Commodity Booms and Busts and Investment Inefficiency

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This paper examines firms' investment inefficiency across sectors in a resource-rich country during commodity boom and bust periods. Understanding the effect of commodity price fluctuations on investments is essential to understanding the transmission channel of commodity price shocks to the economy. This paper estimates the prevalence of firms' investment inefficiency (particularly overinvestment) across sectors and the role of commodity price fluctuations in driving overinvestment. Subsequently, it examines the consequence of overinvestment during the boom period on firms' financial performance in the bust period. The data is panel data of Indonesian listed firms between the 1990s and 2019. The empirical result shows that commodity price growth increases the likelihood of firms' overinvestment in the resource sector and, to some extent, in the service sector. A one standard deviation increase in commodity price growth increases the probability of overinvestment in the resource sector by around 20 percent during the boom period. However, the effect is smaller during a higher volatility period. In addition, overinvested firms tend to have weaker financial performance in the subsequent bust periods. The commodity price boom is likely to trigger overinvestment in resource firms through an increase in free cash flow and lower cost of external financing.

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1 Introduction

The macroeconomic implication of commodity price fluctuations has long attracted the research and attention of academics and policymakers, particularly in resource-rich countries. Recent research has shown commodity price fluctuations account for the largest share of business cycle fluctuations in commodity-exporting countries (e.g., Fernández, González, and Rodriguez 2018, Fernández, Schmitt-Grohé, and Uribe 2017), could result in banking crisis during the bust period (e.g., Eberhardt and Presbitero 2021), and in the long term could negatively affect the long term economic growth (i.e., the resource curse hypothesis). With the recent rally in the commodity price since mid-2020, policymakers and firms in resource-rich countries ought to apply any lessons learned from the previous commodity boom 2003-2011 period. In doing so, it is essential to understand the transmission channels of commodity price shocks to the economy.

There are several channels of commodity price shocks to macroeconomic fluctuation discussed in the recent literature.[1] However, the investment channel of commodity price shocks is still less explored in these papers.[2] Investment is an essential determinant of economic performance. It is usually the second most significant component of GDP after consumption. While consumption exhibits excess smoothness, investment has been described as relatively volatile. Its volatility might be even more critical in resource-rich economies.

As the movement of commodity prices is uncertain and volatile, firms in resource-rich countries, particularly the ones in the resource sector, make investment decisions under significant uncertainty. An over-optimism could lead to overinvestment, resulting in an elevated boom during the commodity boom period. Similarly, over-pessimism during the bust period could also lead to underinvestment, hence an excessive downturn in economic activity. The role of commodity booms and busts in driving firms' investment inefficiencies could be the reason why commodity booms and busts explain a significant share of business cycle fluctuations in these economies. Besides potentially explaining the business cycle, overinvestment during the commodity boom period might also negatively affect firms' financial performance in the subsequent bust period. Deterioration in firms'

[1] For instances, countercyclical country interest rate channel (Fernández, González, and Rodriguez 2018, Drechsel and Tenreyro 2018, Shousha 2016), working capital channel, financial accelerator channel, demand channel (Fernández, González, and Rodriguez 2018), income and substitution effect channel, and exchange rate channel.

[2] The importance of investment channel in business cycle was discussed by Bernanke (1983). Under investment uncertainty and irreversibility, the interactions of investor learning and the optimal timing of investments would give rise to large fluctuations in demand for capital goods, hence showing the importance of investment channels in explaining the business cycle. Furthermore, the theory of financial accelerator by Bernanke, Gertler, and Gilchrist (1999) states that financial-market imperfections can propagate and amplify business cycle fluctuations. Positive economic shocks would increase the firm's profit and retained earnings. Higher retained earnings would increase firms' investment, further strengthening the shocks. The channel could also go through asset prices. Higher asset prices during the boom period (e.g., land owned by the firm) could increase the firm's net wealth and lead to more investment.

financial performance during the bust period might transmit the shocks to the financial system through a higher default rate or non-performing loan. The negative effect on the banking sector would further aggravate the impact of commodity price shocks on the economy.

Moreover, commodity price fluctuations in resource-rich economies might not only affect firms in the natural resource sector but could also affect firms in other sectors of the economy. This sectoral effect might also contribute to why commodity price shocks have such a large share in the business cycle fluctuation of resource-rich countries. Indeed, one of the central research themes in commodity price fluctuations is how the resource boom affects economic sectors outside the resource sector. Research on the Dutch Disease theory, for instance, examines whether the tradable (manufacturing) sector and the non-tradable (service) sector, would be affected by the resource boom.[3] In particular, how the manufacturing sector is affected is a primary concern because this sector usually generates positive spillovers to the economy and has positive learning-by-doing effects. The evidence, however, has been mixed, and some recent researches even show evidence *against* Dutch Disease effect, i.e., there is, in fact, a positive effect of commodity price boom on other sectors in the economy. As the debate is still unsettled, more evidence is needed, mainly using microdata (Van Der Ploeg and Poelhekke 2017).

This paper examines the effect of commodity price fluctuations (both commodity price growth and commodity price volatility) on firms' investment efficiency (i.e., over or under-investment) across various sectors in the economy of a resource-rich country. This paper follows the measure of overinvestments by Richardson (2006). Investment is regressed on its determinants commonly used in the literature, including growth opportunities, cash stock, leverage, and size. A firm is categorized as overinvested when it invests more than predicted by its investment function.[4] Subsequently, this paper assesses whether overinvestment negatively affects firms' financial performance in the following periods.

On the hypothesis, the evidence in the literature is still mixed on whether uncertainty could lead to higher or lower firm investment (Irawan and Okimoto 2021). Firms could overinvest as a strategic move when facing uncertainty or underinvest due to the

[3]The classic model of dutch disease by Corden (1984) postulates there are two effects of resource boom across sectors. The first effect is the resource movement effect. Since profitability and the marginal product of labor increased in the booming (resource) sector, the demand for labor increased, inducing labor movement out of lagging (tradable) and non-tradable sectors. The second effect is the spending effect. Higher spending of extra income from the booming (resource) sector will increase demand for non-tradable sector and its price (Note: demand for (the lagging) tradable sector will also increase. However, since its price is determined at international market, higher demand is compensated by higher imports). This will draw resources (labor and capital) out of the booming (resource) sector and lagging (tradable) sector into the non-tradable sector. As a result of the two combined effects, the output of the lagging (tradable) sector will decline; meanwhile, the output of the non-tradable sector could be higher or lower.

[4]This approach to identifying overinvestment has been used extensively in many studies. For instance, Su, Fung, and Yau (2013), Di Meo (2014), Liao and Liu (2014), Xu, Huang, and Jiang (2017), Yu et al. (2020), and Irawan and Okimoto (2021) among many others.

investment's irreversibility. This paper follows the prediction pattern of Dutch Disease theory on differential effects across sectors. There would be overinvestment during the commodity boom in the natural resource and, to some extent, in the services sector, yet underinvestment in the manufacturing sector. Furthermore, overinvested firms might have a worse financial performance during the commodity bust period and experience more financial distress than the other firms.

Several studies examine the importance of commodity price fluctuations on firms' investment determinants.[5] Magud and Sosa (2017), for instance, finds that an increase in the commodity price will lead to a rise in firms' investment. However, the paper does not differentiate the result across sectors and examines the incidence of investment inefficiency caused by commodity prices. Cherkasova 2019 and Irawan and Okimoto 2021 might be the only two papers that examine firms' overinvestment in relation to commodity price fluctuation.[6] These two papers, however, did not examine the impact across sectors in the economy, did not examine the financial implications during the bust period, and might contain some econometric misspecification.[7]

This paper uses the data of 500 publicly listed non-financial firms in Indonesia, a resource-rich emerging market economy, from the 1990s to 2019. The period covers the commodity super cycle boom 2003-2011 and the subsequent bust period. The firms are categorized into the resource, manufacturing, and service sector based on their primary Standard Industrial Classification (SIC) code. This paper identifies the main (most relevant) commodity price for firms in the resource sector. Meanwhile, for comparison across sectors, this paper uses the aggregate commodity price index and multiplies it with a measure of a firm's sensitivity to commodity price movement. The measure of the firm's sensitivity is obtained from the coefficient of the firm's daily stock price return regression on daily commodity price return for each firm year. This paper uses the S&P GSCI commodity price index as the baseline for commodity price. This price index is based on

[5]At the aggregate level, Fernández, González, and Rodriguez (2018) finds commodity price is procyclical with aggregate investment. It leads the cycle of investment by around three periods ahead.

[6]Cherkasova (2019) examines the role of macroeconomic factors and internal factors on overinvestment. It uses data from 104 public companies in Russia between 2012 and 2017. It finds that oil and exchange rate volatility reduces the probability of overinvestment in Russian companies. However, the study does not differentiate the result across industries and subsequently analyzes the effect of overinvestment on firms' financial performance. Meanwhile, Irawan and Okimoto (2021) examines the impact of the business cycle and macroeconomic uncertainties on firms in resource sector overinvestment. The data uses 584 resource companies across 32 countries from 1986 to 2017. The result shows that overinvestment is relatively sector-specific. Firms in the forestry and paper sector tend to overinvest, while firms in the alternative energy sector tend to underinvest. Furthermore, commodity price inflation is more important in driving firms' overinvestment than commodity price uncertainty. Since Irawan and Okimoto (2021) focuses on resource sector firms, it did not examine any differential effect on the manufacturing and services sectors.

[7]In particular, Irawan and Okimoto (2021) uses panel fixed-effect ordinary least square model to estimate a dynamic panel data. In this context, the model could suffer from Nickell bias. Furthermore, they use a panel probit model to estimate a dynamic panel probit specification. The model might be inconsistent due to the correlation between lagged dependent variable and the unobserved heterogeneity.

a futures contract, reflecting the market participant's expectation. Following Richardson (2006), new investment is defined as total investment less the investment needed to maintain existing assets. In practical term, new investment is equal to capital expenditure less receipt from assets disposal and depreciation expenses.

Estimation of the investment determinants uses several approaches. The approaches include static fixed effect model, difference GMM, and system GMM (baseline). Meanwhile, the estimation of overinvestment determinants also uses several approaches. This includes the correlated random effect (CRE) pooled probit model (baseline), CRE maximum likelihood (MLE) probit model, the standard MLE probit model, the conditional logit model, and the linear model (panel fixed effect model).

The data shows there is a comovement in investment patterns across sectors. The comovement is stronger between resource and service sector. During the commodity boom in the early 2000s, investment increased across all sectors, particularly in the resource and service sectors. Similarly, during the commodity bust period, investment declined across all sectors. The decline in the resource sector is also somewhat more prominent than in the other sectors. Furthermore, the data also shows that the financial performance of firms in the resource sector tends to co-move with the commodity price boom. During the boom period in the 2000s, resource firms' profitability (return on equity) increased while their indebtedness (debt-to-capital ratio) declined. The opposite is also true during the bust period.

The empirical exercise shows the followings. *First*, the share of firms overinvested is around 36 to 39 percent during both the boom and post-boom periods. However, the magnitude of overinvestment is slightly higher during the boom period than the post-boom period, particularly in the resource sector. Across sectors, during the boom period, firms in the resource sector had higher overinvestment, at around 5% of total assets, compared to 4% in the services sector and 3% in the manufacturing sector.

Second, higher commodity price growth is associated with a higher probability of overinvestment for resource firms in both the All Period (the 1990s-2019) and Boom Period (2003-2011). A one standard deviation increase in the commodity price growth rate (i.e., around 22 percentage points) would increase the likelihood of overinvestment by 3.4 percentage points in the All Period and double that at 8.4 percentage points in the Boom Period. The size is quite significant for the boom period, considering the average probability of overinvestment among resource firms is 35%. A one standard deviation increase in the commodity price growth during the boom period would increase the likelihood of overinvesting by around 20%. This effect is slightly dampened during a higher commodity price volatility period. This suggests that resource firms would hold back investment during a higher price volatility period.

Third, The results for sectors outside the resource sector show some spillover effect on the service sector but not on the manufacturing sector. In particular, for the probability of overinvesting (extensive margin), the results are not statistically significant in the service and manufacturing sectors. However, for the degree of overinvestment (intensive margin), the effect is statistically significant for the service sector. Hence, higher commodity price growth increases the overinvestment in both the resource and service sectors. This result confirms the co-movement between the resource and service sector investment in the data.

Fourth, overinvestment adversely affects firms' financial performance. For instance, the positive effect of investment on firms' financial performance is lower had the firms are overinvested. Furthermore, if the firms overinvest most of the time during the nine-year boom period (2003-2011), their financial performance during the bust period (2012-2019) is relatively weaker compared to firms that overinvest less. Looking specifically at the trough of the bust period (2015), which is usually marked by economy-wide financial distress, resource firms that overinvest most of the time during the boom period would have a higher likelihood of having low profitability at the trough of the bust period. These firms might pose risks to the financial system, particularly regarding their external and domestic banking sector debt, during the bust period.

Overall, the analysis shows commodity price growth increases the likelihood of firms overinvesting, especially for firms in the resource sector and, to some extent, the service sector. Meanwhile, higher uncertainty works in the opposite direction. This result might not represent the overall economy because listed firms are generally larger and have better funding access. As a robustness check, this paper conducts structural vector autoregressive (SVAR) analysis using aggregate firm investment data at a quarterly frequency. This data, which comes from Indonesia's investment coordinating agency, covers listed and non-listed firms, hence more representative of the economy. The firms are classified into primary, secondary, and tertiary sectors. The impulse response function shows that commodity price shocks lead to higher investment in the primary sector and, to some extent, in the tertiary sector but not in the secondary sector. Overall, the result of SVAR analysis by using listed and non-listed firms is similar to the baseline result. That is, commodity price has a positive effect on investment in the resource sector and, to some extent, in the service sector.

There are several channels of commodity price growth on overinvestment. These include free cash flow level and external finance cost. Firms that overinvest tend to have higher free cash flow than underinvested firms. Overinvested firms have around five times more free cash flow during the boom than underinvested firms. Across sectors, firms in the resource sector have higher free cash flow than manufacturing and services. Regression analyses show that higher commodity price growth leads to higher free cash flow, particularly for resource firms. Subsequently, overinvesting firms with good liquidity (positive free cash flow) would increase their overinvestment when their free cash flow increases. This result supports the agency costs hypothesis on why firms overinvest. For underinvest firms, firms with negative free cash flow would also increase their investment (less underinvestment) when their free cash flow increases. This result is evidence of the funding constraint hypothesis.

In addition to free cash flow, external funding costs also play a role. Firms that overinvest has lower effective interest rate compared to underinvest firms. The interest rate gap between the overinvest and underinvest firms is larger during the boom period. Regression analyses show that higher commodity price growth reduces the effective interest rate of firms in the resource sector. Furthermore, a lower effective interest rate is associated with higher overinvestment across sectors, particularly in the resource sectors.

This paper also complements the analysis by using corporate loan-level data. The data also supports the findings from the balance sheet data above. In particular, the loan spread is lower, and collateral requirement is more lenient during the boom period. Furthermore, most corporate loans in the data set are in US dollars. The exchange rate appreciation during the boom period might entice the firms to take advantage of lower interest rates abroad. Overall, this easy financing condition might lead to over-borrowing and more significant investment inefficiency during the boom period.

This paper makes several contributions. First, in terms of research questions. It goes beyond assessing the importance of commodity prices in driving the business cycle of resource-rich countries by examining the role of investment channels. It also looks at the sectoral effect of commodity fluctuations and assesses the implication of investment inefficiencies during the boom period on the financial condition during the bust period. Furthermore, this paper also analyzes the transmission mechanism of the commodity price boom to a firm's investment inefficiency. Second, in terms of empirical methods and data. It uses a more consistent estimator compared to the existing studies. It also uses the commodity price most relevant for each resource firm and estimates firms' sensitivity to commodity prices to aid comparison across sectors. It also complements the analysis by using corporate loan-level data.

There are several policy implications from the findings. *First*, the importance of greater monitoring of the corporate sector's finances during the commodity boom period, particularly for firms in the resource sector. This includes monitoring its external debt, which tends to increase during the boom period, and its deposit and borrowing linkage with the banking sectors. Between 2009 (after the global financial crisis) and 2011 (the peak of commodity price), the external debt of non-financial corporate sectors in Indonesia increased by 50 percentage points from around 60 billion US dollars to 90 billion US dollars. The situation might be more pronounced in the resource sector, where around 96% of corporate loans are in the US Dollar, compared to 86% in the overall sample. This foreign currency debt risks a balance sheet effect problem during the bust period. *Second*, the importance of countercyclical macroprudential policies to tame the procyclicality of firms' investments, financial performance, and banks' financial performance. This could be in the form of more stringent lending standards and higher collateral requirements. As the bank's performance is also procyclical to the commodity price cycle, a weaker bank's financial condition during the bust period due to high lending exposure to the resource sector could amplify the adverse terms-of-trade shocks. *Third*, it might be essential to conduct stress tests, not only for the banking sector or financial firms but also for the non-financial corporate sector. For instance, how the crash in commodity price could affect a firm's liquidity and solvency and its effect on the overall financial system stability. *Fourth*, the importance of having a good firm exit resolution to ensure an orderly exit of resource firms during the bust period. This policy could prevent the 'zombie' firm problem, which exists in some countries following an end to an economic boom.

This paper is related to several branches of literature, including literature on the macroeconomic effect of commodity price fluctuation, investment efficiency, investment under uncertainty, and the natural resource curse and Dutch Disease. Literature on the macroeconomic effect of commodity price fluctuation typically shows that commodity price shocks have a significant role in explaining the business cycle. The role of investment as a transmission channel for commodity price shocks has yet to be explored. This paper provides evidence that firms' investments are affected by commodity price fluctuation and subsequently affect their financial performance. In the literature on investment efficiency, the role of commodity price fluctuations on investment efficiency and their implication for a firm's financial performance is still not well documented. Finally, in the literature on the resource curse and Dutch Disease, there is debate whether the resource boom empirically has negative or positive spillovers to the other sectors, including the manufacturing sector, which the theory predicts to be negatively affected by the boom. This paper presents new evidence using firm-level data on the effect of the commodity price boom across sectors. It shows, indeed, there is some evidence of Dutch Disease in Indonesian firms during the 2003-2011 boom period. There was expansion of investment and greater overinvestment in the resource and services sectors during the boom period, yet contraction of investment and underinvestment in the manufacturing sector.

The rest of the paper is organized as follows. Section 2 provides background context for the Indonesian economy during the commodity boom and bust in the 2000s. Section 3 discusses the theoretical framework. Sections 4 and 5 follow with a description of the empirical methodology and the data. The following section presents empirical results and robustness checks. It is closed with the concluding section and policy discussion.

2 Indonesian economy during commodity price booms and busts in 2000s

Indonesian economy was part of the East Asian growth miracle story in the 1980s and 1990s. Following oil price collapse in the mid-1980s, an export-oriented industrialization policy was introduced. As a result, the economy frequently registered 7% to 9% GDP growth rate since then. The economy, however, collapsed during Asian Financial Crisis in 1998, where growth contracted by around 13% in 1998. The recovery was slow and the economy was finally turned around by the boom in commodity prices starting in 2003.[8]

The resource booms and busts in the 2000s have transformed the Indonesian economic structure. Table 1 and 23 (in Appendix) shows the composition of Indonesia's exports and its economic structure over the years. Table 23 shows the agriculture and mining sector constitute around a quarter of Indonesian GDP in 2011 (before commodity prices collapsed), and the share fell to 19% in 2019. In terms of export composition Table 1 shows in 2003, before the commodity boom started, the percentage of primary commodities in Indonesian export was around 48%. By the peak of the commodity boom period in 2011, the share climbed to 65%. The share since then has fallen to around 56% in 2018.

Table 1: Indonesian export structure (in percent)

Products	**2003**	**2011**	**2018**
Petroleum	12	9	4
All Fuels	26	34	23
Primary commodities, excluding fuels	22	31	32
Primary commodities	**48**	**65**	**56**

The fall in commodity prices in 2011 has negatively affected the Indonesian economy. Indonesian GDP growth rate has fallen from over 6% in the years of the commodity boom 2003-2011 to around 5% since then. The current account has fallen from a surplus of around 3% of GDP in the boom years into a deficit of around 3% of GDP in the post-boom period. The exchange rate during the post-boom period is also around 30% weaker than in the boom period. In terms of the business cycle, the contribution of commodity price shocks to Indonesian output fluctuation is relatively large at around 35% to 40% (Prassetya 2020).

