_t - Capital_{t-1}}{\overline{Asset}}$ [8]	8,165	0.05	0.33	-2.61	2.43	Worldscope
ROA	Operating Income / Average of Assets	8,165	0.01	0.15	-0.92	0.71	Worldscope
V/A	Market Capitalization / Average of Assets	8,165	1.05	1.08	0.01	7.76	Worldscope
V/P	Equity / Market Capitalization	8,165	1.03	1.00	-3.62	7.79	Worldscope
LEV	Total Liabilities / Total Assets	8,165	0.20	0.21	0.00	2.78	Worldscope
$CASH$	Total Cash / Total Assets	8,165	0.10	0.15	0.00	1.00	Worldscope
$SIZE$	Log of Total Assets	8,165	13.75	3.89	2.30	25.36	Worldscope
$RTRN$	Growth of Market Capitalization (%)	8,165	0.33	1.15	-0.97	12.00	Worldscope
AGE	Age – No Transformation	8,165	16.29	9.84	2.00	53.00	Worldscope
$\sigma COMM$	Natural Log of Std Dev of Goldman Sachs Commodity Index	8,165	5.73	0.73	3.81	7.58	Datastream
$\Delta COMM$	Difference of Natural Log of Goldman Sachs Commodity Index	8,165	-0.67	22.31	-48.23	50.91	Datastream
$WGDP$	Annual Growth of the Home Country GDP	8,165	2.78	1.46	-1.69	4.62	World Bank
$HGDP$	Annual Growth of the World Economy	8,157	2.79	2.63	-8.27	25.12	World Bank
GEOPOL	Geopolitical Risk - Global	8,165	4.39	0.38	3.50	5.32	Caldara and Iacoviello (2016)
GEPU	Economic Policy Uncertainty - Global	7,666	4.72	0.31	4.14	5.24	Davis (2016)
WGI	Worldwide Governance Index - Country	7,740	-1.19	0.67	-1.97	0.91	World Bank
$INFL$	Percentage – No Transformation	8,165	2.63	2.25	-4.48	14.11	World Bank

[8] 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 3 Correlation Between Variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1)	$INVT$	1																
(2)	ROA	0.18	1															
(3)	V/A	0.31	0.01	1														
(4)	V/P	-0.09	-0.04	-0.38	1													
(5)	LEV	-0.07	0.12	-0.22	-0.04	1												
(6)	$CASH$	0.05	-0.20	0.12	-0.16	-0.20	1											
(7)	$SIZE$	0.07	0.49	-0.06	0.10	0.38	-0.31	1										
(8)	$RTRN$	0.23	-0.01	0.23	-0.26	-0.06	0.16	-0.08	1									
(9)	AGE	-0.02	0.19	0.08	0.02	0.13	-0.14	0.28	-0.10	1								
(10)	$\sigma COMM$	0.08	-0.02	-0.02	-0.05	-0.07	0.06	-0.07	-0.01	-0.19	1							
(11)	$\Delta COMM$	0.09	0.06	-0.03	-0.08	-0.03	0.02	-0.01	-0.01	-0.11	0.26	1						
(12)	$WGDP$	0.07	0.03	0.04	-0.10	0.00	0.03	0.00	0.07	-0.01	-0.06	0.59	1					
(13)	$HGDP$	0.03	0.10	-0.01	-0.03	0.08	-0.03	0.19	0.01	-0.12	-0.01	0.31	0.47	1				
(14)	$INFL$	0.07	0.15	-0.01	0.05	0.05	-0.08	0.25	0.00	-0.11	0.20	0.22	0.07	0.31	1			
(15)	GEOPOL	-0.06	-0.01	-0.07	0.03	0.05	0.01	-0.01	0.01	0.09	-0.20	-0.09	0.10	0.07	-0.10	1		
(16)	GEPU	-0.04	0.02	0.09	0.15	0.04	-0.06	0.06	-0.13	0.21	-0.49	-0.21	-0.30	-0.18	-0.04	0.11	1	
(17)	WGI	0.02	0.27	-0.08	0.05	0.25	-0.16	0.58	-0.01	-0.07	-0.01	0.00	-0.01	0.46	0.58	0.01	0.02	1