Overall, the response of the Indonesian economy during the commodity cycle follows the standard economic response to a large increase in terms-of-trade (Garnaut 2015). Expansion in the booming sectors leads to real appreciation and decline in other tradable industries (manufacturing). The expansion of the middle class during the boom period has also fueled demand for non-tradable (services) (World Bank 2014).

[8]Indonesia's main commodity exports are natural gas, coal, palm oil, iron ore, precious metals, and rubber.

3 Theoretical Framework

3.1 Theory and empirical evidence of investment at the firm level

Theoretically, investment at the firm level is influenced by the profitability of the investment opportunities (as measured by Tobin's q), the firm's net worth or internal resources, the cost of external finance, and agency conflict between managers and outside stockholders (Hubbard 1998, Stein 2003). Higher costs of external finance might lead to underinvestment, while asymmetric information and agency conflict might lead to overinvestment. Managers of publicly traded firms may pursue their own private objectives, which do not necessarily coincide with outside stockholders. For instance, managers may have an excessive taste for running a large firm rather than a profitable one. This could lead to overinvestment, mainly when the level of free cash flow relative to investment opportunities is higher than expected (Stein 2003).

Uncertainty could also affect the level of a firm's investment. Under the assumption of uncertainty and irreversibility (a sunk cost), a firm's decision to wait to invest is part of a value-maximizing investment decision. In particular, firms need to make investment timing decisions that trade off the extra returns from early investment commitment against the benefits of increased information gained by waiting (Bernanke 1983). By incorporating the option to delay the investment, the firm would only invest if Tobin's q exceeds unity with a margin sufficiently large to compensate for the loss of the opportunity to postpone (Hubbard 1994).

A firm's investment could also be influenced by and act as an amplifier of macroeconomic shocks. The financial accelerator theory by Bernanke states that financial-market imperfections could propagate and amplify the business cycle. In particular, positive economic shocks would increase a firm's profit and retained earnings. This would translate to higher firm investment, hence further amplifying the shocks. The channel could also be through asset price. Higher asset prices during the boom period could increase a firm's net worth or collateral value, enabling it to raise more funds for investment.

Empirically, the literature has established that firms with higher investment opportunities (higher Tobin's q) would invest more. The coefficient of q, however, is usually small because stock price could move mainly due to non-fundamental reasons (Caballero 1999). Firms with more cash on hand and less debt also invest more (Stein 2003). Furthermore, positive changes in net worth or internal funds are significantly correlated with higher investment. This correlation is most important for firms that face information-related capital-market imperfection (Hubbard 1998). Kaplan and Zingales (1997) show firm's investment is increasing in the firm's internal resources. Firms with a large debt burden would have difficulty raising funds to undertake new investments.

3.2 Tobin's q investment adjustment cost model

The standard Tobin's q model suggests that investment is a positive function of a variable q, defined as the ratio of the market value of capital to the capital's replacement cost (Obstfeld and Rogoff 1996). The traditional efficient-market theory states that there would be a strong association between Tobin's q and firm investment because Tobin's q is a summary statistic for the market's information about investment opportunities (Stein 2003, Caballero 1999).

The standard model is as follows. The problem of representative firm i in period t over an infinite horizon is to maximize the present discounted value of the flow of dividends, D_t, given by

$$\mathbf{E}_t \sum_{t=0}^{\infty} \beta^t D_{t+i} \tag{1}$$

Where β is the discount factor. Firm's dividend flow is given by

$$D_t = A_t F(K_t, L_t) - w_t L_t - P_t^k I_t - \frac{\chi}{2} \frac{I_t^2}{K_t}, \tag{2}$$

Where A_t is the productivity level, K_t is the stock of capital, L_t is the number of labor, w_t is the wage rate, P_t^k is the price of installing capital, and the last term $\frac{\chi}{2} \frac{I_t^2}{K_t}$ is the investment or capital adjustment cost.

The stock of capital changes overtime, as

$$K_{t+1} = I_t + (1 - \delta) K_t \tag{3}$$

The Bellman equation for the firm's problem is given by

$$V(K_t, A_t) = \max_{I_t, K_{t+1}, L_t} \left(A_t F(K_t, L_t) - w_t L_t - P_t^k I_t - \frac{\chi}{2} \frac{I_t^2}{K_t} + \beta \mathbf{E}_t [V(K_{t+1}, A_{t+1})] \right) \tag{4}$$

subject to the capital transition equation. The first order condition with respect to investment I_t results in:

$$P_t^k + \chi \frac{I_t}{K_t} = \beta \mathbf{E}_t [V_k(K_{t+1}, A_{t+1})] \tag{5}$$

Since tobin's q by definition is the shadow price of capital, the equation 5 could be written as

$$P_t^k + \chi \frac{I_t}{K_t} = \beta \mathbf{E}_t q_{t+1} \tag{6}$$

By rearranging, we obtain

$$\frac{I_t}{K_t} = \frac{1}{\chi}[\beta \mathbf{E}_t q_{t+1} - P_t^k] \tag{7}$$

This equation shows investment is a positive function of a variable q. Furthermore, investment is positive only when the shadow price q of installed capital exceeds the price of new uninstalled capital.

Building on Magud and Sosa (2017), the standard Tobin's q model above could be extended for a low-income commodity exporting country. In this model, the firm operates in one of the three sectors: the commodity sector, manufacturing sector, and service sector. The manufacturing sector uses commodities as input.

In a low-income commodity-exporting country, most of its exports are commodity products, and its imports are manufacturing products. Hence, the terms of trade are equal to the ratio of commodity price to manufacturing goods price. Furthermore, this country imports most of its capital goods and face financing constraint. Hence, the domestic price of capital goods P_t^k depends on the real exchange and interest rates. Both real exchange rate and real interest rate, in turn, are a function of terms-of-trade. Hence, a terms-of-trade boom would appreciate the domestic currency and lower borrowing costs for firms. Both would reduce the price of installing new capital.

With this addition, the investment equation for firms in each sector is the following:[9]

$$\frac{I_t}{K_t} = \frac{1}{\chi}\left[\beta \mathbf{E}_t q_{t+1} + e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right) - 1\right] \tag{8}$$

Similar to the standard Tobin's q model, this equation shows investment is a positive function of a variable q. Furthermore, higher terms-of-trade would appreciate the exchange rate and reduce the interest rate, leading to more increased investment. This equation also suggests that the residuals of empirical estimation of equation 7 (i.e. firms' investment inefficiencies) would be correlated with commodity price.

[9]Further explanation is outline in Appendix section A.1.

4 Empirical methodology

4.1 The effect of commodity price booms and uncertainty on firm's overinvestment

4.1.1 Estimating firms' investment and overinvestment

The estimation is conducted through two steps to examine the effect of commodity price booms and uncertainty on firms' overinvestment across sectors. The first step is estimating the magnitude of firms' overinvestment. The second is estimating the determinants of overinvestment, where commodity price growth and volatility will be included as explanatory variables.

Following Richardson (2006), total investment expenditure could be decomposed into two components. First is investment to maintain existing asset in place. Second is new investment. Furthermore, new investment could be decomposed into two. First is expected investment on new project and second is investment inefficiency on new project. Mathematically could be written as follows.

$$\begin{aligned} I_{total,t} =& I_{maintenance,t} + I_{new,t} \\ =& I_{maintenance,t} + [I^{*}_{new,t} + I^{\epsilon}_{new,t}] \end{aligned} \tag{9}$$

Total investment is defined as capital expenditure less receipt from sale of property, plant, and equipment. Meanwhile investment to maintain existing assets in place is approximated by depreciation expense. Hence new investment is equal to capital expenditure less sale of PPE and depreciation expense.

After obtaining new investment estimate $I_{new,it}$, investment inefficiency is estimated as the residuals of the following dynamic panel data regression model 10.

$$\begin{aligned} I_{new,it} =& \beta_0 + \beta_1 V/P_{i,t-1} + \beta_2 Leverage_{i,t-1} + \beta_3 Cash_{i,t-1} + \beta_4 Age_{i,t-1} \\ &+ \beta_5 Size_{i,t-1} + \beta_6 I_{new,it-1} + \varepsilon_i + \varepsilon_t + \epsilon_{it} \end{aligned} \tag{10}$$

Where $I_{new,it}$ is new investment of firm i at time t, $V/P_{i,t-1}$ is a measure of firm's growth opportunities. It is proxied by Tobin's q (i.e., market value of total assets deflated by the book value of total assets).[10] The rest of the variables are control variables that have been shown in the standard finance literature as the determinants of investment decision. These include leverages $Leverage_{i,t-1}$ (the ratio of total debt balance to total

[10] It is calculated as the ratio of the number of shares multiplied by the market price plus the book value of total debts to the book value of total assets. In the robustness check section, sales growth rate is used as alternative proxy for growth opportunities.

assets), firm size $Size_{i,t-1}$ (the natural logarithm of total assets), firm age $Age_{i,t-1}$, stock of cash $Cash_{i,t-1}$, and prior firm investment level $I_{new,it-1}$. ε_i and ε_t are the firm and year fixed effects, respectively. They capture any time-invariant or entity-invariant unobservable variables that can influence the investment and potentially correlate with the observed explanatory variables. All regressors are lagged by one period to avoid reverse causality (endogeneity).

The model is estimated through several approaches. The first is the static panel approach. This is done by omitting the lagged investments from explanatory variables.[11] The second is a dynamic panel model by using Within Estimator. This Within Estimator, in the context of dynamic panel data, is known to suffer from Nickel bias when N is large, and T is small. To correct this, the third approach is by using Arellano and Bond (1991) approach. That is by taking the first difference of the model and then used the lagged of outcome variable as the instrument. This approach, however, is not consistent when the coefficient of lagged dependent variable is highly persistent. To correct this, the fourth approach uses Blundell and Bond (1998) System GMM, where variables in levels are instrumented with suitable lags of their own first differences. This approach, however, is based on the assumption that instrumenting variables are uncorrelated with the fixed effects. In other words, it requires the samples are not too far from steady states; hence deviation from the long-run average is not systematically related to fixed effects (Roodman 2009). This system GMM approach will be the baseline estimate. A robustness check by using the estimates from Difference GMM and Within Estimator is discussed in the robustness check section.

To estimate the overinvestment, let the residuals $\varepsilon_t + \varepsilon_i + \epsilon_{it} = \mu_{i,t}$. A positive $\mu_{i,t}$ implies overinvestment. Meanwhile, negative value implies underinvestment. In the baseline specification, overinvestment $OVIT_{i,t}$ is measured as binary variable. The robustness check section discusses the result for measuring overinvestment as ordered multinomial and as residuals in level.

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

4.1.2 Estimating the role of commodity price fluctuations on overinvestment

Analysis on the effect of commodity price fluctuations on overinvestments is divided into two parts: (i) on resource firms; and (ii) on firms across sectors (resource, manufacturing, and service sector). For resource firms, this paper uses commodity price that is most relevant for each firm, i.e. the price of commodity that the firm mainly produces or

[11] Hausman's specification test is used to decide between Random Effect and Fixed Effect model. A robust standard error that corrects for cross-sectional heteroskedasticity and within-panel (serial) correlation is used.

mines. Meanwhile for analysis across sectors, this paper uses aggregate commodity price multiplied with the estimates of firms' sensitivity towards commodity price movement. This will be further elaborated below.

4.1.2.1 On firms in resource sector

The estimating equation 11 examines the effect of the commodity price boom and uncertainty on overinvestment in resource firms. The estimation is conducted through several approaches. These include correlated random effect (CRE) pooled probit model, CRE MLE probit model, the standard MLE probit model[12], conditional logit, and linear model (within-estimator FE model). For CRE method, the covariates include firm-specific means of all covariates.

$$
\begin{aligned}
Prob(OVIT_{it} = 1) =& \Phi\Big(\beta_0 + \beta_1 \Delta COMM_{i,t-1} + \beta_2 \sigma COMM_{i,t-1} \\
& + \beta_3 \Delta COMM_{i,t-1} \times \sigma COMM_{i,t-1} + \varepsilon_t + \varepsilon_{i,t}\Big)
\end{aligned} \tag{11}
$$

Where $\Delta COMM_{i,t-1}$ is annual percentage price change of the main commodity produced by firm i and $\sigma COMM_{i,t-1}$ is standard deviation of commodity price (in log) of firm i as measure of commodity price uncertainty.

It is reasonable to assume no Indonesian firms' overinvestment affects world commodity price growth and its standard deviation. This is because each firm is a relatively small supplier of world supply. Hence they are price takers in the international market. To avoid reverse causality, the explanatory variables in estimating equation 11 are also lagged by one period.

The main coefficient of interest from equation 11 are β_1 and β_2. They reflect the response of firms' overinvestment to commodity price fluctuation. The hypothesis is β_1 has a positive value, which implies resource firms have a higher likelihood of overinvestment during the period of commodity price increase/growth. Meanwhile, β_2 is expected to have a negative value; that is, higher commodity price volatility is expected to reduce the probability of overinvestment.

4.1.2.2 On firms across sectors

In analyzing the role of commodity price fluctuation on each firm's overinvestment across sectors (resource, manufacturing, and services), ideally, a good identification requires knowledge of the importance of commodities for each firm in its input. Since the

[12] Hausman's specification test was conducted after both FE and RE models. The result suggests the RE model.

data is unavailable, this paper estimates the importance of commodity prices for each firm. Following Agarwal, Duttagupta, and Presbitero (2020), this paper computes a time-varying sensitivity measure for each firm by estimating the following regression equation 12 on a one-year rolling window for each year and each firm by using daily data.

$$P_{id} = \beta_0 + \beta_1 COMM_d + \beta_2 MarketIndex_d + \epsilon_{id} \tag{12}$$

Where P_{id} is the daily return of the stock price of firm i in day d, $COMM_d$ is the daily growth rate of commodity price in day d, and $MarketIndex$ is the daily return of Indonesia Stock Exchange composite index in day d. The coefficient β measures firm i's sensitivity towards commodity price fluctuation. The measures for firm i's sensitivity in year t ($SENS_{it}$) is the average of daily β_i in year t.

After obtaining the sensitivity measure, the following regressions 13 would be carried out. The models are also estimated by using CRE pooled probit, CRE MLE probit, standard MLE probit, conditional logit and linear model. The baseline result is based on CRE pooled probit.

$$\begin{aligned} Prob(OVIT_{it} = 1) =& \Phi\Big(\beta_0 + \beta_1 \Delta COMM_{t-1} + \beta_2 \sigma COMM_{t-1} + \beta_3 SENS_{i,t-1} \\ &+ \beta_4 \Delta COMM_{t-1} \times SENS_{i,t-1} + \beta_5 \sigma COMM_{t-1} \times SENS_{i,t-1} \\ &+ \beta_6 \Delta COMM_{t-1} \times \sigma COMM_{t-1} \times SENS_{i,t-1} + \varepsilon_t + \varepsilon_{i,t}\Big) \end{aligned} \tag{13}$$

Where $SENS_{t-1}$ is measure of firm i's sensitivity to commodity price fluctuation in year t. $\Delta COMM_{t-1}$ is the annual growth rate of aggregate commodity price index, and $\sigma COMM_{t-1}$ is the standard deviation of aggregate commodity price volatility.

The main coefficient of interest from equation 13 are β_4 and β_5. They reflect the heterogeneous response of firms' overinvestment to commodity price fluctuation, depending on their sensitivity to the commodity sector. The hypothesis is β_5 has a positive value, which implies firms that are more exposed commodity sector will have a higher likelihood of overinvestment during the period of commodity price increase/growth. Meanwhile, β_6 is expected to have a negative value; that is, higher commodity price volatility is expected to reduce the probability of overinvestment.

The estimation is conducted for three groups of firms: (i) resource sector, (iii) manufacturing, and (iv) services sector.

In addition to analyzing the effect of commodity price fluctuations on the probability of overinvestment (extensive margin), this paper also examine the effect on the degree of overinvestment (intensive margin). In doing so, the residuals (investment inefficiency estimate) will be used directly as dependent variable in equation 11 and 13.

4.2 The effect of overinvestment on future financial performance

Firms' overinvestment might negatively affect their financial performance. This study assesses the effect of overinvestments on financial performance through three time frames. The first is in the immediate three years after the investment. Second is during the trough of commodity price bust (i.e. the lowest point of commodity price, which is in 2015). Third is during overall busts period (2012-2019).

4.2.1 Financial performance three period ahead

To examine the effect of overinvestment to firms' future financial performance and financial distress, various measures of financial performance and distress are regressed on investment and overinvestment dummy as well as several control variables commonly identified in the literature as determinants of firms financial performance.[13] The estimating equation 14 is as follows.

$$\begin{aligned} FIN_{i,t} = & \beta_0 + \beta_1 INVT_{i,t-1} + \beta_2 OVIT_{i,t-1} + \beta_3 INVT_{i,t-1} \times OVIT_{i,t-1} \\ & + \beta_4 INVT_{i,t-2} + \beta_5 OVIT_{i,t-2} + \beta_6 INVT_{i,t-2} \times OVIT_{i,t-2} \\ & + \beta_7 INVT_{i,t-3} + \beta_8 OVIT_{i,t-3} + \beta_9 INVT_{i,t-3} \times OVIT_{i,t-3} \\ & + \beta_{10} FIN_{i,t-1} + \beta_{11} SIZE_{i,t-1} + \beta_{12} AGE_{i,t-1} + \varepsilon_i + \varepsilon_t + \epsilon_{i,t} \end{aligned} \tag{14}$$

Where $FIN_{i,t}$ refers to: (i) Return on equity (Profitability measure), (ii) Current ratio (Liquidity measure), (iii) Debt-to-capital ratio (indebtedness measure), and (iv) Total asset turnover ratio (Asset management measure). These variables will be used as a dependent variable one at a time. $INVT_{i,t-1}$ is investment and $OVIT_{i,t-1}$ is overinvestment dummy. $SIZE_{i,t-1}$ is firm sized, proxied by total asset, and $AGE_{i,t-1}$ is firm age. Meanwhile ε_i and ε_t are firm and year fixed effect. All explanatory variables are also lagged by one period to avoid reverse causality.

The main coefficients of interest are the coefficients of $INVT_{i,t-j}$, $OVIT_{i,t-j}$, and $INVT_{i,t-j} \times OVIT_{i,t-j}$, where $j = [1, 2, 3]$. Positive coefficients of $INVT_{i,t-j}$ implies higher investments are associated with better financial performance in the next period(s). Similarly, a negative value of $OVIT_{i,t-j}$ implies higher overinvestment is associated with worse financial performance. A negative value in the coefficient of interaction term $INVT_{i,t-j} \times OVIT_{i,t-j}$ implies the positive effect of past investment on financial performance is reduced if there was overinvestment in that period.

The equation was estimated through several approaches, including within regressor, Difference GMM, and system GMM. The result of system GMM estimations is used as a baseline and presented across various sectors.

[13] e.g. in McWilliams and Siegel (2000), etc.

4.2.2 Financial performance at the trough of bust period

To investigate the effect of overinvestment on firms' financial performance during the trough of the bust period, that is in 2015, the following estimating equation 15 is used on the cross-section of firms in 2015. The trough period or the lowest point of commodity price during the bust period is usually characterized by nation-wide financial distress. It is important to know what influence firms' financial performance during the period.

$$\begin{aligned} Prob(FINlow_{i,2015} = 1) =& \Phi\Big(\beta_0 + \beta_1 FINlow_{i,2014} + \beta_2 OVITYR_i + \beta_3 SIZE_{i,2014} \\ & + \beta_4 AGE_{i,2014} + \varepsilon_{i,t}\Big) \end{aligned} \tag{15}$$

Where $FINlow_t$ is a binary variable of low financial performance (defined as values below the median for each firm), for four financial indicators (i.e., ROE, current ratio, debt-to-capital ratio, and total asset turnover ratio). $OVITYR_{i,t-1}$ is the number of years whereby the firms overinvest during the boom period. The number ranges from 0 (no overinvestment at all during the boom period) to nine (always overinvest during boom period 2003-2011).

The main coefficient of interest is β_2. The hypothesis is the sign of β_2 for ROE, current ratio, and asset turnover to be positive, which indicates the higher occurrence of overinvestment during the boom period would increase the likelihood of low financial performance at the trough of the bust period. Meanwhile, the coefficient for the debt-to-capital ratio is expected to be negative.

4.2.3 Financial performance during overall bust period

Finally, to investigate the effect of overinvestment on firms financial performance during overall bust period (2012-2019), the following estimating equation 16 is used.

$$\begin{aligned} FIN_{i,t} =& \beta_0 + \beta_1 FIN_{i,t-1} + \beta_2 FIN_{i,t-1} \times OVITYR_i + \beta_3 SIZE_{i,t-1} + \beta_4 AGE_{i,t-1} \\ & + \varepsilon_i + \varepsilon_t + \epsilon_{i,t} \end{aligned} \tag{16}$$

Where $FIN_{i,t}$ refers to financial performance, $OVITYR_{i,t-1}$ is the number of years the firms overinvested during the boom period. The number ranges from zero (no overinvestment at all during the boom period) to nine (always overinvest during boom period 2003-2011).

The main coefficient of interest is β_2. The hypothesis is β_2 has a negative sign, which indicates the higher occurrence of overinvestment during the boom period would negatively affect financial performance during the overall bust period.

5 Data and descriptive statistics

5.1 Firms investment and financial data

This paper examines the effect of the commodity price fluctuations on firms' overinvestment across sectors. There are several measures of firm-level investment used in the literature. This paper follows Richardson (2006), where total investment expenditure is equal to the sum of capital expenditure, minus sale of property, plant, and equipment. Meanwhile, as shown by equation 9, total *new* investment is obtained from total investment less investment to maintain existing assets in place, which is approximated by depreciation expenditure.[14]

The primary data source is Refinitive Datastream. For Indonesia, there are 661 listed firms. By excluding banks, financial services, and insurance sectors, 508 firms remain. The classification of firms into resource, manufacturing, and services sector is based on the Standard Industrial Classification (SIC) code of the firm.[15] SIC codes 01-09 (Agriculture, Forestry, Fishing) and 10-14 (Mining) are classified as resource sector. SIC code 20-39 (Manufacturing) is classified as the manufacturing sector. All other SIC codes are classified as services sector. The number of firms for each SIC code and the corresponding sector is listed in Table 26 to 28 in Appendix.

5.2 Commodity prices data

This study uses both firm-specific commodity prices and aggregate commodity price indexes. The firm-specific commodity price is the price of commodity mainly produced by each resource firm. Meanwhile the aggregate commodity price index is the commodity price composite index.

Both firm-specific commodity prices and aggregate commodity price index come from three alternative sources of commodity price data. The first one is S&P Goldman Sachs Commodity Index (GSCI). This index is based on a futures contract, reflecting current market expectations of future commodity prices. The second is the World Bank commodity price. This is based on the actual price realization rather than a future contract. While the value of GSCI and World Bank commodity price indices are the same for all countries, the third alternative for commodity price is a country-specific (in this case

[14]There are several alternative definitions of investment used in literature. For instance, the one by Magud and Sosa (2017) uses capital expenditure as a share of total assets as the investment. Another alternative definition is an investment as the change in total capital divided by the average total assets (e.g., Irawan and Okimoto (2021)). Where capital represents a 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. Other alternatives are the change in the value of net fixed asset (e.g. Albulescu et al. (2018)) and capital expenditures per existing unit of capital (e.g. Barrero, Bloom, and Wright (2017)).

[15]As a firm might produce goods classified into several SIC code, this paper use the SIC code of main products made by firms.

Indonesia-specific) commodity terms-of-trade index by Gruss and Kebhaj (2019). This index is also based on the actual price realization, not reflecting expectation as in GSCI data. In all cases of the indices, both the annual growth rate and annual standard deviation will be used to analyze the effect of commodity price growth rate and uncertainty, respectively. The baseline estimates use GSCI index, while the World Bank and IMF indices are used as a robustness check.

5.3 Descriptive statistics

5.3.1 Summary statistics

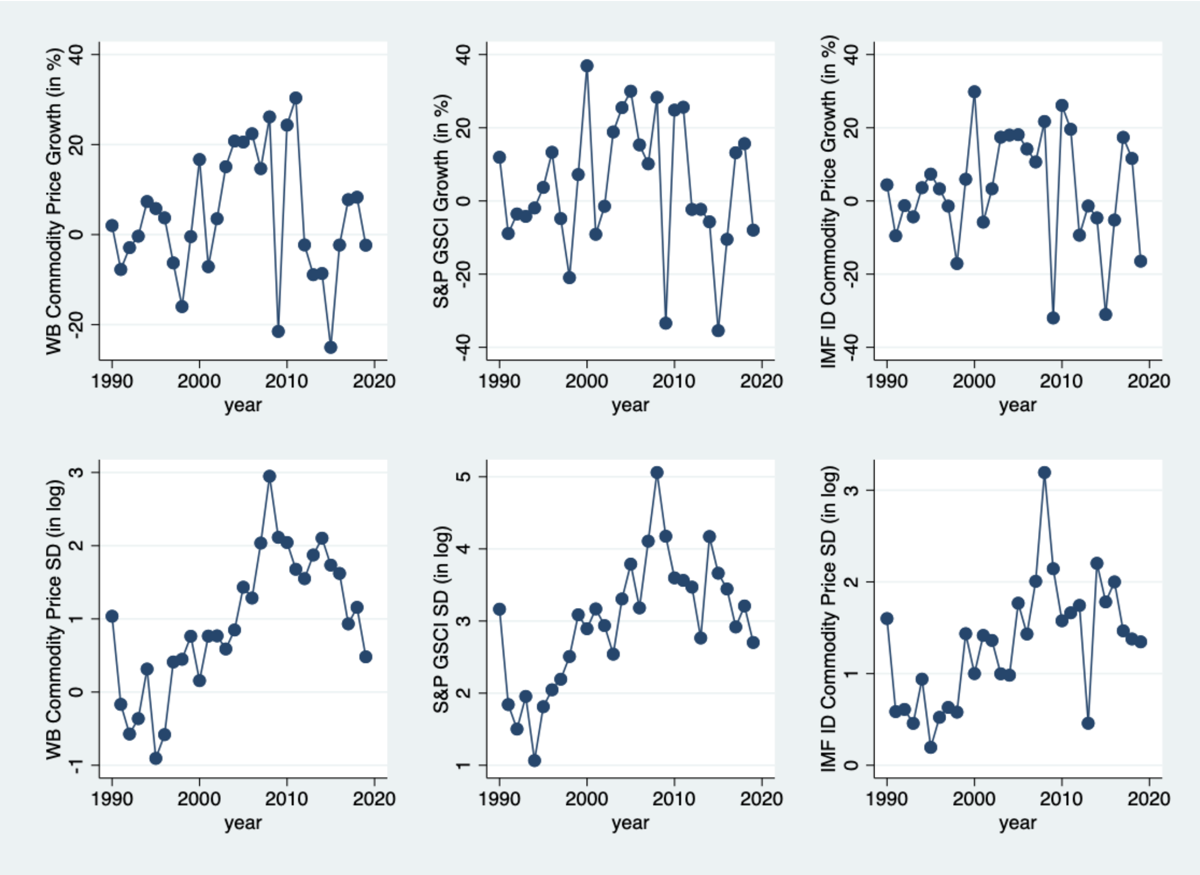
Table 24 and Table 25 in Appendix show summary statistics and correlation table across selected variables, respectively.[16] The summary statistics show the average investment level (capital expenditure net of depreciation) is around two percent of total asset. It is slightly higher is the resource sector, compared to the other sector. Meanwhile capital expenditure and depreciation expense is also generally higher in the resource sector. Tobin's Q, as measure of growth opportunities is also higher in the resource sector. The level of cash, age, and assets are also slightly higher in the resource sector. Meanwhile the correlation table shows the correlation between investment and commodity price growth rate is positive and statistically significant. Its correlation with commodity price standard deviation (a measure of price volatility) is negative and statistically significant. The table also shows firms' financial performance is related to firms' investment. The measure of firms' profitability (i.e., ROE) is positively correlated with investment. Meanwhile, measures of firms' indebtedness (debt-to-asset ratio and debt-to-capital ratio) are negatively correlated with investment, suggesting firms with high debt tend to have low investment. The correlation between investment and Tobin's Q is positive and statistically significant as expected.

5.3.2 Commodity price index

Figure 1 shows the growth rate and standard deviation of S&P GSCI index, World Bank commodity price index, and the Indonesia-specific IMF commodity price index. The pattern of the three series of commodity price indexes are similar, even though the GSCI index is based on a futures contract and the other two indices are based on the actual price realization. The standard deviation shows an increasing trend from the mid-1990s to 2008 and then a relatively volatile movement afterward. Commodity price growth rates are around 20 percent annually during the commodity boom 2003-2011 period (except during the global financial crisis 2009).

[16] Data definition, transformation, and source are described in the Appendix

Figure 1: Commodity price index



Source: Refinitive Datastream, World Bank, and IMF.

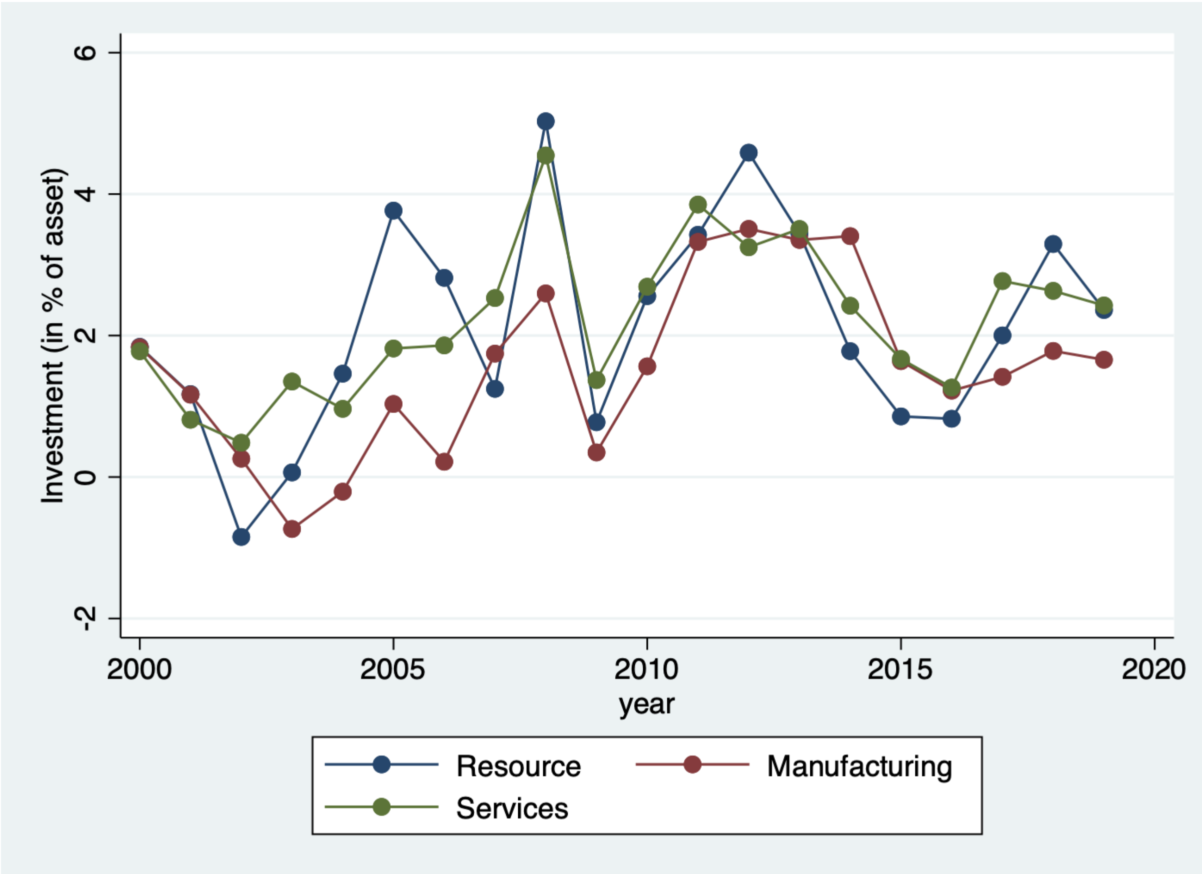
Note: The first row is the annual percentage change in commodity price growth. The second row is the yearly standard deviation obtained from monthly data each year. WB = World Bank, S&P GSCI = Standard and Poor's Goldman Sachs Commodities Index, IMF = International Monetary Fund.

5.3.3 Investment across sectors

Figure 2 shows the average of firms' investment across years and sectors from the year 2000 onward.[17] The data shows that the investment of resource sector firms is slightly higher than the other sectors during the commodity boom period, reaching 5% of total assets. The size of investment in the service sector closely follows the resource sector, suggesting a spillover from the resource boom. Meanwhile, the manufacturing sector's investment is generally lower than the other sectors, suggesting Indonesia's dutch disease or deindustrialization during the commodity boom period.

[17] Data in the 1990s are omitted to show a clearer pattern of investment during booms and busts in 2000s. A figure with complete data (since 1990s) shows an elevated level of investments in the 1990s, reflecting the overinvestment prior to the devastating Asian Financial Crisis 1998.

Figure 2: Firms investment across sectors



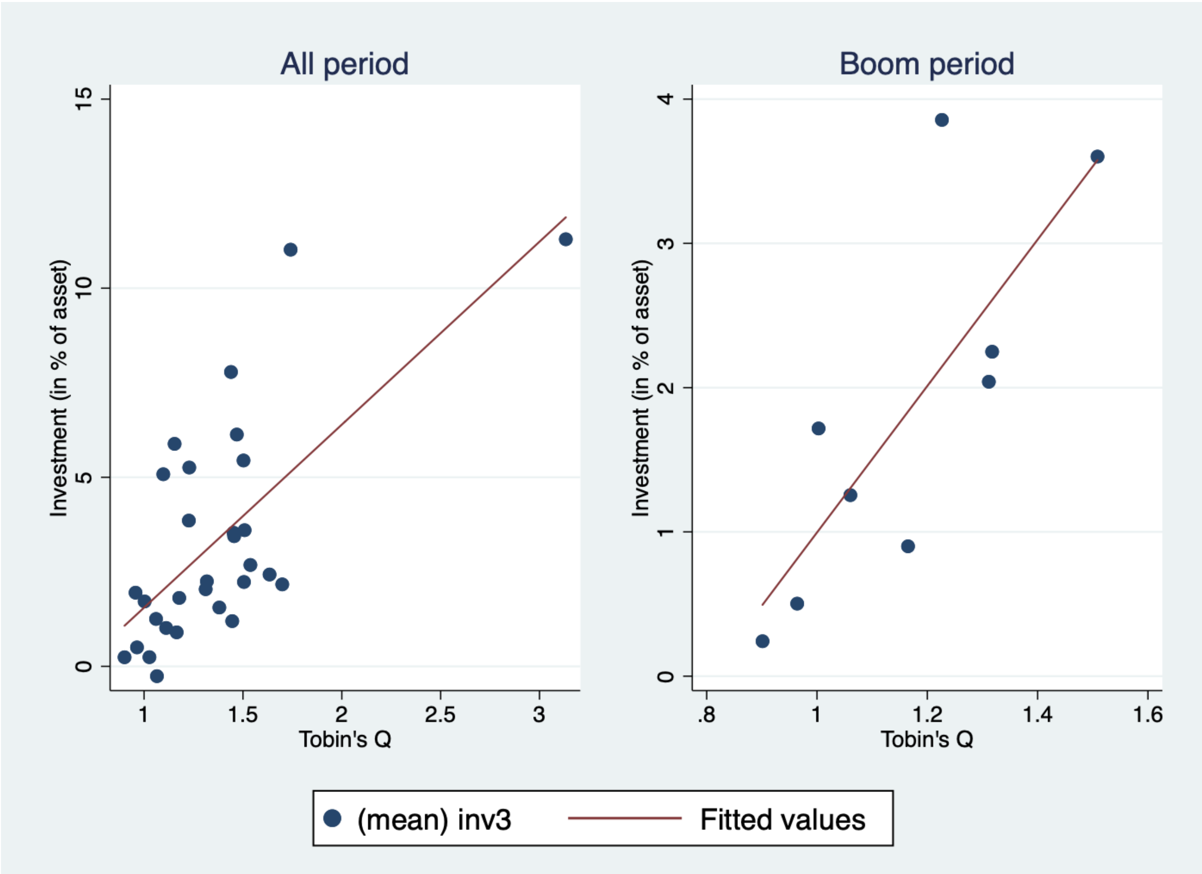
Source: Refinitive Datastream.

Note: Firm's investment refers to new investment, calculated as capital expenditure less receipt of asset disposal and depreciation expense. Sectoral classification is based on SIC 2 digit code.

5.3.4 Tobin's Q

Figure 3 shows the scatter plot between Tobin's q and investment during both All and Boom Period. The result confirms the theory that a higher Tobin's q value is associated with higher investments.

Figure 3: Firms investment and Tobin's q



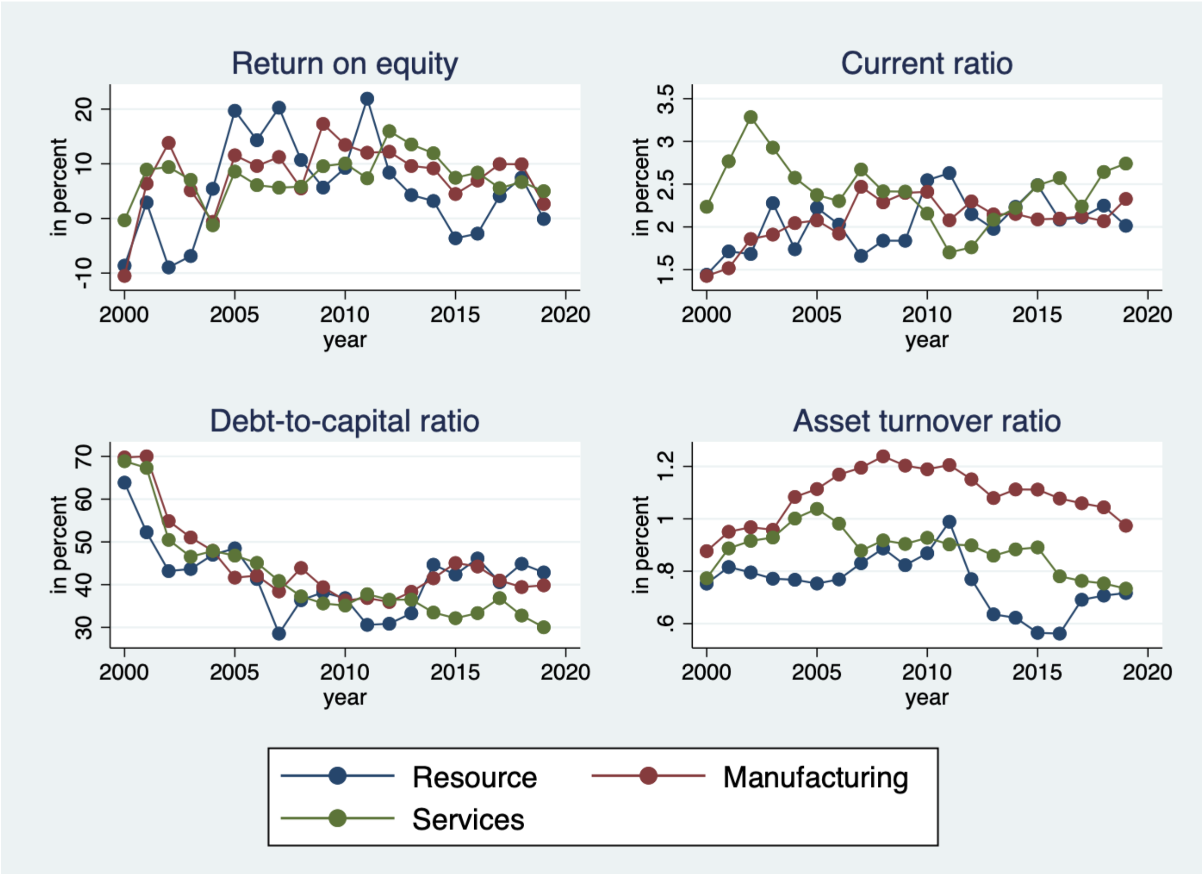
Source: Refinitive Datastream.

Note: Tobin's q is calculated as the ratio of the number of shares multiplied by the market price plus the book value of total debts to the book value of total assets.