Table 4 Overinvestment – Full Period

Dependent Variable: $INVT_t$

Variable	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry & Paper	Mining	Oil & Gas
V/P_{t-1}	-0.0555***	-0.089	-0.0511**	0.0206	-0.2086**	-0.0813***	0.0234
LEV_{t-1}	-0.0780***	-0.0438***	-0.0928***	-0.0953***	-0.0279***	-0.0947***	-0.0906***
$CASH_{t-1}$	-0.0476	-0.0255	-0.0517	-0.2685	0.0025	-0.0718	0.0055
$SIZE_{t-1}$	0.0394	0.1728	0.0132	-0.0499	0.4479**	0.0616	-0.0943
$RTRN_{t-1}$	-0.0425***	-0.0676***	-0.0433***	-0.1235***	-0.0324	-0.0359***	-0.0606***
$INVT_{t-1}$	0.0204***	0.0276***	0.0161***	0.0119	0.0375***	0.0083	0.0341***
AGE_{t-1}	0.0031***	0.0015	0.0045***	-0.0577	-0.0011	0.0032*	0.0076***
$YRTR$	YES	YES	YES	YES	YES	YES	YES
Constant	0.6373***	1.0518***	0.6255***	2.6743**	0.5535*	0.5581***	0.8125***
Observation	8165	2057	6108	595	1462	4093	2015
R-Squared	0.0954	0.1111	0.1054	0.2291	0.1145	0.1171	0.1151

*** P < 10% ** P < 5% *** P < 1%**

Table 5 Overinvestment – Before 2008

Dependent Variable: $INVT_t$

Variable	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry & Paper	Mining	Oil & Gas
V/P_{t-1}	-0.098	-0.0428	-0.1194	-0.1549	-0.025	-0.2842***	0.2372
LEV_{t-1}	-0.0517***	-0.0423***	-0.0550***	-0.1291***	-0.0242*	-0.0281**	-0.1320**
$CASH_{t-1}$	0.079	0.0707	0.1122	-0.1702	0.0298	-0.014	0.3324*
$SIZE_{t-1}$	0.0013	0.1444	-0.016	0.099	0.1087	-0.0076	-0.0421
$RTRN_{t-1}$	-0.0312**	-0.0543***	-0.0410**	-0.0695	-0.0431***	-0.0370*	-0.0511*
$INVT_{t-1}$	0.0144**	0.0062	0.0162*	-0.0215*	0.0234	0.0186*	0.016
AGE_{t-1}	0.0067***	0.0016	0.0108***	0.0363	-0.0001	0.0137***	0.0061*
$YRTR$	YES	YES	YES	YES	YES	YES	YES
Constant	0.4845***	0.8697***	0.5575**	0.8181	0.7167***	0.4747*	0.7545**
Observation	2867	860	2007	172	688	1290	717
R-Squared	0.0932	0.1098	0.1162	0.3489	0.1092	0.1378	0.2465

*** P < 10% ** P < 5% *** P < 1%**

Table 6 Overinvestment – After 2008

Dependent Variable: $INVT_t$

Variable	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry & Paper	Mining	Oil & Gas
V/P_{t-1}	-0.0573**	-0.1548*	-0.0470*	0.0224	-0.2710***	-0.0756***	0.0193
LEV_{t-1}	-0.0801***	-0.0387***	-0.0970***	-0.0709***	-0.0203*	-0.1025***	-0.0845***
$CASH_{t-1}$	-0.1107**	-0.1166	-0.1277**	-0.3062**	0.0483	-0.1174*	-0.1575
$SIZE_{t-1}$	0.0593	0.2107*	0.034	0.0147	0.7009*	0.1212	-0.1805
$RTRN_{t-1}$	-0.1322***	-0.1741***	-0.1274***	-0.1498***	-0.2119***	-0.1116***	-0.1663***
$INVT_{t-1}$	0.0114*	0.0327**	0.0038	0.0211	0.0432*	-0.0071	0.0257
AGE_{t-1}	0.0067**	-0.0054	0.0120***	-0.0031	-0.0033	0.0152***	0.0079
$YRTR$	YES	YES	YES	YES	YES	YES	YES
Constant	1.8031***	2.8651***	1.5959***	2.1476***	3.5903***	1.2807***	2.3756***
Observation	4787	1081	3706	383	698	2531	1175
R-Squared	0.127	0.1483	0.136	0.1635	0.2022	0.152	0.1366