5.3.5 Financial performance across sectors

Figure 4 shows the average of firms' financial performance across years and sector. It shows several notable observations. *First*, on profitability, the ROE of firms in the resource sector shows high co-movement with the resource boom period. As the commodity boom gained pace in the early 2000s, the ROE of firms in the resource sector increased quite considerably, reaching around 20 percent, higher than firms in other sectors. Nonetheless, as the commodity boom ended, the ROE declined sharply, whereas generally, firms in the resource sector have lower ROE than other sectors. *Second*, on liquidity, the figure shows resource firms' current ratio increased slightly during the boom period. *Third*, the debt-to-capital percentage of all firms, including the resource firms, declined since the early 2000s. During a boom period, firms in the resource sector generally have a lower debt-to-capital ratio but increase substantially after the boom ends. *Fourth*, on total asset turnover (TAT), the TAT of resource firms is generally lower than the other firms. The TAT increases during boom period and falls considerably during the post-boom period, showing an inefficient use of assets after the end of the boom. Overall, the figure shows the financial performance of resource-rich firms is strongly linked to the commodity price boom from 2003-2011.

Figure 4: Firms financial performance across sectors



Source: Refinitive Datastream.

6 Empirical results

6.1 Estimating overinvestment across sectors

Table 2 shows the determinants of investment across different panel data models (i.e., static fixed effect, dynamic fixed effect, difference GMM, and system GMM) presented in equation 10. In general, the signs of the coefficients are consistent across the four models, and they are as expected from the theory. For instance, the previous period's investment is associated with higher investment in the next period. The coefficient is roughly 0.3 across models. The previous period Tobin's q, a measure of growth prospect, is positively associated with an investment in the next period. The stock of cash is also positively associated with investments. Meanwhile, the coefficients of age and size are negative, showing that a more mature and large firm tends to have a lower investment ratio. Similarly, the leverage ratio is negatively associated with the investment, showing that highly indebted companies invest less in the next period.

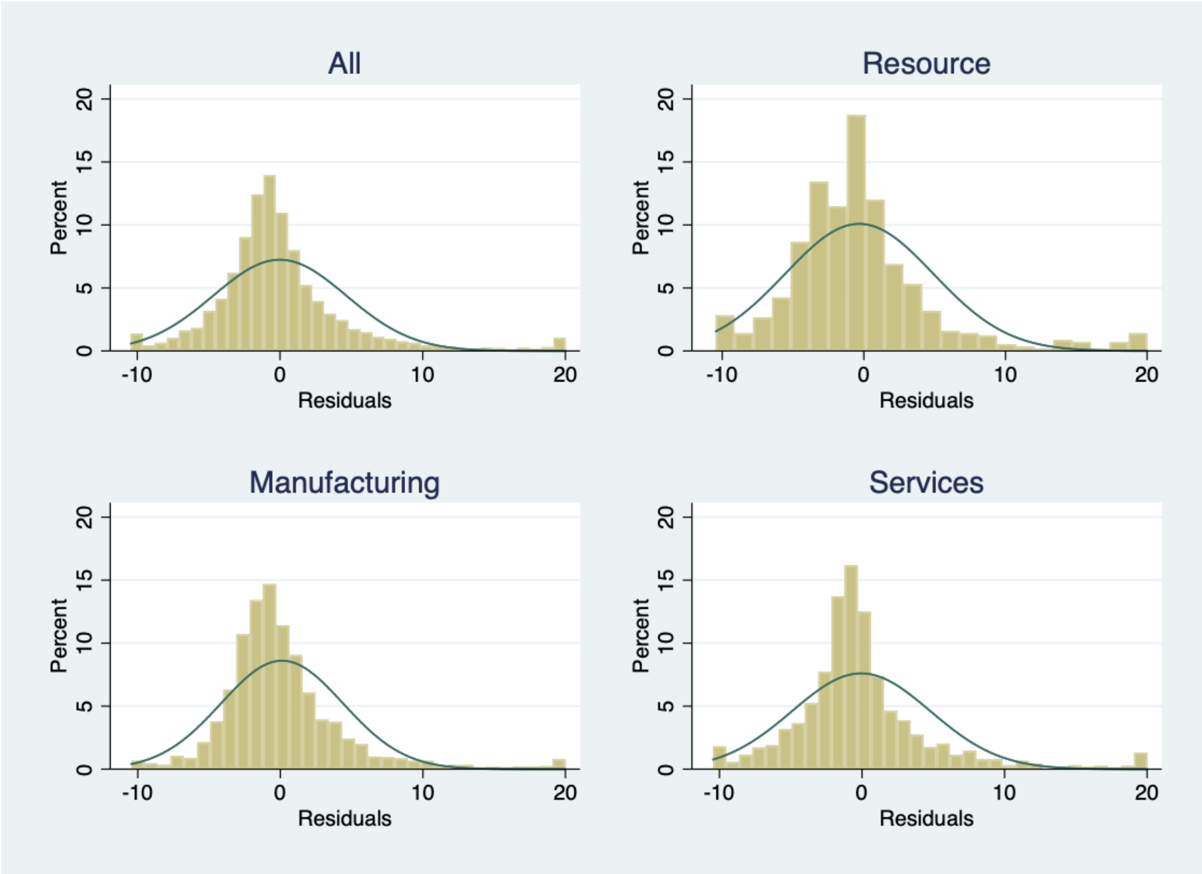
Table 2: Determinants of firms investments across different approaches

	(1) Static FE	(2) Dynamic FE	(3) Difference GMM	(4) System GMM
Investment (t-1)		0.329***	0.340***	0.360***
		(0.023)	(0.038)	(0.035)
Tobin's Q (t-1)	0.274**	0.160	0.024	0.218**
	(0.120)	(0.101)	(0.256)	(0.086)
Leverage (t-1)	-0.040***	-0.031***	-0.039***	-0.025***
	(0.007)	(0.005)	(0.010)	(0.004)
Cash (t-1)	0.084***	0.089***	0.089***	0.064***
	(0.023)	(0.021)	(0.027)	(0.019)
Age (t-1)	-0.768***	-0.571***	0.167***	-0.031*
	(0.251)	(0.214)	(0.064)	(0.017)
Size (t-1)	-0.028	-0.401**	-2.805***	0.136**
	(0.208)	(0.169)	(0.652)	(0.065)
Constant	17.357**	21.074***		-1.752
	(6.745)	(5.578)		(1.420)
Observations	4979	4949	4516	4949
R^2	0.115	0.222		

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable is new investment at time t. New investment in measured as total capital expenditure less depreciation expense divided by total assets. Estimations for the four models include both firm and year fixed effects. Robust standard error is used.

The result of system GMM estimation (column 4) is used as the baseline specification to calculate firms' investment inefficiency (i.e., the residuals or the difference between an actual investment with the predicted values from investment functions). Figure 5 shows the distribution of firms' investment residuals. It generally shows the distribution is slightly skewed to the left, showing the majority of firms or observations underinvest in the sample period.

Figure 5: Histogram of firms' investment residuals estimates



Source: Estimation result.

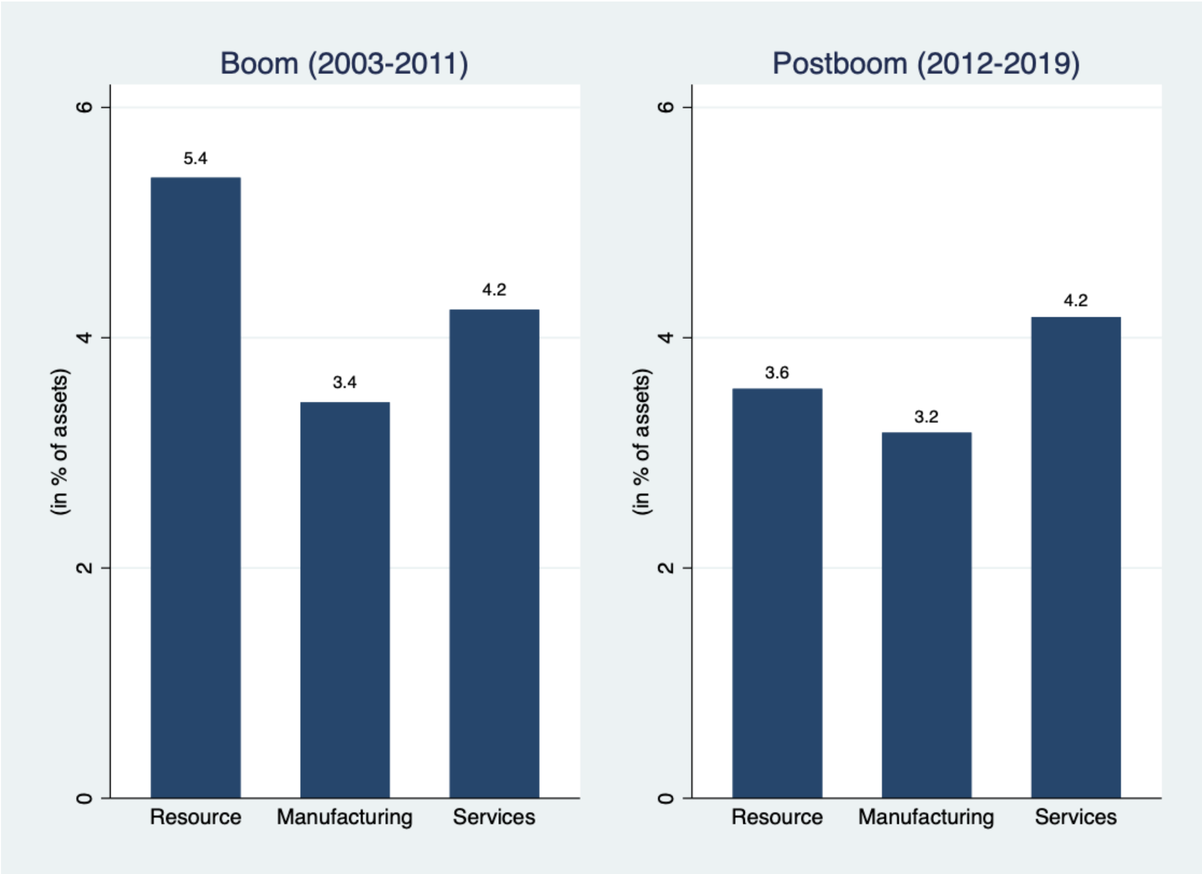
Note: Firm's investment inefficiency is obtained from the residuals of regression equation 10.

Figure 16 in the Appendix shows the share of observations overinvested during the boom (2003-2011) and post-boom period (after 2011). The figure shows that the share of firms that overinvest is modest, at around 36 to 38 percent during the boom period and 36 to 45 percent during the post-boom period. During the boom period, the share of firms overinvested is about the same across all sectors. Meanwhile, during the post-boom period, the share of firms overinvested is also about the same in the resource and service sector but slightly more prominent in the manufacturing sector at 45%.

Figure 16, however, does not consider the magnitude of overinvestment. Figure 6 shows the average magnitude of overinvestment across sectors for both the boom and post-boom periods. It shows that the magnitude of overinvestment is slightly higher during the boom period (between 3% to 5% of assets) than during the post-boom period

(3% to 4% of assets). Across sectors, the magnitude is higher in the resource and services sector during the boom and the services sector during the post-boom period. Within the resource sector, Figure 18 in the Appendix shows that overinvestment during the boom period is more prominent in the oil and coal industry and relatively low in the palm oil industry.

Figure 6: Average of firms overinvestment estimates across sectors



Source: Estimation result.

Note: The bar shows the average magnitude of overinvestment residuals (positive investment inefficiency) across sectors.

6.2 Determinants of overinvestment

6.2.1 Firms in resource sector

What determines the overinvestment? Do commodity price fluctuations play a role? Table 3 shows the determinants of overinvestment by using variations of the panel probit model in equation 11 for firms in the resource sector in the All Period (1990-2019). Meanwhile, Table 4 shows the result for the Boom Period (2003-2011).

The result for All Period in Table 3 shows several notable observations. *First*, the coefficient of commodity price growth is positive and statistically significant across all specifications.[18] This confirms the hypothesis that a commodity price boom will increase the likelihood of resource firms overinvesting. *Second*, the coefficient of commodity price volatility (standard deviation) is also positive and statistically significant. However, the interaction between commodity price growth and volatility is negative and statistically significant. This negative coefficient suggests that the effect of commodity price growth on overinvestment in resource firms is reduced when the volatility of commodity prices is higher. The result across various models are consistent.

Table 3: Determinants of overinvestments of resource firms across different specifications (All Period)

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.054***	0.055***	0.045**	0.018***
	(0.015)	(0.019)	(0.019)	(0.005)
CP SD (t-1)	0.338***	0.327**	0.227*	0.075
	(0.118)	(0.132)	(0.122)	(0.046)
CP growth x CP SD	-0.016***	-0.017***	-0.014***	-0.005***
	(0.005)	(0.005)	(0.005)	(0.001)
Observations	566	566	566	566

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

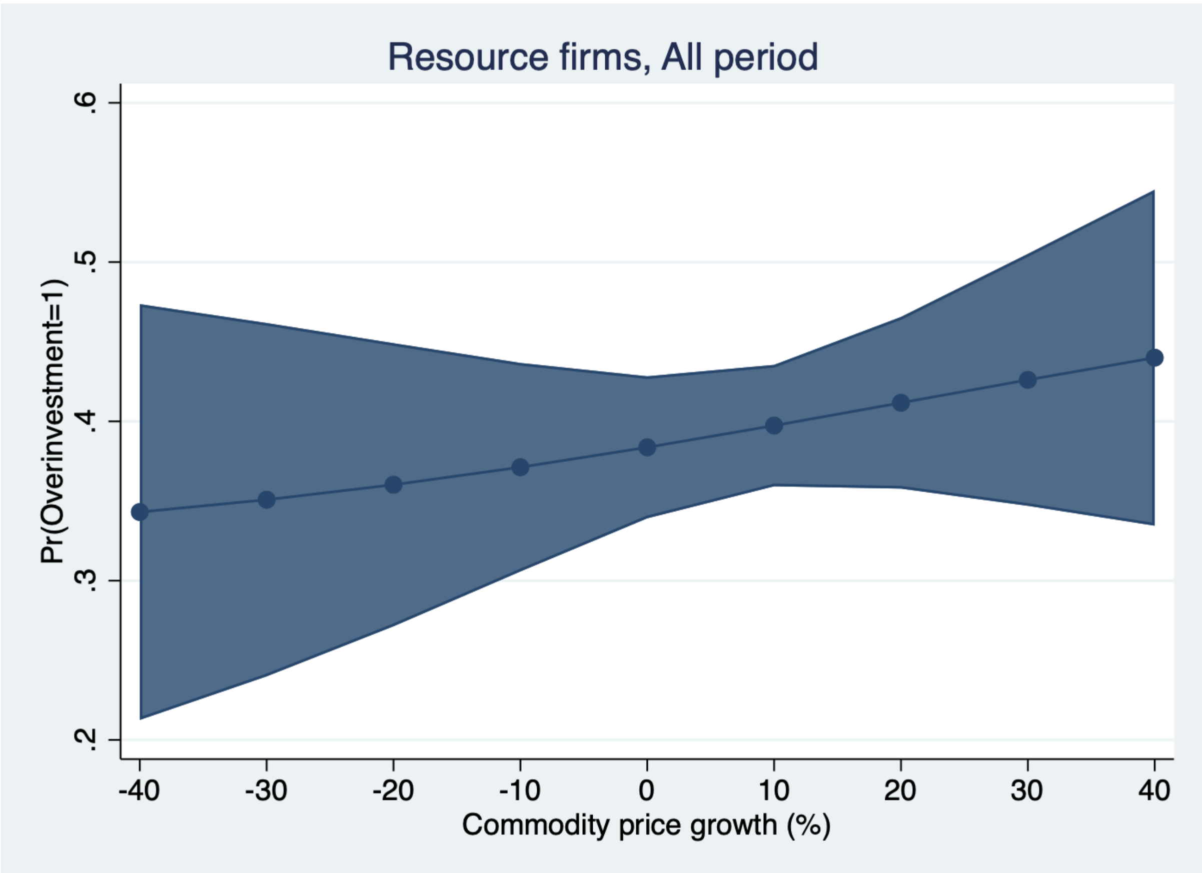
In terms of marginal effect, one standard deviation increase in the commodity price growth rate (i.e., around 22 percentage points) would increase the likelihood of overinvestment by 3.4 percentage points. The size is modest, considering the average probability

[18]The result for the conditional logit model is not shown to save space. The sign and statistical significance are also similar to the other models.

of overinvestment among resource firms is 38%. Hence, one standard deviation increase in commodity price growth would increase the likelihood of overinvesting by almost 10%.

Figure 7 shows the average adjusted probability (AAP) of overinvestment across various values of commodity price growth while holding all other variables at their observed values during the All Period.[19] It shows that higher commodity price growth leads to a higher probability of overinvestment. An increase in commodity price growth from zero to 20%, for instance, increases the probability of overinvestment from 38% to 41%. Meanwhile, Figure 8 shows the effect of commodity price volatility on the AAP. Higher commodity price growth leads to a higher probability of overinvestment during a low commodity price volatility (set at two standard deviations below the mean). Meanwhile, during a high commodity price volatility period (set at two standard deviations above the mean), a higher commodity price growth would lead to a lower probability of overinvestment. This result shows that firms tend to be more careful when investing during high uncertainty.

Figure 7: Average adjusted prediction of overinvestment over commodity price growth rate (All Period)



Source: Estimation result.

[19]The estimate is based on CRE Pooled Probit estimate (column 1 of Table 3).

Figure 8: Average adjusted prediction of overinvestment during low and high volatility (All Period)

Source: Estimation result.

Note: High and low volatility refers to plus and minus two standard deviation of commodity price growth rate.

The estimation result for the Boom Period (2003-2011) is shown in Table 4. Similar to the result in All Period, the sign of commodity price growth is positive and statistically significant. The interaction with commodity price volatility is also negative and statistically significant. It reaffirms that higher commodity price growth would lead to a firm's overinvestment. The coefficient for commodity price growth is slightly larger in the Boom Period than in the All Period.

In terms of marginal effect, one standard deviation increase in the commodity price growth rate (i.e., around 24 percentage points) would increase the likelihood of overinvestment by 8.4 percentage points (around double the effect in the All Periods). The size is relatively large, considering the average probability of overinvestment among resource firms during the Boom Period is 36%. Hence, one standard deviation increase in commodity price growth would increase the likelihood of overinvesting by around 23%.

Table 4: Determinants of overinvestments of resource firm across different specifications (Boom Period)

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.101*** (0.028)	0.101*** (0.032)	0.075** (0.033)	0.030*** (0.010)
CP SD (t-1)	0.322 (0.229)	0.321 (0.250)	0.256 (0.220)	0.084 (0.073)
CP growth x CP SD	-0.028*** (0.008)	-0.028*** (0.009)	-0.022** (0.009)	-0.008*** (0.002)
Observations	169	169	169	169

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

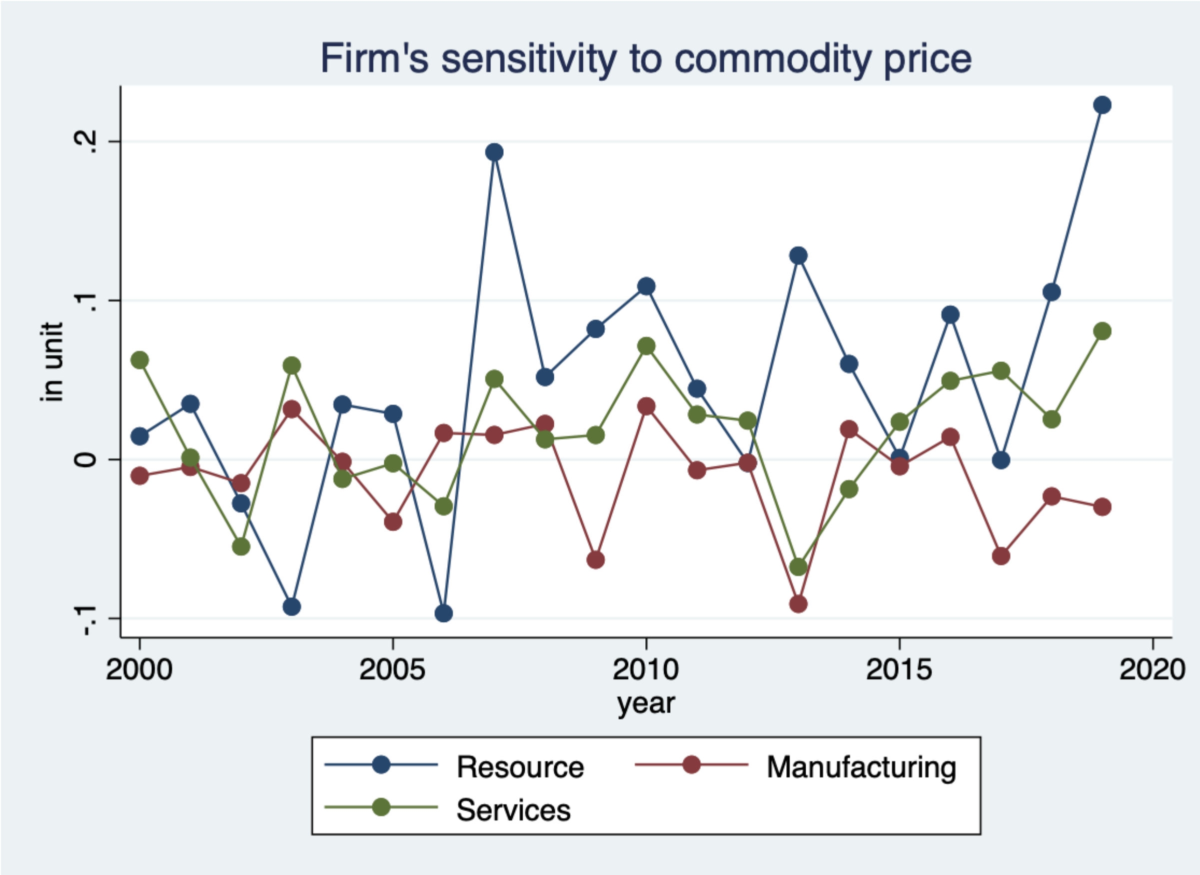
6.2.2 Firms across sectors

Do the effects of commodity price fluctuations on overinvestment probability differ across sectors? The identification of the impact of commodity price *across sectors* is based on the estimates of each firm's sensitivity to commodity price movement as discussed in section 4.1.2.2. The following section discusses the result of firms' sensitivity estimates from regression equation 12 and the corresponding determinants of overinvestments in regression equation 13.

6.2.2.1 Firms' sensitivity to commodity price fluctuations

Figure 9 shows the estimates of firms' sensitivity to commodity price fluctuations (yearly average) across sectors. As expected, the sensitivity is generally positive and higher for firms in the resource sector. The sensitivity revolves around zero for the manufacturing sector. Meanwhile, for the service sector, the estimates are slightly higher than the manufacturing sector but lower than the resource sector. This heterogeneity across sectors is per the theoretical prediction that the service sector would expand during the commodity boom.

Figure 9: Estimates of firms' sensitivity to commodity price fluctuations



Source: Refinitive Datastream and IMF.

Note: The graph shows the estimates of firm's sensitivity to commodity price from regression equation 12.

6.2.2.2 Determinants of overinvestment probability across sectors (extensive margin)

Table 5 and 6 show the determinants of overinvestments (extensive margin) across sectors for All and Boom Period observations by using the CRE pooled probit specification (first column in Table 3). The first, second, and third columns show the results of the resource, manufacturing, and service sectors. For the All Period, comparison across sectors shows that the interaction term coefficient between commodity price growth and firms' sensitivity is only positive and statistically significant in the service sector. The coefficient is positive in the resource sector and negative in the manufacturing sector. This different sign is as predicted by the theory. However, they are not statistically significant.

Meanwhile, Table 6 shows the result across sectors for the *boom* period. Similar to the All Period result, the service sector's coefficient is only statistically significant. Overall, the results of comparison across sectors show commodity price boom would increase the

Table 5: Determinants of overinvestments probability (extensive margin) across sectors (All Period)

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	0.919	0.168	-0.019
	(0.825)	(0.403)	(0.486)
Commodity price growth (t-1)	0.055	-0.070	0.007
	(0.097)	(0.261)	(0.006)
Commodity price SD (t-1)	-1.135	-0.502	0.593*
	(1.657)	(2.302)	(0.343)
SENS x Commodity price growth	0.063	-0.005	0.102**
	(0.087)	(0.038)	(0.044)
SENS x Commodity price SD	-0.289	-0.090	-0.040
	(0.279)	(0.145)	(0.167)
SENS x CP growth x CP SD	-0.012	0.002	-0.030**
	(0.027)	(0.012)	(0.014)
Observations	566	2110	2272

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

overinvestment probability in the services sector. The effect on the other sectors are not statistically significant.

Table 6: Determinants of overinvestments probability (extensive margin) across sectors (Boom Period)

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-4.270	-1.687	-0.738
	(4.136)	(2.335)	(2.133)
Commodity price growth (t-1)	0.002	0.001	-0.007**
	(0.008)	(0.003)	(0.003)
Commodity price SD (t-1)	0.015	0.203	-0.356*
	(0.499)	(0.198)	(0.205)
SENS x Commodity price growth	0.332	0.050	0.253**
	(0.269)	(0.128)	(0.119)
SENS x Commodity price SD	1.226	0.335	0.099
	(1.154)	(0.603)	(0.596)
SENS x CP growth x CP SD	-0.090	-0.008	-0.070**
	(0.073)	(0.032)	(0.032)
Observations	169	724	698

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

6.2.2.3 Determinants of the degree of overinvestment across sectors (intensive margin)

The previous subsection shows that the effect of commodity price growth in terms of extensive margin (likelihood to overinvest) is limited in the services sector only. Does the result also similar in terms of intensive margin? The paper uses the estimates of firms' investment inefficiencies (residuals) as the dependent variable to examine this.

Tables 7 to 8 show the comparison across sectors.[20] It shows a slightly different result compared to the extensive margin. For the All Period, higher commodity price leads to higher overinvestment in both resource and services sectors. Previously, the coefficient was only statistically significant for the service sector in the extensive margin. However,

[20]The result for resource sector is shown in Table 45 in Appendix. It shows a similar result with an extensive margin.

intensive margin results are not statistically significant for the Boom Period for any sector.

Table 7: Determinants of the degree of overinvestments (intensive margin) across sectors (All Period)

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	0.261	-1.116	-1.429
	(3.629)	(2.125)	(1.870)
Commodity price growth (t-1)	-0.052	0.412	-1.655***
	(0.070)	(2.020)	(0.110)
Commodity price SD (t-1)	-1.844	-5.496	16.051***
	(2.451)	(17.341)	(1.390)
SENS x Commodity price growth	0.826***	-0.025	0.177*
	(0.304)	(0.133)	(0.101)
SENS x Commodity price SD	-0.075	0.288	0.533
	(1.135)	(0.674)	(0.610)
SENS x CP growth x CP SD	-0.217**	0.010	-0.057*
	(0.096)	(0.042)	(0.033)
Observations	566	2110	2273

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment estimates (residuals of investment function in equation 11). Estimations use Random-effects GLS regression and include firm and year fixed effects. Robust standard error is used.

Table 8: Determinants of the degree of overinvestments (intensive margin) across sectors (Boom Period)

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-3.933	-2.181	-3.079
	(14.603)	(3.841)	(8.347)
Commodity price growth (t-1)	-0.010	-0.002	0.005
	(0.031)	(0.009)	(0.008)
Commodity price SD (t-1)	-0.005	0.002	0.013
	(0.191)	(0.058)	(0.064)
SENS x Commodity price growth	1.172	0.111	0.629
	(0.845)	(0.258)	(0.467)
SENS x Commodity price SD	1.432	0.676	0.815
	(4.162)	(1.053)	(2.254)
SENS x CP growth x CP SD	-0.310	-0.011	-0.166
	(0.235)	(0.069)	(0.116)
Observations	169	724	698

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Dependent variable: Overinvestment estimates (residuals of investment function in equation 11). Estimations use Random-effects GLS regression and include firm and year fixed effects. Robust standard error is used.

6.2.2.4 Evidence from aggregate data: VAR approach

The results so far use publicly listed firm-level data to analyze the influence of commodity price fluctuations on firms' investment inefficiency, both for firms in the resource sector only and comparison across sectors (resource, manufacturing, and service sector). The result shows that commodity price growth increases the likelihood of firms overinvesting, particularly for firms in the resource sector, and to some extent, for firms in the service sector. Since the data is based on publicly listed firms, the result might be different for non-listed firms.

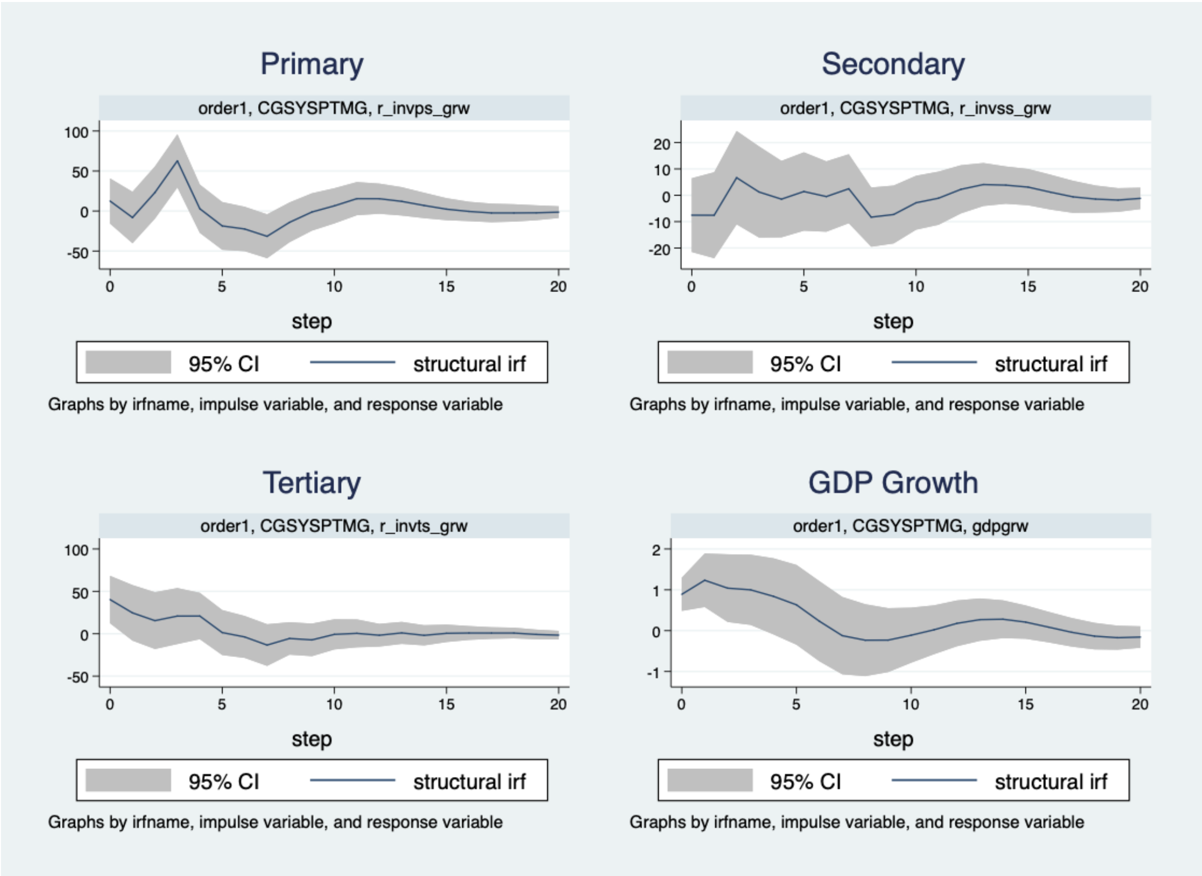
As a robustness check, this section presents evidence of the Structural Vector Autoregression (SVAR) model using aggregate investment data across sectors (primary, secondary, and tertiary), which cover both listed and non-listed firms.

The data is published by the investment coordinating agency (BKPM). BKPM issues investment licenses for both domestic and foreign direct investment in Indonesia. Every quarter, each firm should file an Investment Performance Report detailing their investment realization/disbursement amount to BKPM. The data, however, exclude investment in the upstream oil and gas sector, banking, non-bank financial institution, insurance, home industry, and micro & small business.[21]

The data is quarterly data from 1993Q1 to 2020Q1. The result generally confirms the firm-level data findings. Granger causality test shows commodity price shocks granger cause investment in the primary sector but not in the other sectors. Meanwhile, the impulse response analysis in Figure 10 shows commodity price shocks would increase investment in the primary sector with around a three-quarter lag. The effect dies out quite quickly. The response of investment in the secondary sector is not significant, however, the response of the service sector is statistically significant. Overall, this analysis supports the theoretical prediction of the effect of commodity booms across sectors.

[21] The investment license for firms in these sectors does not fall within BKPM mandate.

Figure 10: Impulse response function (Commodity price shocks)



Source: Author estimates.

Note: The graph shows the response of investment in the primary, secondary, and tertiary sector from one standard deviation shocks in commodity price growth. The SVAR specification uses block exogeneity restrictions, where commodity price is not affected by the other variables other than its own lags. The impulse response functions is identified by using the Cholesky decomposition.

6.3 The effect of overinvestment on financial performance

Does overinvestment leads to worse financial performance? This section analyzes the effect of overinvestment on firms' financial performance across three time periods: (i) three-years ahead; (ii) during the trough of bust period (i.e. 2015); and (iii) during the overall bust period (2012-2019).

6.3.1 Financial performance three years ahead

Does a firm's overinvestment affect its financial performance in the subsequent (three) periods after the firm invested? This section reports the result of the regression model 14 for four outcome variables: profitability (proxied by ROE), liquidity (proxied by current ratio), leverage (proxied by debt-to-capital ratio), and efficiency of assets management/use (proxied by total assets turnover).

Table 9 shows the regression result across four financial indicators. The coefficient of interest is the coefficient of the interaction term between investment and overinvestment ($InvestOVER$). A negative coefficient implies that overinvestment negatively affects a firm's financial performance by reducing the positive effect of investment. The table shows that the coefficient of $InvestOVER$ is negative and statistically significant for ROE, current ratio (CR), and TAT (total assets turnover). This shows that overinvestment would lead to lower profitability (up to three periods ahead), less liquidity, and less efficient use of assets. Meanwhile, the coefficient of $InvestOVER$ is positive (yet not statistically significant) for DCR (debt-to-capital ratio). This shows that overinvestment would lead to higher indebtedness.

Does the effect vary across sectors? Table 10 shows the regression result for ROE across sectors. The coefficients of $InvestOVER$ are statistically significant in the manufacturing, services, and overall sector. Table 31, 32, and 33 in the Appendix shows the result across sectors for Current ratio, Debt-to-capital ratio, and Total asset turnover, respectively. Most of these variables' results are not statistically significant for the resource sector.

6.3.2 Financial performance at the peak of bust period

The result in the previous section shows some evidence of the adverse effect of firms' overinvestment on financial performance in the immediate one to three years after the firm invested. A related question is whether firms that overinvest most of the time during the boom period would have a weaker financial performance during the trough of busts period (i.e., in 2015, when commodity prices reached the lowest point). In doing so, equation 15 is estimated, where the dependent variables are dummy variables equal to one if the value of financial performance is low (below the median). Table 11 presents the result. The main coefficient of interest is the coefficient of $OVITYR$. A positive

Table 9: Firms performance three-periods ahead across financial indicators

	(1) ROE	(2) CR	(3) DCR	(4) TAT
ROE (t-1)	0.139***			
	(0.049)			
Current ratio (t-1)		0.674***		
		(0.065)		
Debt-to-capital ratio (t-1)			0.737***	
			(0.058)	
Asset turnover (t-1)				0.785***
				(0.065)
Investment (t-1)	0.862**	0.032**	-0.444	0.006**
	(0.334)	(0.014)	(0.313)	(0.003)
Investment (t-2)	0.213	0.018*	-0.499**	-0.002
	(0.343)	(0.011)	(0.228)	(0.002)
Investment (t-3)	0.594**	0.004	-0.209	-0.002
	(0.262)	(0.009)	(0.200)	(0.002)
OVER (t-1)	-2.422**	-0.148**	1.581	0.003
	(1.161)	(0.064)	(1.019)	(0.011)
OVER (t-2)	-0.465	-0.166***	2.126**	0.011
	(1.076)	(0.062)	(1.042)	(0.011)
OVER (t-3)	-1.488	-0.027	1.308	0.016
	(1.233)	(0.045)	(1.002)	(0.010)
InvestOVER (t-1)	-0.717**	-0.024**	0.412	-0.008***
	(0.340)	(0.012)	(0.318)	(0.003)
InvestOVER (t-2)	-0.271	-0.012	0.358	0.002
	(0.364)	(0.010)	(0.240)	(0.003)
InvestOVER (t-3)	-0.598**	-0.014	0.299	0.000
	(0.294)	(0.010)	(0.215)	(0.002)
Size (t-1)	0.685	-0.060***	1.155***	-0.010
	(0.576)	(0.021)	(0.383)	(0.008)
Age (t-1)	0.268*	0.007	-0.102	0.002
	(0.141)	(0.005)	(0.105)	(0.002)
Observations	3504	3595	3759	3825

Note: *** p<0.01, ** p<0.05, * p<0.10. ROE = Return on Equity; CR = Current Ratio; DCR = Debt-to-Capital ratio; TAT = Total Asset Turnover; OVER = overinvestment dummy (equal to one if firm overinvests); InvestOVER = interaction term between investment and overinvestment dummy. The dependent variable is ROE t. Estimations use System GMM approach and include both firm and year fixed effects. Robust standard error is used.

Table 10: Firms performance (ROE) three-periods ahead across sectors

	(1) All sector	(2) Resource	(3) Manufacturing	(4) Services
ROE (t-1)	0.139***	0.345	0.122***	0.080
	(0.049)	(.)	(0.044)	(0.097)
Investment (t-1)	0.862**	-0.781	1.208**	1.037**
	(0.334)	(.)	(0.509)	(0.465)
Investment (t-2)	0.213	0.284	1.055*	0.221
	(0.343)	(.)	(0.537)	(0.483)
Investment (t-3)	0.594**	0.817	1.378***	0.381
	(0.262)	(3.568)	(0.431)	(0.372)
OVER (t-1)	-2.422**	-13.350	-1.368	-2.304
	(1.161)	(.)	(1.483)	(2.111)
OVER (t-2)	-0.465	-1.393	-1.593	2.252
	(1.076)	(48.864)	(1.594)	(2.273)
OVER (t-3)	-1.488	-15.008	-1.235	-1.326
	(1.233)	(14.101)	(2.003)	(1.634)
InvestOVER (t-1)	-0.717**	1.591	-0.908*	-0.916*
	(0.340)	(4.104)	(0.472)	(0.507)
InvestOVER (t-2)	-0.271	-0.658	-0.810*	-0.589
	(0.364)	(3.650)	(0.482)	(0.494)
InvestOVER (t-3)	-0.598**	0.409	-1.195***	-0.366
	(0.294)	(.)	(0.398)	(0.443)
Size (t-1)	0.685	0.858	-0.893	1.240
	(0.576)	(4.785)	(0.747)	(0.951)
Age (t-1)	0.268*	-0.099	0.814**	0.111
	(0.141)	(.)	(0.318)	(0.182)
Observations	3504	388	1562	1554

Note: *** p<0.01, ** p<0.05, * p<0.10. OVER = overinvestment dummy (equal to one if firm overinvests); InvestOVER = interaction term between investment and overinvestment dummy. Dependent variable is ROE *t*. Estimations use System GMM approach and include both firm and year fixed effects. Robust standard error is used.

coefficient of $OVITYR$, where for instance, $LowROE$ is the dependent variable, suggests firms that overinvest the most during the boom period would have a higher likelihood of having low profitability during the peak of the bust period.

The result in Table 11 shows the coefficients of $OVITYR$ for Low ROE, Low Current Ratio, and Low Total Assets Turnover are indeed positive as hypothesized. This result suggests that higher overinvestment years during the boom period are associated with a higher likelihood of having a low value of ROE, CR, and TAT at the trough of the bust period. The coefficients, however, are statistically significant only for the liquidity indicator (current ratio).