*** P < 10% ** P < 5% *** P < 1%**

Table 7 Overinvestment by Sector

SECTORS	FULL PERIOD					BEFORE 2008					AFTER 2008				
	Mean ($\mu 1$)	St Dev ($\mu 1$)	Observations			Mean ($\mu 1$)	St Dev ($\mu 1$)	Observations			Mean ($\mu 1$)	St Dev ($\mu 1$)	Observations		
			Under	Over	Total			Under	Over	Total			Under	Over	Total
Alternative Energy	-0.0579	0.2939	345	250	595	-0.0515	0.2743	95	77	172	-0.0657	0.2912	229	154	383
Forestry and Paper	0.1432	0.2668	388	1,074	1,462	0.1439	0.2187	180	508	688	0.1501	0.3063	182	516	698
Mining	-0.0507	0.3967	2,306	1,787	4,093	-0.0263	0.2736	727	563	1,290	-0.0592	0.4460	1,408	1,123	2,531
Oil and Gas Producers	0.0162	0.3500	924	1,091	2,015	0.0177	0.2373	331	386	717	0.0111	0.3987	538	637	1,175
Total	**0.0000**	**0.3653**	**3,963**	**4,202**	**8,165**	**0.0240**	**0.2620**	**1,333**	**1,534**	**2,867**	**-0.0119**	**0.4123**	**2,357**	**2,430**	**4,787**

All numbers are based on variable $\mu 1$, which represents residuals from 'Full Sample – Full Period' overinvestment regression from the equation (1). We classify the degree of over- and underinvestment analysis into three categories in this table, based on mean value:

$$\text{degree of misinvestment}\begin{cases}\text{'overinvest'} & \text{if} \quad \text{mean} \geq 0.5 \quad \rightarrow \quad \text{red shade} \\ \text{'neutral'} & \text{if} \quad -0.5 < \text{mean} < 0.5 \quad \rightarrow \quad \text{white shade} \\ \text{'underinvest'} & \text{if} \quad \text{mean} \leq -0.5 \quad \rightarrow \quad \text{yellow shade}\end{cases}$$