Table 11: Firms performance in 2015

	(1) low ROE	(2) low CR	(3) low DCR	(4) low TAT
Low ROE (t-1)	1.026***			
	(0.160)			
Low Current Ratio (t-1)		0.913***		
		(0.143)		
Low Debt capital ratio (t-1)			1.330***	
			(0.149)	
Low Asset turnover (t-1)				1.182***
				(0.148)
OVITYR (t-1)	0.047	0.076*	-0.039	-0.041
	(0.049)	(0.045)	(0.046)	(0.043)
Size (t-1)	0.058	-0.008	0.014	0.148***
	(0.049)	(0.042)	(0.044)	(0.043)
Age (t-1)	-0.009	-0.019	0.010	0.017
	(0.016)	(0.014)	(0.014)	(0.013)
Observations	308	341	344	351

Note: *** p<0.01, ** p<0.05, * p<0.10. OVITYR = the number of years whereby firms overinvested during commodity boom 2003-2011 period. ROE = Return on Equity; CR = Current Ratio; DCR = Debt-to-Capital ratio; TAT = Total Asset Turnover. The dependent variable is dummy variable, where one equal to the value below the median. Estimations use Probit model. Robust standard error is used.

Meanwhile, Table 12 specifically shows ROE in 2015 across sectors. The coefficient for $OVITYR$ in the resource sector is positive and statistically significant. This result shows that firms in the resource sector that overinvest the most during boom years would have a higher likelihood of having low profitability during 2015.

Table 12: Firms performance (ROE) in 2015 across sectors

	(1) All sector	(2) Resource	(3) Manufacturing	(4) Services
Low ROE (t-1)	1.026***	0.948*	1.202***	0.911***
	(0.160)	(0.528)	(0.268)	(0.233)
OVITYR (t-1)	0.047	1.017***	0.035	0.006
	(0.049)	(0.365)	(0.076)	(0.073)
Size (t-1)	0.058	0.194	0.097	0.001
	(0.049)	(0.184)	(0.098)	(0.062)
Age (t-1)	-0.009	-0.073	-0.024	-0.001
	(0.016)	(0.062)	(0.025)	(0.023)
Observations	308	40	110	158

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. OVITYR = the number of years whereby firms overinvested during commodity boom 2003-2011 period. The dependent variable is various financial variable. Estimations use Probit model. Robust standard error is used.

6.3.3 Financial performance during overall busts period

Another related question is whether firms' financial performance was adversely affected during the overall bust period (2012-2019) had the firms overinvested most of the time during the boom period (2003-2011). To put it differently, do firms that overinvest most of the time during boom period have poorer financial performance during bust period compared to firms that only overinvest in fewer years. Table 13 shows the estimation result for equation 16 across four financial indicators. The coefficients of interest are the interaction between the lagged financial variable and $OVITYR$ (the number of firms overinvesting during the boom period). A negative coefficient implies that overinvestment negatively affects financial performance by reducing the persistence of the financial ratio. Indeed, the table shows that all of the interaction terms are negative and statistically significant. This suggests that firms that overinvest most of the year during the boom period would have lower profitability, liquidity, asset efficiency, and, surprisingly, lower debt during the bust period.

Does the effect differ across sectors? Table 14 shows the regression result for ROE as a dependent variable across sectors. Similarly, the main coefficient of interest is the coefficient of $ROEOVITYR$. The result shows that the sign is negative and statistically significant across sectors. This result shows that firms across sectors that overinvested most of the years during the boom period would have weaker financial performance.

Table 13: Firms performance during busts period (2012-2019) across financial indicators

	(1) ROE	(2) CR	(3) DCR	(4) TAT
ROE (t-1)	0.457*** (0.128)			
ROEOVITYR (t-1)	-0.187*** (0.037)			
Current Ratio (t-1)		0.687*** (0.175)		
CROVITYR (t-1)		-0.217*** (0.061)		
Debt-to-capital ratio (t-1)			1.191*** (0.433)	
DCOVITYR (t-1)			-0.245*** (0.065)	
Total Asset Turnover (t-1)				0.991*** (0.154)
TATOVITYR (t-1)				-0.252*** (0.036)
Size (t-1)	-4.790* (2.684)	0.213 (0.150)	-0.296 (12.160)	0.318*** (0.101)
Age (t-1)	7.163* (3.931)	-0.240 (0.245)	0.812 (16.292)	-0.566*** (0.196)
Observations	2784	3015	1013	1679

Note: *** p<0.01, ** p<0.05, * p<0.10. OVITYR = The number of years each firm overinvest during boom period (2003-2011); ROEOVITYR = interaction term between ROE and OVITYR; CROVITYR = interaction term between Current Ratio (CR) and OVITYR; DCROVITYR = interaction term between Debt-to-capital ratio (DCR) and OVITYR; TATOVITYR = interaction term between Total Asset Turnover (TAT) and OVITYR. The dependent variable is ROE, CR, DCR, abd TAT. Estimations use Difference GMM approach and include both firm and year fixed effects. Robust standard error is used. Variable debt asset ratio is omitted for DCR specification due to endogeneity.

Table 14: Firms performance (ROE) during busts period (2012-2019) across sectors

	(1) All sector	(2) Resource	(3) Manufacturing	(4) Services
ROE (t-1)	0.457***	0.314	0.444***	0.545***
	(0.128)	(0.198)	(0.169)	(0.202)
ROEOVITYR (t-1)	-0.187***	-0.116**	-0.192***	-0.241***
	(0.037)	(0.047)	(0.056)	(0.069)
Size (t-1)	-4.790*	-9.660	-5.870*	-0.106
	(2.684)	(7.912)	(3.054)	(3.230)
Age (t-1)	7.163*	15.335	7.627**	0.421
	(3.931)	(12.595)	(3.777)	(5.717)
Observations	2784	353	960	1471

Note: *** p<0.01, ** p<0.05, * p<0.10. ROEOVITYR = interaction term between ROE and the number of years whereby firms overinvested during commodity boom 2003-2011 period. The dependent variable is ROE. Estimations use Difference GMM approach and include both firm and year fixed effects. Robust standard error is used.

6.4 Transmission mechanism

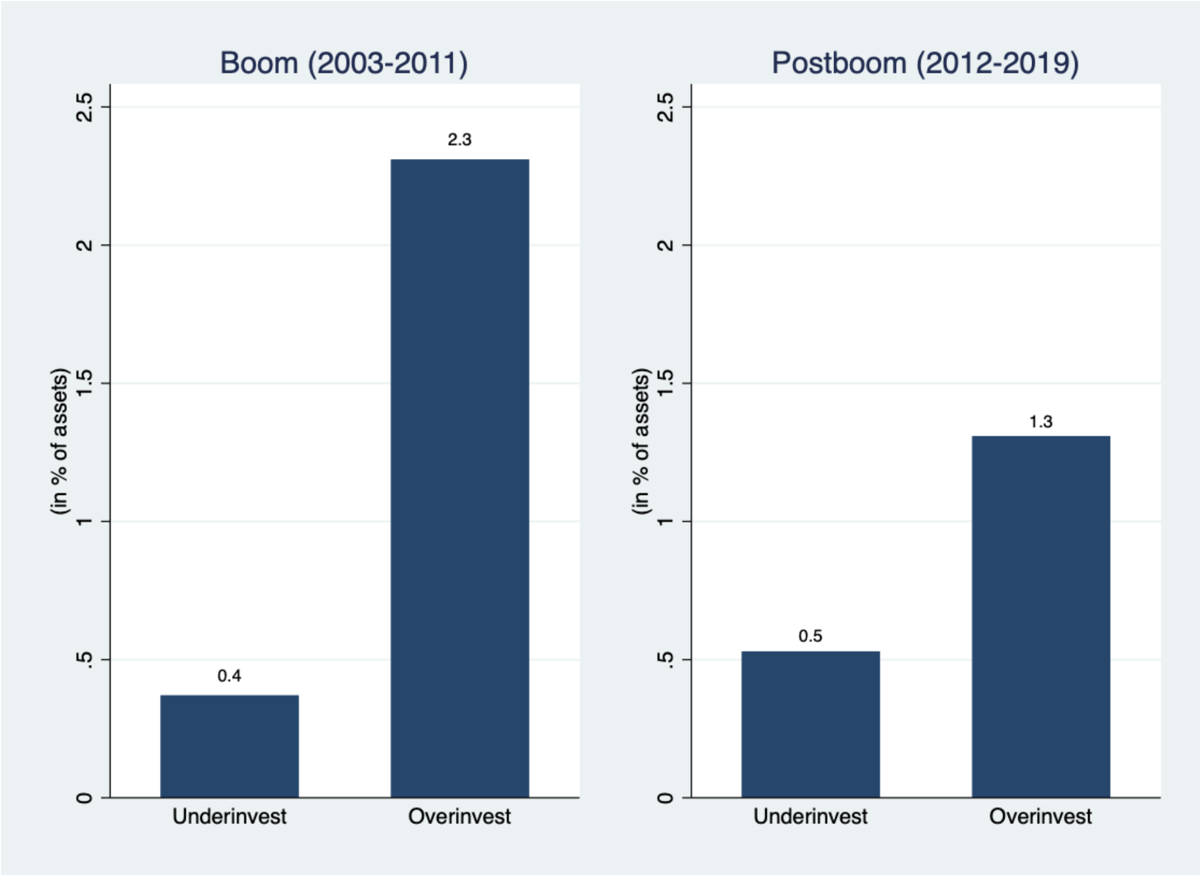
The previous sections show that commodity price growth increases the likelihood of firms' overinvestment, particularly in the resource sector. Furthermore, overinvestment could result in worse financial performance in subsequent periods.

Several factors could trigger firms to overinvest during the boom period. First is the agency problem (asymmetric information). Higher free cash flow during the boom period provides room for managers to invest more recklessly (Richardson 2006, Guariglia and Yang 2016). The second is lower financing constraints. Capital market imperfection creates difficulty for firms to obtain external financing. During the boom period, this constraint might ease, for instance, due to higher collateral value, higher (expected) earnings, and more lax lending standards. Third is overoptimism. The commodity price is relatively uncertain and volatile. Overoptimism on the future trajectory of commodity prices might induce firms to invest more to anticipate greater future demand. The following subsection discusses free cash flow and effective interest rate as the transmission channels of commodity price boom on a firm's overinvestment. It subsequently complements the discussion with results from loan-level data.

6.4.1 Free cash flow

Free cash flow is computed as net cash flow from operating activities minus depreciation and expected investment obtained from regression equation 10. Figure 11 shows that overinvest tend to have higher free cash flow than underinvest firms, either during the boom or post-boom period. During the boom period, overinvested firms, on average, have five times more free cash flow than underinvested firms. The gap reduces during the post-boom period, where overinvested firms have around twice of free cash flow of underinvested firms. This result is intuitive because the boom period might provide resource firms with higher cash flow, and firms used that cash flow to invest more.

Figure 11: Free cash flow across underinvest and overinvest firms

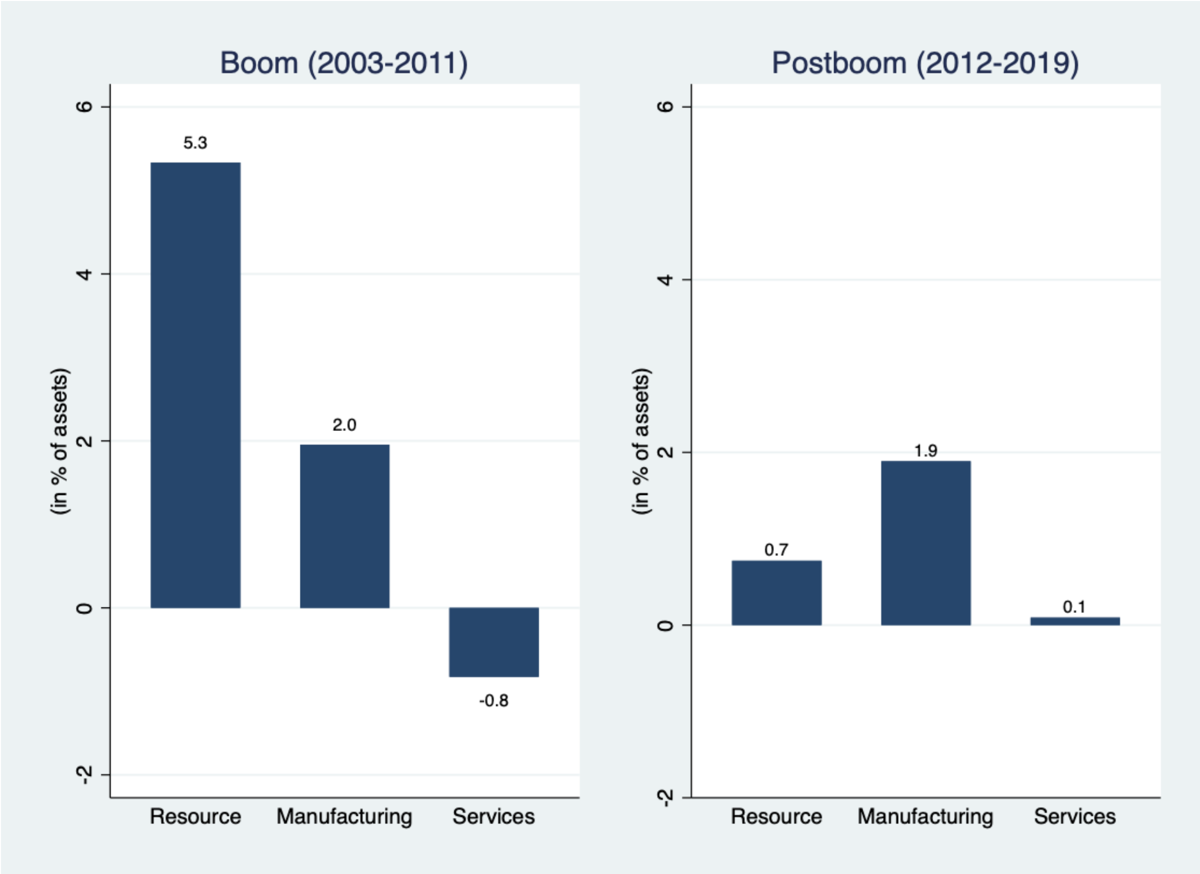


Source: Author estimates.

Note: Free cash flow is computed as net cash flow from operating activities minus depreciation and expected investment obtained from regression equation 10.

Figure 12 shows the average of free cash flow *across sectors* during both the boom and post-boom period. It shows that during the boom period, firms in the resource sector have significantly more free cash flow than the other sectors. This result is as anticipated.

Figure 12: Free cash flow across sectors



Source: Author estimates.

Note: Free cash flow is computed as net cash flow from operating activities minus depreciation and expected investment obtained from regression equation 10.

Table 15 shows the effect of commodity price growth on free cash flow in the next period. The table shows that higher commodity price growth results in increased free cash flow in the resource sector. The coefficients for the services sector are also positive, while for the manufacturing sector are negative. However, they are not statistically significant.

The following equation 17 tests the effect of free cash flow on over and underinvestment more formally. Positive and negative free cash flow is allowed to have an asymmetric impact. The hypothesis is as follows. First, higher free cash flow would lead to higher overinvestment for firms that overinvest and have positive free cash flow. This result reflects the agency costs. Second, increased free cash flow would lead to less underinvestment for firms that underinvest and have negative free cash flow. This result demonstrates the financing constraint that these firms face.

$$\begin{aligned} OVIT_{it} = &\beta_0 + \beta_1 FCF_{i,t-1} \times 1(FCF > 0) \\ &+ \beta_2 FCF_{i,t-1} \times 1(FCF < 0) + \varepsilon_i + \varepsilon_t + \varepsilon_{i,t} \end{aligned} \tag{17}$$

Table 15: The effect of commodity price growth on free cash flow across sectors (All Period)

	(1) Resource	(2) Manufacturing	(3) Services
Commodity Price Growth (t-1)	0.508*	-0.061	0.309
	(0.267)	(0.056)	(0.569)
Observations	558	2059	2255

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Free cash flow. Estimations use within estimator regression and include firm and year fixed effects. Robust standard error is used.

Table 16 shows the result of equation 17. The results confirm the hypothesis that higher free cash flow would lead to greater overinvestments for firms with positive cash flow. This result supports the agency costs hypothesis. Similarly, increased free cash flow would lead to less underinvestment for firms that underinvest and have negative free cash flow. This result supports the financing constraint hypothesis.

Table 16: The effect of free cash flow on investment inefficiency (All Period)

	(1) Overinvestment	(2) Underinvestment
$FCF(t-1) \times \mathbb{1}(FCF > 0)(t-1)$	0.036**	-0.007
	(0.016)	(0.006)
$FCF(t-1) \times \mathbb{1}(FCF < 0)(t-1)$	-0.024	0.011**
	(0.015)	(0.006)
Observations	1760	2663

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment estimates (residuals of investment function in equation 11). Estimations use within estimator regression and include firm and year fixed effects. Robust standard error is used.

Finally, Table 17 zooms in at the boom period and compares across sectors. The result shows higher free cash flow would lead to higher overinvestment for firms with positive cash flow in the resource sector. This result implies higher overinvestment for firms in the resource sector during the boom period might be partly driven by agency costs.

6.4.2 Effective interest rate

In addition to the availability of free cash flow, another channel of commodity price growth on firms' overinvestment is through the cost of external borrowing. Higher commodity

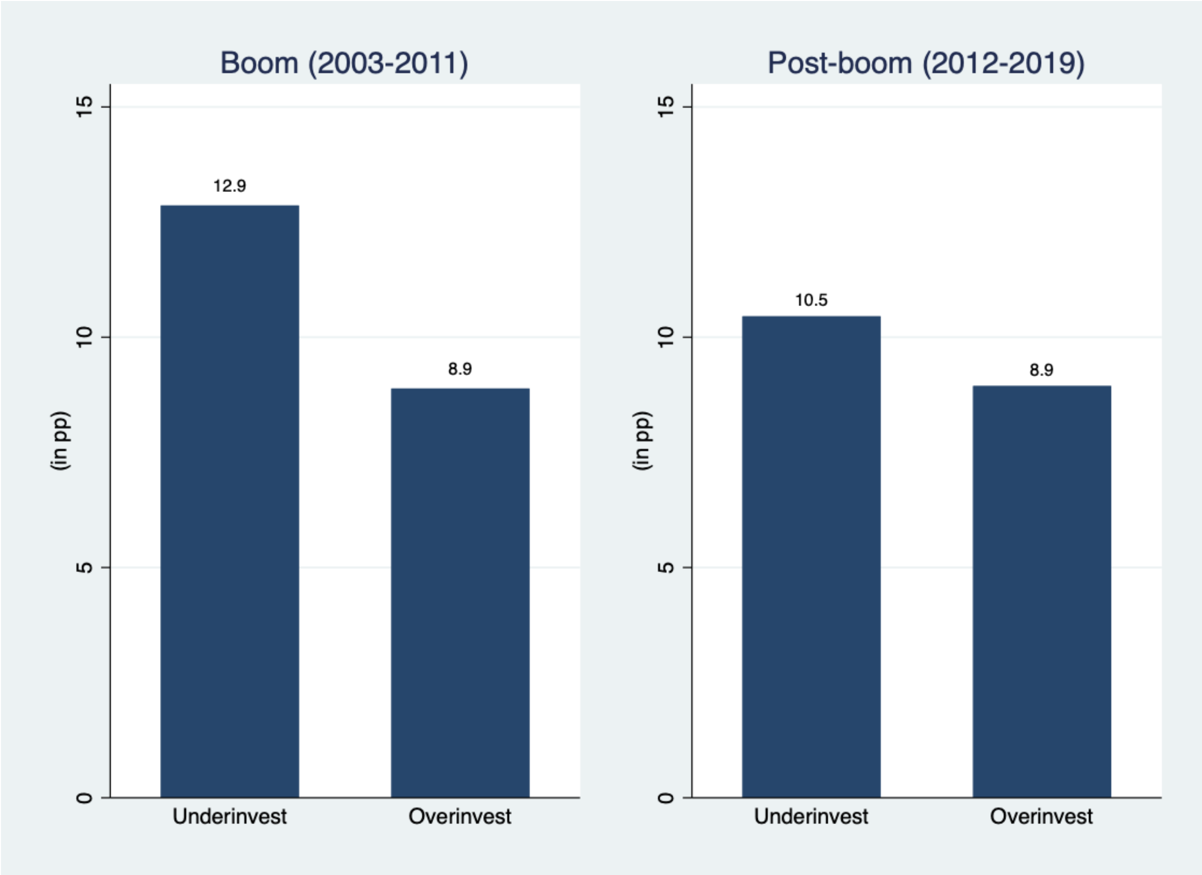
Table 17: The effect of free cash flow on investment inefficiency across sectors (Boom Period)

	(1) Resource	(2) Manufacturing	(3) Services
$FCF(t-1) \times \mathbb{1}(FCF > 0)(t-1)$	0.109*	0.013	-0.095
	(0.062)	(0.038)	(0.068)
$FCF(t-1) \times \mathbb{1}(FCF < 0)(t-1)$	0.482	0.016	-0.015
	(0.393)	(0.036)	(0.015)
Observations	58	272	256

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment estimates (residuals of investment function in equation 11). Estimations use within estimator regression and include firm and year fixed effects. Robust standard error is used.

price growth might lower the cost of fund, especially for firms in the resource sector. This lower cost of the fund would subsequently induce firms to overinvest. Indeed, Figure 13 shows firms that overinvest tend to have lower interest rates than underinvested firms. The cost of external funds of overinvested firms is around four percentage points lower compared to the underinvested firms. This gap fell to approximately one percent during the post-boom period. This result suggests the boom period would help firms to have lower external debt costs and subsequently finance the overinvestment.

Figure 13: Effective interest rate across sectors



Source: Author estimates.

Note: Effective interest rate is computed as total interest payment divided by total debt.

More formally, Table 18 shows the regression result on the effect of commodity price growth on a firm's effective interest rate in the next period. The table shows that higher commodity price growth results in lower effective interest rates for firms in the resource sector. The sign is also negative in the manufacturing and services sector. However, they are not statistically significant. This negative correlation between commodity price growth and effective interest rates at the firm-level data is in accordance with evidence from aggregate data. By using country-level data, Shousha (2016), Fernández, González, and Rodriguez (2018), and Drechsel and Tenreyro (2018) find there is negative correlation between commodity price growth and a country's risk premia in sovereign bond spread.

Finally, Table 19 shows the effect of firms' effective interest rate on firms' overinvestment during the Boom period. The table shows an inverse relationship between a firm's effective interest rate and overinvestment. This result confirms the hypothesis that commodity price growth would result in higher firms' investment inefficiency through lower interest rate.

There are several possible explanation on why commodity price growth has inverse relationship with borrowing costs. From demand side (debtor or firm), there could be

Table 18: The effect of commodity price growth on effective interest rate across sectors (All Period)

	(1) Resource	(2) Manufacturing	(3) Services
Commodity Price Growth (t-1)	-1.637**	-0.786	-0.059
	(0.765)	(0.486)	(0.807)
Observations	698	2340	2865

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Effective interest rate. Effective interest rate is computed as total interest payment divided by total debt. Estimations use within estimator regression and include firm and year fixed effects. Robust standard error is used.

Table 19: The effect of effective interest rate on investment inefficiency (Boom Period)

	(1) Resource	(2) Manufacturing	(3) Services
Effective Interest Rate (t)	-0.051***	-0.019**	-0.016
	(0.013)	(0.009)	(0.011)
Observations	147	628	612

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Investment inefficiency residuals (intensive margin). Estimations use within estimator regression and include firm and year fixed effects. Robust standard error is used.

improved repayment capacity to the creditors as reflected in higher value of collateral. During commodity booms, the value of assets used as collateral, for instances, farm lands, mining sites, and equipment of resource firms might increase. In addition to collateral, a higher expected profitability would also improve the repayment capacity of resource firms. From supply side, domestic banks might have cheaper funding during commodity booms and foreign creditors are more willing to provide lending. Kaminsky, Reinhart, and Végh (2004) documents that net capital inflow is procyclical in developing countries, that is net capital inflows tend to be larger during good times.

6.4.3 Evidence from loan-level data

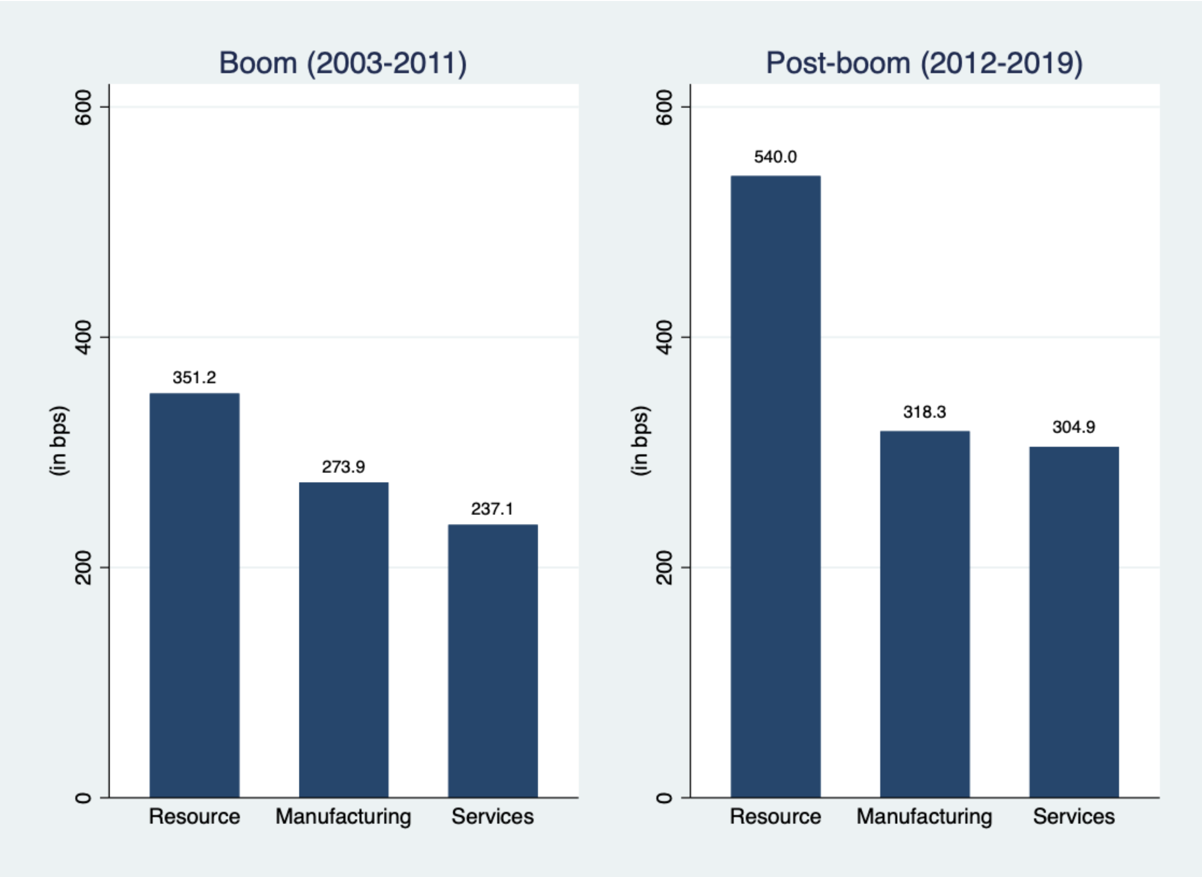
The previous sub-section uses the firm's balance sheet data and shows firm's effective interest rate is one of the transmission channels of commodity price movement to investment inefficiency. This sub-section uses corporate loan-level data to examine loan terms during commodity booms and busts period and their relationship with investment inefficiency. The data source is Refinitiv LoanConnector Dealscan, which provides detailed information on corporate loans. By excluding data for financial and non-listed firms, 341 loan deals data came from 128 unique Indonesian firms between 1990 and 2019. This data is matched with the Datastream data.

There are several stylized facts from the loan data. *First*, commodity boom eases financing constraints. Figure 14 shows loan spread across sectors is slightly lower during the boom period.[22] The difference between loan spread during the boom and post-boom period is particularly prominent in the resource sector. This suggests the financing constraint is especially eased during the commodity boom period for firms in the resource sector.[23]

[22] T-test for the two samples (boom and post-boom period) shows the spread is lower at boom period, statistically significant at ten percent significance level.

[23] Notice that loan spread is generally higher in the resource sector compared to the other sectors, particularly in the post-boom period. This might reflect higher risks associated with lending to the resource sector due to volatile commodity prices and the possibility of harvest failure due to weather change, among many others.

Figure 14: Corporate loan spread (in bps) across sectors



Source: Refinitiv LoanConnector Dealscan.

Note: The loan spread refers to all-in spread charged by the bank over the benchmark rate (the London Interbank Offered Rate) for the drawn portion of the loan facility.

Second, there is an inverse relationship between loan spread and investment inefficiency. Table 20 shows the regression result of investment inefficiency on loan spread and some loan characteristics. The result shows lower spread is associated with higher investment inefficiency. This result is similar to the result in the previous sub-section, which shows an inverse relationship between effective interest rate and investment inefficiency using the firm's balance sheet data. The coefficient during the Boom Period is also four times larger than the All Period. Overall, this result suggests commodity boom period would lower the loan spread and increase investment inefficiency.

Third, the collateral requirement is relatively more lenient during the boom period. Table 21 shows that during the boom period, around 11% of loans require collateral in the resource sector. However, during the post-boom period, around 29% of the loans in the resource sector require collateral. This relatively lenient collateral requirement might enable firms to borrow more during the boom period and overinvest.

Finally, the deal currency is overwhelmingly in US Dollar. Table 22 shows that around 86% of the loan across sectors are in US Dollars. However, the share is more significant in

Table 20: Corporate loan spread and investment inefficiency

	(1) Boom Period	(2) All Period
All-In Spread (Drawn)	-0.013***	-0.003***
	(0.004)	(0.001)
Deal Amount	-0.004	0.000
	(0.005)	(0.000)
Tenor Maturity	0.068***	0.026***
	(0.022)	(0.006)
Constant	3.063	-0.313
	(1.852)	(0.288)
Observations	33	220

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable is the average of firm's investment inefficiency during Boom or All Period. The model is estimated through ordinary least square, with robust standard error.

Table 21: Collateral requirements

Secured	Boom (2003-2011)				Post-Boom (2012-2019)			
	Sector			Total	Sector			Total
	Res.	Mfg.	Serv.		Res.	Mfg.	Serv.	
No	88.46	85.19	71.43	82.43	70.59	79.17	81.58	78.48
Yes	11.54	14.81	28.57	17.57	29.41	20.83	18.42	21.52
Total	100	100	100	100	100	100	100	100

Source: Refinitiv LoanConnector Dealscan.
Note: Res.=Resource, Mfg.=Manufacturing, and Serv.=Services sector.

Table 22: Corporate loan deal currency

Deal Currency	Res.	Mfg.	Serv.	Total
Indonesian Rupiah	1.79	7.78	23.73	12.32
Japanese Yen	1.79	1.20	0.85	1.17
U.S. Dollar	96.43	91.01	75.42	86.51
Total	100	100	100	100

Source: Refinitiv LoanConnector Dealscan.

the resource sector, at 96%. Currency appreciation during the boom period might tempt firms to obtain cheaper loans abroad. This foreign currency borrowing could adversely affect the firms during the bust period, which usually marked exchange rate depreciation.

All in all, data on corporate loans support findings in the previous sub-section that financing constraint is easier during the boom period. In particular, the loan spread is lower, and collateral requirement is more lenient during the boom period. These might lead to over-borrowing and more significant investment inefficiency during the boom period.

7 Robustness check

7.1 Using World Bank commodity price index

The baseline estimates Table 3 and 5 use the S&P Goldman Sachs Commodity Index(GSCI), which is based on futures contracts hence reflecting the market's price expectation. As a robustness check, the World Bank commodity price index replaces the GSCI price index in the estimating equation 11. The results for the World Bank commodity price index (shown in Table 34, 35, 36, 37) are similar with the baseline, where higher commodity price growth increase the likelihood of overinvestment for firms in the resource sector. The (extensive margin) effect across sectors is also only statistically significant for the service sector.

7.2 Using IMF commodity price index

In another robustness check, the IMF commodity price index is used to replace the S&P GSCI index in the estimating equation 11. The result for the IMF commodity price index (shown in Table 38, 39, 40, 41) are also similar with the baseline, where higher commodity price growth increases the likelihood of overinvestment for firms in the resource sector.

7.3 Using multinomial investment inefficiency in equation 11

The baseline estimates transform investment residuals (investment inefficiency) into a binary variable. As a robustness check, the investment residuals are transformed into ordered multinomials. They are divided into five categories (1-5), with five being the top 20% (overinvests) and one as the lowest 20% (underinvests). Tables 42 to 44 in Appendix show the result of the ordered probit model. The coefficient is slightly larger for the boom period. Meanwhile, for comparison across sectors, the coefficient tends to be not statistically significant. For firms in the resource sector, the conclusion remains that higher commodity price growth leads to a higher probability of overinvesting in both the All Period and Boom Period.

7.4 Limiting observation to post-2000

Indonesia experienced severe economic contraction during the Asian Financial Crisis of 1998. The economic growth fell to a negative 13% at the height of the crisis. To remove any plausible influence of crisis on firms investment estimation, a robustness check is carried out by estimating the model using data from 2000 onward only, as opposed to from 1991 in the baseline estimation.

The result shows that the estimation result is robust to the change in the sample period. As an example, Figure 19 shows the average of firms' investment inefficiencies estimates using the regression residuals of the new (limited) sample period. The resulting graph is similar in magnitude to the baseline estimates in Figure **??**.

The estimation result also shows commodity price growth increases the likelihood of resource firms overinvesting during the All and Boom Period. Interestingly, across sectors, the intensive margin and multinomial estimates show higher commodity price growth reduces the magnitude of firms' investment inefficiency in the manufacturing sector (Table 46 and 47). This is as anticipated from the Dutch Disease theory. The reason why the result for the manufacturing sector is statistically significant for the post-2000 sub-sample but not for the baseline (sample from the 1990s) might be because of a more prominent decline in the manufacturing sector in the 2000s, which coincides with the commodity boom period.

7.5 Splitting the boom period into 2003-2008 and 2010-2013

The boom period 2003-2011 could be split into two periods: before and after the global financial crisis in 2009. In this exercise, the boom period is split into 2003-2008 and 2010-2013. Using 2010-2013 instead of 2010-2011 to increase the number of observations. Furthermore, commodity prices, albeit showing a declining trend since 2011, remained elevated until 2013. Only in 2014 did the price decline significantly due to falling oil prices.

The results are reported for resource firms (using firm specific-commodity prices) and across sectors. The result for firms in the resource sector shows the sign of commodity price growth remains positive and statistically significant for the period 2003-2008 (Table 48), but not statistically significant for 2010-2013 (Table 49) period. Hence for the resource sector, commodity price growth drives overinvestment only during the first boom period (2003-2008).

Meanwhile, the comparison across sectors shows for the 2003-2008 period (Table 50), the coefficient is statistically significant only for the resource sector. Meanwhile, for the 2010-2013 period (Table 51), it shows commodity price growth reduces the likelihood of overinvestment in the manufacturing sector and increases it in the service sector. The result for the resource sector is not statistically significant.

In conclusion, this robustness check shows during the first half of the commodity supercycle period, the effect of the commodity boom on overinvestment in the resource sector was quite prominent. Meanwhile, during the second half of the supercycle period, the impact of the commodity boom was more evident across sectors. Specifically, it reduces the likelihood and magnitude of overinvestment in the manufacturing sector while increasing it in the service sector. Hence, the sectoral effect predicted by the Dutch Disease theory is more prominent during the second -half of the boom. This delayed effect is quite intuitive. It might take some time for the various economic agents (e.g., property developers) to form an expectation that the commodity boom would be long-lasting. Hence they become much more optimistic about conducting investment during the second half of the boom.

7.6 Taking into account stock liquidity in estimating firm's sensitivity

In the regression equation 12 on estimating firms' sensitivity to commodity price, a firm might have a low sensitivity because of the relative illiquidity of the stock. As a robustness check, this paper includes the stock turnover ratio as an additional control variable. The estimating equation becomes:

$$P_{id} = \beta_0 + \beta_1 COMM_d + \beta_2 TURNOVER_d + \beta_3 MarketIndex_d + \epsilon_{id} \tag{18}$$

Where $TURNOVER_d$ is the ratio of stock traded on day d with its total stock outstanding. The results in the appendix (Table **??** to 53) show the same conclusion as the baseline.

7.7 Taking into account the heterogeneity of Tobin's Q effect across sectors

In the equation 10, the effect of Tobin's Q, as a measure of growth opportunity, on the level of investment might differ across the sector. To control for this, Tobin's q also interacted with the sector dummy, as shown in the equation below.

$$\begin{aligned} I_{new,it} =& \beta_0 + \beta_1 V/P_{i,t-1} + \beta_2 Leverage_{i,t-1} + \beta_3 Cash_{i,t-1} + \beta_4 Age_{i,t-1} \\ & + \beta_5 Size_{i,t-1} + \beta_6 I_{new,it-1} + \gamma V/P_{i,t-1} \times Sector_i + \varepsilon_i + \varepsilon_t + \epsilon_{it} \end{aligned} \tag{19}$$

The results are presented in Table 54 to 57 in the Appendix. The results are almost identical to the baseline regarding statistical significance and sign. Higher commodity price growth increases the likelihood of resource firms overinvesting.

7.8 Using alternative measure of firm's growth opportunities

Tobin's Q might not accurately reflect the firm's growth opportunity. As a robustness check, the sales growth rate is used in place of Tobin's Q in equation 10 to approximate the firm's growth opportunity. Table 58 to 61 in Appendix show the result for resource firms in All Period and Boom Period. The results are still the same as the baseline. Higher commodity price growth increases the likelihood of resource firms overinvesting.

7.9 Using alternative sector classification

The baseline classification is based on the firm's first/primary SIC code. Firms might involve in multiple business activities. For instance, a manufacturing firm might also own a plantation. As a robustness check, a firm is classified as a resource firm if any of its first three SIC codes classifies as natural resource activities. As a result, the number of firms in the resource sector increased from 59, in the baseline, to 78.

Table 62 to 65 show the result. Overall, the result is similar to the baseline. For resource firms, by using firm-specific commodity prices, higher commodity price increases the likelihood of overinvesting during the All and Boom Period. Comparing across sectors, the result is also the same as the baseline. Commodity price growth increases the likelihood of overinvestment in the service sector but not in the other sectors.

8 Conclusion and policy discussion

Recent research has concluded that commodity price accounts for the largest share of business cycle fluctuations in commodity-exporting countries. One possible transmission channel is the firms' investment. As investment accelerator and business cycle literature find, positive economic shocks stimulate investment, further amplifying the effect of the shocks. This paper examines whether commodity price fluctuations drive a firm's overinvestment during the commodity boom period. Subsequently, it examines the financial impact of overinvestment, and the transmission mechanism of commodity price boom to overinvestment.

The paper finds comovement in investment patterns across sectors using Indonesian publicly listed firm data. The comovement is stronger between resource and service sector. During the commodity boom in the early 2000s, investment increased across all sectors, particularly in the resource and service sectors. However, the rise of investment in the resource sector is relatively more significant. Similarly, during the commodity bust period, investment declined across all sectors. The decline in the resource sector is also more prominent than in other sectors. Furthermore, the data also shows that the financial performance of firms in the resource sector tends to co-move with the commodity price boom. During the boom period in the 2000s, resource firms' profitability (ROE) increased while their indebtedness (debt-to-capital ratio) declined. The opposite is valid during the bust period.

The empirical exercise shows the followings. *First*, the share of firms overinvested is around 36 to 39 percent during both the boom and post-boom periods. However, the magnitude of overinvestment is slightly higher during the boom period than the post-boom period, particularly in the resource sector. Across sectors, during the boom period, firms in the resource sector had higher overinvestment, at around 5% of total assets, compared to 4% in the services sector and 3% in the manufacturing sector.

Second, higher commodity price growth is associated with a higher probability of overinvestment for resource firms in both the All Period (the 1990s-2019) and Boom Period (2003-2011). A one standard deviation increase in the commodity price growth rate (i.e., around 22 percentage points) would increase the likelihood of overinvestment by 3.4 percentage points in the All Period and double that at 8.4 percentage points in the Boom Period. The size is quite significant for the boom period, considering the average probability of overinvestment among resource firms is 35%. A one standard deviation increase in the commodity price growth during the boom period would increase the likelihood of overinvesting by around 20%. This effect is slightly dampened during a higher commodity price volatility period. This suggests that resource firms would hold back investment during a higher price volatility period.

Third, The results for sectors outside the resource sector show some spillover effect on the service sector but not on the manufacturing sector. In particular, for the probability of overinvesting (extensive margin), the results are not statistically significant in the service and manufacturing sectors. However, for the degree of overinvestment (intensive margin), the effect is statistically significant for the service sector. Hence, higher commodity price growth increases the overinvestment in both the resource and service sectors. This result confirms the co-movement between the resource and service sector investment in the data.