Table 8 Overinvestment by Market

No	Market	FULL PERIOD					BEFORE 2008					AFTER 2008				
		Mean ($\mu 1$)	St Dev ($\mu 1$)	Observations			Mean ($\mu 1$)	St Dev ($\mu 1$)	Observations			Mean ($\mu 1$)	St Dev ($\mu 1$)	Observations		
				Under	Over	Total			Under	Over	Total			Under	Over	Total
1	Australia	-0.1218	0.4195	1196	600	1796	-0.1064	0.2877	468	192	660	-0.1387	0.4820	650	367	1017
2	Austria	0.1194	0.0749	0	29	29	0.1079	0.0730	0	19	19	0.1506	0.0760	0	9	9
3	Belgium	-0.0356	0.0924	18	9	27	-0.0085	0.0745	9	8	17	-0.0785	0.1109	8	1	9
4	Brazil	0.2096	0.2451	6	27	33	0.2123	0.0770	0	3	3	0.2288	0.2549	5	22	27
5	Bulgaria	-0.1026	0.1574	19	2	21	-0.1651	0.0000	1	0	1	-0.0979	0.1698	16	2	18
6	Canada	-0.1189	0.4091	831	431	1,262	-0.0187	0.2617	150	123	273	-0.1419	0.4380	616	282	898
7	China	0.1437	0.2113	58	193	251	0.0496	0.1042	21	43	64	0.1942	0.2282	29	142	171
8	Croatia	0.0564	0.0862	3	7	10						0.0552	0.0913	3	6	9
9	Denmark	0.1071	0.1375	2	16	18	0.0938	0.0999	1	7	8	0.1237	0.1753	1	8	9
10	Finland	0.0793	0.2520	29	47	76	0.1436	0.2685	12	39	51	-0.0302	0.1319	14	7	21
11	France	-0.0067	0.1972	98	102	200	0.0208	0.1460	46	66	112	-0.0264	0.2414	46	34	80
12	Germany	-0.0570	0.2320	177	87	264	-0.0390	0.2124	56	27	83	-0.0637	0.2361	110	55	165
13	Hong Kong SAR	0.0517	0.3918	199	245	444	-0.0122	0.2153	85	66	151	0.0819	0.4555	100	166	266
14	Hungary	0.3438	0.1114	0	18	18	0.3382	0.0879	0	8	8	0.3396	0.1368	0	9	9
15	India	0.1669	0.2437	45	260	305	0.2099	0.1117	3	68	71	0.1496	0.2693	38	172	210
16	Indonesia	0.4285	0.2835	5	207	212	0.4477	0.2227	0	62	62	0.4247	0.3065	5	131	136
17	Ireland	-0.0988	0.2199	64	28	92	-0.1209	0.1684	28	9	37	-0.0730	0.2527	31	18	49
18	Italy	0.1103	0.1147	7	24	31	0.1928	0.0354	0	11	11	0.0689	0.1101	6	12	18
19	Japan	0.1875	0.1275	31	416	447	0.2025	0.1145	11	247	258	0.1724	0.1436	18	153	171
20	Mexico	0.3074	0.3215	1	10	11	0.2849	0.0000	0	1	1	0.3743	0.2865	0	9	9
21	Netherlands	0.1477	0.0870	1	22	23	0.1297	0.0452	0	13	13	0.1803	0.1249	1	8	9
22	Poland	-0.0976	0.3098	10	11	21	0.0095	0.0000	0	1	1	-0.0747	0.2884	9	9	18
23	Portugal	0.0345	0.1376	32	44	76	0.0527	0.1426	13	20	33	0.0222	0.1421	17	21	38
24	Romania	0.1600	0.0722	0	11	11	0.0194	0.0000	0	1	1	0.1821	0.0556	0	9	9
25	Russia	0.3503	0.2338	3	79	82	0.2719	0.1522	1	25	26	0.4086	0.2613	1	47	48
26	Slovenia	-0.0033	0.0711	7	7	14	0.0072	0.0254	1	3	4	0.0030	0.0815	5	4	9
27	South Africa	0.0999	0.2187	63	195	258	0.0873	0.1835	21	76	97	0.1021	0.2337	37	108	145
28	South Korea	0.3470	0.1949	13	258	271	0.4021	0.1710	1	101	102	0.3219	0.2027	11	142	153
29	Spain	0.0373	0.1953	54	80	134	0.0543	0.1221	22	45	67	0.0204	0.2578	29	32	61
30	Sweden	0.1075	0.1772	34	98	132	0.1094	0.1594	21	51	72	0.0947	0.2021	13	41	54
31	Turkey	0.0391	0.2246	19	20	39	-0.0188	0.1728	5	4	9	0.0869	0.2216	11	16	27
32	United Kingdom	-0.0758	0.3649	622	364	986	-0.0772	0.2056	205	104	309	-0.0735	0.4216	378	239	617
33	United States	-0.0338	0.3122	316	255	571	-0.0400	0.2528	152	91	243	-0.0324	0.3544	149	149	298
Total		**0.0000**	**0.3653**	**3,963**	**4,202**	**8,165**	**0.0240**	**0.2620**	**1,333**	**1,534**	**2,867**	**-0.0119**	**0.4123**	**2,357**	**2,430**	**4,787**

All numbers are based on variable $\mu 1$, which represents residuals from 'Full Sample – Full Period' overinvestment regression from the equation (1). We classify the degree of over- and underinvestment analysis into three categories in this table, based on mean value:

$$\text{degree of misinvestment}\begin{cases} \text{'overinvest'} & \text{if} \quad \text{mean} \geq 0.5 \quad \rightarrow \text{red shade} \\ \text{'neutral'} & \text{if} \quad -0.5 < \text{mean} < 0.5 \quad \rightarrow \text{white shade} \\ \text{'underinvest'} & \text{if} \quad \text{mean} \leq -0.5 \quad \rightarrow \text{yellow shade} \end{cases}$$

Table 9 Overinvestment and Uncertainty – Full Period

Dependent Variable: $OVIT_t$

Variable	**Full Sample**	**Renewable**	**Non-Renewable**	**Alternative Energy**	**Forestry & Paper**	**Mining**	**Oil & Gas**
$OVIT_{t-1}$	0.3311***	0.6670***	0.3194***	-0.1382	0.5708***	0.3435***	0.3928***
$\sigma COMM_{t-1}$	0.0909	0.0809	0.0449	-0.2912	0.1318	0.0039	0.1246
$\Delta COMM_{t-1}$	0.0078**	0.0184**	0.0064*	0.0057	0.0084	0.0069	-0.0036
$WGDP_{t-1}$	0.3975	0.9063	0.4513	-1.4487*	1.1534*	0.3821	0.0235
$HGDP_{t-1}$	-0.013	0.0636***	-0.0178	0.0951	0.0101	-0.0308*	0.01
$GEOPOL_{t-1}$	0.0095	0.7194**	-0.0415	1.1252	0.1295	-0.0521	-0.3598
$GEPU_{t-1}$	0.6158**	1.6979**	0.3191	-0.0685	2.0420**	0.2919	-0.2473
WGI_{t-1}	0.8792***	0.6712***	0.9536***	2.2628**	0.3729***	0.8629***	0.9733***
$INFL_{t-1}$	-0.0228	0.0085	-0.0427**	0.4843***	0.0148	-0.0398*	-0.0614*
$YRID$	YES	YES	YES	YES	YES	YES	YES
Constant	-3.4644	-13.9902**	-1.5163	2.6872	-14.4038**	-0.9489	3.1625
Observation	7051	1707	5344	527	1176	3602	1742

*** P < 10%   ** P < 5%   *** P < 1%**

Table 10 Overinvestment and Uncertainty – Before 2008

Dependent Variable: $OVIT_t$

Variable	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry & Paper	Mining	Oil & Gas
$OVIT_{t-1}$	0.6121***	0.7319**	0.6075***	1.5947	0.6408**	1.0758***	0.2046
$\sigma COMM_{t-1}$	0.4226	-0.2421	0.2129	12.1753	-0.5418	0.4203	-0.3311
$\Delta COMM_{t-1}$	0.0006	0.0085	0.0025	0.0425	0.0048	0.0096	0.0046
$WGDP_{t-1}$	0.0073	-0.0672	0.0606	-1.8244	0.1949	-0.2795	-0.1503
$HGDP_{t-1}$	-0.0530**	0.0186	-0.0920***	-0.1533	0.0191	-0.0119	-0.1708**
$GEOPOL_{t-1}$	-0.4598**	0.1919	-0.3542	11.0834	0.2699	-0.0957	-0.0211
$GEPU_{t-1}$	1.3781	-0.5968	0.8989	-7.6736	-0.7712	-0.4048	-1.3358
WGI_{t-1}	0.8824***	1.1455**	1.1153***	0.5184	1.4293***	0.6849***	1.3184***
$INFL_{t-1}$	-0.0079	0.0753	-0.0344	0.0929	0.0072	-0.0026	0.0278
$YRID$	YES	YES	YES	YES	YES	YES	YES
Constant	-5.4898	4.0177	-2.3346	-85.3647	5.7512	0.9065	10.3524
Observation	1902	551	1351	126	421	873	478

*** P < 10%   ** P < 5%   *** P < 1%**

Table 11 Overinvestment and Uncertainty – After 2008

Dependent Variable: $OVIT_t$

Variable	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry & Paper	Mining	Oil & Gas
$OVIT_{t-1}$	0.4807***	2.5813***	0.4117***	-0.0589	3.4659***	0.4632***	0.7657***
$\sigma COMM_{t-1}$	0.1017	0.0888	-0.0126	0.0638	-0.0939	-0.0426	0.0787
$\Delta COMM_{t-1}$	0.0024	0.0082	-0.0042	-0.0041	0.0098	-0.0011	-0.0087
$WGDP_{t-1}$	-0.0053	-0.1795	0.0486	0.0701	-0.2537	-0.0055	0.096
$HGDP_{t-1}$	0.0099	0.0709***	0.0123	0.032	0.0455	0.0519**	0.0285
$GEOPOL_{t-1}$	-0.0028	0.0243	0.0335	-0.0722	0.7149	0.0925	-0.3508
$GEPU_{t-1}$	0.2548	0.2055	0.163	-0.2197	-0.7343	0.0777	0.0656
WGI_{t-1}	1.7587***	0.3537***	1.6694***	1.2307**	0.2617*	1.3968***	1.5088***
$INFL_{t-1}$	-0.0655**	-0.0920***	-0.0569	0.1139	-0.0920**	-0.0103	-0.0881
$YRID$	YES	YES	YES	YES	YES	YES	YES
Constant	0.2978	-1.9274	1.0036	2.1525	0.2381	0.967	2.0088
Observation	4205	952	3253	336	616	2219	1034

*** P < 10%   ** P < 5%   *** P < 1%**

Table 12 Overinvestment and Performance – Full Period

Dependent Variable: ROA_t

Variable	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry & Paper	Mining	Oil & Gas
$INVT_{t-3}$	-0.0331***	-0.0322	-0.0357***	-0.0181	-0.0192	-0.0380***	-0.0235
$OVIT_{t-3}$	0.0025	0.0103*	0.003	-0.0168	0.0009	0.0068	-0.0003
$INVT * OVIT_{t-3}$	0.0422***	0.0438*	0.0443***	0.0652	0.0128	0.0530***	0.01
VA_{t-1}	0.0065**	0.0103	0.0036	0.0073	0.0199**	0.0024	0.005
ROA_{t-1}	0.3886***	0.2773***	0.3920***	0.2480***	0.2999***	0.3596***	0.4624***
$SIZE_{t-1}$	-0.0088***	-0.0239***	-0.0081**	-0.0499***	-0.0125	-0.0114***	0.0041
$YRID$	YES	YES	YES	YES	YES	YES	YES
Constant	0.0843**	0.3825***	0.0277	0.6581***	0.2410*	0.039	-0.0835
Observation	6353	1639	4714	451	1188	3134	1580
R-Squared	0.1878	0.153	0.2082	0.2049	0.1844	0.1877	0.3494

*** P < 10% ** P < 5% *** P < 1%**

Table 13 Overinvestment and Performance – Before 2008

Dependent Variable: ROA_t

Variable	Full Sample	Renewable	Non-Renewable	Alternative Energy	Forestry & Paper	Mining	Oil & Gas
$INVT_{t-3}$	-0.1012	-0.038	-0.1257	-0.0095	-0.0397	-0.1986	-0.1173
$OVIT_{t-3}$	0.001	-0.0059	-0.0027	0.0023	0.0002	0.0164	-0.0063
$INVT * OVIT_{t-3}$	0.1197	0.0616	0.1352	0.1088	0.0546	0.2485	0.1038
VA_{t-1}	0.0289***	0.0509***	0.0153*	0.0536***	0.0439*	0.0161	0.0231*
ROA_{t-1}	0.2490**	0.1885***	0.2261	-0.0801	0.2487***	0.0204	0.6675***
$SIZE_{t-1}$	-0.0065	-0.0385**	-0.0017	-0.0539**	-0.0337*	-0.0111	0.0042
$YRID$	YES	YES	YES	YES	YES	YES	YES
Constant	0.0847	0.5951***	-0.0038	0.6320**	0.5496*	0.0801	-0.0559
Observation	1706	575	1131	94	481	696	435
R-Squared	0.1932	0.2007	0.2508	0.4881	0.1941	0.1847	0.6151

*** P < 10% ** P < 5% *** P < 1%**

Table 14 Overinvestment and Performance – After 2008

Dependent Variable: ROA_t

Variable	**Full Sample**	**Renewable**	**Non-Renewable**	**Alternative Energy**	**Forestry & Paper**	**Mining**	**Oil & Gas**
$INVT_{t-3}$	-0.0274***	-0.0339	-0.0238**	0.0024	-0.0263	-0.0249**	-0.0187
$OVIT_{t-3}$	0.0131	0.0069	-0.0052	0.0396**	0.0044	-0.0016	0.0253*
$INVT * OVIT_{t-3}$	0.0254*	0.0613	0.0292*	-0.0539	0.0353	0.0354*	-0.0097
VA_{t-1}	0.0041	-0.0001	0.0018	-0.0006	0.0109	-0.0012	0.0065
ROA_{t-1}	0.2492***	0.0666	0.2621***	0.0284	0.1096	0.2365***	0.3056***
$SIZE_{t-1}$	-0.0416***	-0.0592***	-0.0391***	-0.0884***	-0.0069	-0.0395***	-0.0296***
$YRID$	YES	YES	YES	YES	YES	YES	YES
Constant	0.5739***	0.9222***	0.5314***	1.1107***	0.1488	0.5030***	0.4523***
Observation	3065	703	2362	247	456	1605	757
R-Squared	0.1303	0.1243	0.1421	0.2195	0.1045	0.1287	0.3076

*** P < 10% ** P < 5% *** P < 1%**