Fourth, overinvestment adversely affects firms' financial performance. For instance, the positive effect of investment on firms' financial performance is lower had the firms are overinvested. Furthermore, if the firms overinvest most of the time during the nine-year boom period (2003-2011), their financial performance during the bust period (2012-2019) is relatively weaker compared to firms that overinvest less. Looking specifically at the trough of the bust period (2015), which is usually marked by economy-wide financial distress, resource firms that overinvest most of the time during the boom period would have a higher likelihood of having low profitability at the trough of the bust period. These firms might pose risks to the financial system, particularly regarding their external and domestic banking sector debt, during the bust period.

Overall, the analysis shows commodity price growth increases the likelihood of firms overinvesting, especially for firms in the resource sector and, to some extent, the service sector. Meanwhile, higher uncertainty works in the opposite direction. This result might not represent the overall economy because listed firms are generally larger and have better funding access. As a robustness check, this paper conducts structural vector autoregressive (SVAR) analysis using aggregate firm investment data at a quarterly frequency. This data, which comes from Indonesia's investment coordinating agency, covers listed and non-listed firms, hence more representative of the economy. The firms are classified into primary, secondary, and tertiary sectors. The impulse response function shows that commodity price shocks lead to higher investment in the primary sector and, to some extent, in the tertiary sector but not in the secondary sector. Overall, the result of SVAR analysis by using listed and non-listed firms is similar to the baseline result. That is, commodity price has a positive effect on investment in the resource sector and, to some extent, in the service sector.

There are several channels of commodity price growth on overinvestment. These include free cash flow level and external finance cost. Firms that overinvest tend to have higher free cash flow than underinvested firms. Overinvested firms have around five times more free cash flow during the boom than underinvested firms. Across sectors, firms in the resource sector have higher free cash flow than manufacturing and services. Regression analyses show that higher commodity price growth leads to higher free cash flow, particularly for resource firms. Subsequently, overinvesting firms with good liquidity (positive free cash flow) would increase their overinvestment when their free cash flow increases. This result supports the agency costs hypothesis on why firms overinvest. For underinvest firms, firms with negative free cash flow would also increase their investment (less underinvestment) when their free cash flow increases. This result is evidence of the funding constraint hypothesis.

In addition to free cash flow, external funding costs also play a role. Firms that overinvest has lower effective interest rate compared to underinvest firms. The interest rate gap between the overinvest and underinvest firms is larger during the boom period. Regression analyses show that higher commodity price growth reduces the effective interest rate of firms in the resource sector. Furthermore, a lower effective interest rate is associated with higher overinvestment across sectors, particularly in the resource sectors.

This paper also complements the analysis by using corporate loan-level data. The data also supports the findings from the balance sheet data above. In particular, the loan spread is lower, and collateral requirement is more lenient during the boom period. Furthermore, most corporate loans in the data set are in US dollars. The exchange rate appreciation during the boom period might entice the firms to take advantage of lower interest rates abroad. Overall, this easy financing condition might lead to over-borrowing and more significant investment inefficiency during the boom period.

These empirical findings add richness to the existing conclusion in the literature that aggregate investment is procyclical with commodity price fluctuations. There are several policy implications from the findings. *First*, the importance of greater monitoring of the corporate sector's finances during the commodity boom period, particularly for firms in the resource sector. This includes monitoring its external debt, which tends to increase during the boom period, and its deposit and borrowing linkage with the banking sectors. Between 2009 (after the global financial crisis) and 2011 (the peak of commodity price), the external debt of non-financial corporate sectors in Indonesia increased by 50 percentage points from around 60 billion US dollars to 90 billion US dollars. The situation might be more pronounced in the resource sector, where around 96% of corporate loans are in the US Dollar, compared to 86% in the overall sample. This foreign currency debt risks a balance sheet effect problem during the bust period. *Second*, the importance of countercyclical macroprudential policies to tame the procyclicality of firms' investments, financial performance, and banks' financial performance. This could be in the form of more stringent lending standards and higher collateral requirements. As the bank's performance is also procyclical to the commodity price cycle, a weaker bank's financial condition during the bust period due to high lending exposure to the resource sector could amplify the adverse terms-of-trade shocks. *Third*, it might be essential to conduct stress tests, not only for the banking sector or financial firms but also for the non-financial corporate sector. For instance, how the crash in commodity price could affect a firm's liquidity and solvency and its effect on the overall financial system stability. *Fourth*, the importance of having a good firm exit resolution to ensure an orderly exit of resource firms during the bust period. This policy could prevent the 'zombie' firm problem, which exists in some countries following an end to an economic boom.

To conclude, commodity price booms and busts have driven a resource-rich country's business cycle through its effect on firm's investment inefficiency (investment channels). A countercyclical macroeconomic policy mix would minimize the negative costs caused by excessive swings during booms and busts.

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A Appendix

A.1 Tobin's q with three sectors

The domestic price of capital goods P_t^k takes the following form:

$$P_t^k = 1 - e_t\left(\frac{P^c}{P^m}\right) + r_t\left(\frac{P^c}{P^m}\right) \tag{20}$$

where real exchange rate (e_t) and real interest rate (r_t) take the following value.

$$e_t = \begin{cases} \in (-1, 0), & \text{if } \frac{P^c}{P^m} < \left(\overline{\frac{P^c}{P^m}}\right) \\ 0, & \text{if } \frac{P^c}{P^m} = \left(\overline{\frac{P^c}{P^m}}\right) \\ \in (0, 1), & \text{if } \frac{P^c}{P^m} > \left(\overline{\frac{P^c}{P^m}}\right) \end{cases} \tag{21}$$

$$r_t = \begin{cases} \in (0, 1), & \text{if } \frac{P^c}{P^m} < \left(\overline{\frac{P^c}{P^m}}\right) \\ 0, & \text{if } \frac{P^c}{P^m} = \left(\overline{\frac{P^c}{P^m}}\right) \\ \in (-1, 0), & \text{if } \frac{P^c}{P^m} > \left(\overline{\frac{P^c}{P^m}}\right) \end{cases} \tag{22}$$

Where $\left(\overline{\frac{P^c}{P^m}}\right)$ is the long-run value of terms-of-trade.
Commodity and service sector firms problem is given by:

$$D_t = P^j A_t F(K_t, L_t) - w_t L_t - \left[]1 - e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right)\right] I_t - \frac{\chi}{2}\frac{I_t^2}{K_t}, \tag{23}$$

Where j = {C, S}. The stock of capital changes overtime, as

$$K_{t+1} = I_t + (1-\delta)K_t \tag{24}$$

The Bellman equation for the firm's problem is given by

$$V(K_t, A_t, e_t, r_t) = \max_{I_t, K_{t+1}, L_t} \Bigg(P^j A_t F(K_t, L_t) - w_t L_t - \left[1 - e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right)\right] I_t \tag{25}$$

$$- \frac{\chi}{2}\frac{I_t^2}{K_t} + \beta \mathbf{E}_t[V(K_{t+1}, A_{t+1}, e_{t+1}, r_{t+1})]$$

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subject to the capital transition equation. The first order condition with respect to investment I_t results in:

$$1 - e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right) + \chi\frac{I_t}{K_t} = \beta \mathbf{E}_t[V_k(K_{t+1}, A_{t+1}, e_{t+1}, r_{t+1})] \tag{27}$$

Since tobin's q by definition is the shadow price of capital, the equation 27 could be written as

$$1 - e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right) + \chi\frac{I_t}{K_t} = \beta\mathbf{E}_t q_{t+1} \tag{28}$$

By rearranging, we obtain

$$\frac{I_t}{K_t} = \frac{1}{\chi}\left[\beta\mathbf{E}_t q_{t+1} + e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right) - 1\right] \tag{29}$$

Meanwhile the manufacturing sector firm maximizes the following.

$$D_t = P^m A_t F(K_t, L_t) - w_t L_t - \left[1 - e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right)\right] I_t - \frac{\chi}{2}\frac{I_t^2}{K_t} - P^c C_t, \tag{30}$$

Where C_t is the amount of commodity goods used in manufacturing goods' production. The stock of capital changes overtime, as

$$K_{t+1} = I_t + (1-\delta)K_t \tag{31}$$

The Bellman equation for the firm's problem is given by

$$V(K_t, A_t, e_t, r_t) = \max_{I_t, K_{t+1}, L_t}\left(P^m A_t F(K_t, L_t) - w_t L_t - \left[1 - e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right)\right] I_t\right. \tag{32}$$

$$\left. - \frac{\chi}{2}\frac{I_t^2}{K_t} - P^c C_t + \beta\mathbf{E}_t[V(K_{t+1}, A_{t+1}, e_{t+1}, r_{t+1})]\right)$$

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subject to the capital transition equation. The first order condition with respect to investment I_t results in:

$$1 - e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right) + \chi\frac{I_t}{K_t} = \beta\mathbf{E}_t[V_k(K_{t+1}, A_{t+1}, e_{t+1}, r_{t+1})] \tag{34}$$

Since tobin's q by definition is the shadow price of capital, the equation 34 could be written as

$$1 - e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right) + \chi\frac{I_t}{K_t} = \beta\mathbf{E}_t q_{t+1} \tag{35}$$

By rearranging, we obtain

$$\frac{I_t}{K_t} = \frac{1}{\chi}\left[\beta\mathbf{E}_t q_{t+1} + e_t\left(\frac{P^c}{P^m}\right) - r_t\left(\frac{P^c}{P^m}\right) - 1\right] \tag{36}$$

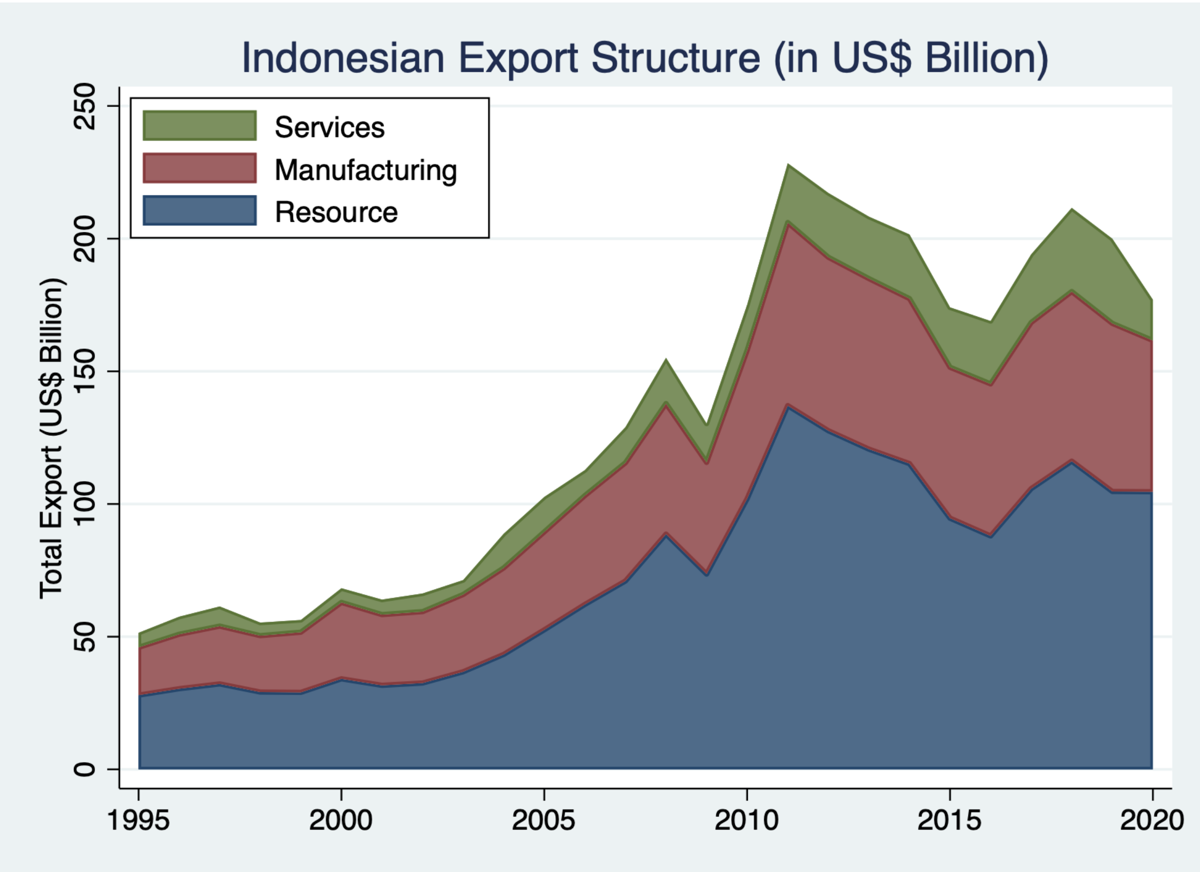
A.2 Indonesian Economic Structure

Table 23: Indonesian economic structure (% of total GDP, constant 2010 price)

Sector	**2011**	**2014**	**2019**
Agriculture	14	13	12
Mining	10	9	7
Manufacturing	22	22	21
Services	54	56	59
Commodity-based (broad definition)	31	29	25

Source: UNCTAD Statistics

Figure 15: Indonesian export structure



Source: UNCTAD Statistics.

A.3 Summary Statistics and Correlation Table

Table 24: Summary statistics by Sector

	Sector			
	1	2	3	Total
Investment (Net capex to asset ratio, in pp)	2.637	2.118	2.453	2.343
	(7.654)	(6.203)	(7.418)	(6.997)
Investment (Capex to assets ratio, in pp)	6.932	5.477	6.044	5.928
	(7.519)	(5.995)	(7.787)	(7.118)
Depreciation expense to assets ratio (in pp)	4.539	3.372	3.749	3.695
	(6.823)	(2.112)	(4.656)	(4.241)
Tobin's Q	1.455	1.359	1.300	1.343
	(1.588)	(1.597)	(1.443)	(1.527)
Growth rate of sales, in pp	31.92	17.47	26.25	23.42
	(86.45)	(48.76)	(73.36)	(66.75)
Leverage (debt to assets ratio, in pp)	30.17	34.79	29.32	31.56
	(26.13)	(31.07)	(28.78)	(29.51)
Cash to assets ratio (in pp)	6.086	4.902	5.966	5.562
	(7.591)	(6.215)	(7.424)	(7.015)
Age (in year)	9.509	11.53	9.212	10.15
	(6.607)	(7.648)	(6.850)	(7.229)
Assets (in log)	21.36	20.80	20.72	20.83
	(1.988)	(1.708)	(1.843)	(1.820)
Return (in pp)	42.12	32.69	29.32	32.26
	(148.8)	(115.0)	(108.5)	(116.7)
Debt to capital ratio	39.83	44.21	39.20	41.22
	(37.68)	(44.44)	(41.62)	(42.36)
Return to equity ratio (in pp)	5.931	8.081	7.071	7.331
	(37.07)	(34.69)	(31.09)	(33.30)
Current ratio (in pp)	2.109	2.064	2.367	2.209
	(2.422)	(2.279)	(3.374)	(2.854)
Asset turnover ratio (in level)	0.728	1.041	0.839	0.905
	(0.564)	(0.716)	(0.933)	(0.824)

Note: Standard deviation in parentheses. Sector 1 = Resource, 2 = Manufacturing, 3 = Services. Net capex to asset ratio refers to capital expenditure less depreciation expense.

Table 25: Correlation Table

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) inv3	1.000										
(2) tobin3	0.071***	1.000									
(3) leverage	-0.081***	0.041***	1.000								
(4) debtcapital	-0.080***	-0.028**	0.840***	1.000							
(5) roe	0.154***	0.167***	-0.295***	-0.320***	1.000						
(6) current	-0.044***	0.027*	-0.323***	-0.310***	0.036***	1.000					
(7) tat	-0.044***	0.111***	-0.087***	-0.082***	0.194***	-0.100***	1.000				
(8) wb allG	0.014	-0.029**	0.003	0.005	0.027**	-0.003	0.045***	1.000			
(9) lnwb allSD	-0.039***	0.013	-0.096***	-0.069***	0.056***	0.020	0.089***	0.145***	1.000		
(10) CGSYSPTMG	0.023*	-0.028**	0.030**	0.029**	0.020	-0.012	0.029**	0.923***	0.056***	1.000	
(11) lnCGSYSPTSD	-0.062***	-0.007	-0.057***	-0.031**	0.042***	0.019	0.091***	0.197***	0.890***	0.160***	1.000

Note: Pairwise correlated table. *** $p<0.01$, ** $p<0.05$, * $p<0.10$. inv3 = investment; tobin3 = Tobin's Q; roe = Return to equity ratio; tat = Total asset turnover ratio; wballG = World Bank commodity price index growth rate; lnwballSD = standard deviation of World Bank commodity price index; CGSYSPTMG = S&P GSCI index growth rate; lnCGSYSPTSD = standard deviation of S&P GSCI index.

A.4 Firm's classification by sector

Table 26: Firm's classification in Resource Sector

SIC 2-digit Name	Freq.	Percent	Cum. Freq.
Agricultural Prod. - Crops	11	18.64	18.64
Agricultural Prod. - Livestock and Animal Specialties	3	5.08	23.73
Coal Mining	24	40.68	64.41
Fishing, Hunting and Trapping	1	1.69	66.10
Metal Mining	11	18.64	84.75
Oil and Gas Extraction	9	15.25	100.00
Total	59	100.00	

Table 27: Firm's classification in Manufacturing Sector

SIC 2-digit Name	Freq.	Percent	Cum. Freq.
Apparel, Finished Products from Fabrics	6	3.68	3.68
Chemicals and Allied Products	27	16.56	20.25
Electronic & Other Electrical Equipment	2	1.23	21.47
Fabricated Metal Products	5	3.07	24.54
Food and Kindred Products	42	25.77	50.31
Furniture and Fixtures	5	3.07	53.37
Industrial and Commercial Machinery and Computer Eq.	3	1.84	55.21
Leather and Leather Products	1	0.61	55.83
Lumber and Wood Products, Except Furniture	5	3.07	58.90
Miscellaneous Manufacturing Industries	1	0.61	59.51
Paper and Allied Products	15	9.20	68.71
Petroleum Refining and Related Industries	1	0.61	69.33
Primary Metal Industries	17	10.43	79.75
Printing, Publishing and Allied Industries	2	1.23	80.98
Rubber and Miscellaneous Plastic Products	7	4.29	85.28
Stone, Clay, Glass, and Concrete Products	6	3.68	88.96
Textile Mill Products	7	4.29	93.25
Tobacco Products	5	3.07	96.32
Transportation Equipment	6	3.68	100.00
Total	163	100.00	

Table 28: Firm's classification in Service Sector

SIC 2-digit Name	Freq.	Percent	Cum. Freq.
Amusement and Recreation Services	2	0.70	0.70
Apparel and Accessory Stores	2	0.70	1.40
Automotive Dealers and Gasoline Service Stations	4	1.40	2.80
Automotive Repair, Services and Parking	2	0.70	3.50
Building Materials, Hardware, Garden Supplies	2	0.70	4.20
Business Services	16	5.59	9.79
Communications	14	4.90	14.69
Construction - General Contractors & Operative Builders	57	19.93	34.62
Construction - Special Trade Contractors	2	0.70	35.31
Depository Institutions	1	0.35	35.66
Eating and Drinking Places	7	2.45	38.11
Electric, Gas and Sanitary Services	6	2.10	40.21
Engineering, Accounting, Research	5	1.75	41.96
Food Stores	7	2.45	44.41
General Merchandise Stores	3	1.05	45.45
Health Services	8	2.80	48.25
Heamy Construction	6	2.10	50.35
Holding and Other Investment Offices	1	0.35	50.70
Home Furniture, Furnishings and Equipment Stores	5	1.75	52.45
Hotels, Rooming Houses, Camps, and Other Lodging Places	20	6.99	59.44
Local & Suburban Transit & Interurban Highway Transport	5	1.75	61.19
Miscellaneous Retail	2	0.70	61.89
Motion Pictures	3	1.05	62.94
Motor Freight Transportation	10	3.50	66.43
Nondepository Credit Institutions	1	0.35	66.78
Real Estate	28	9.79	76.57
Security & Commodity Brokers, Dealers, Exch & Serv.s	1	0.35	76.92
Transportation Services	6	2.10	79.02
Transportation by Air	5	1.75	80.77
Water Transportation	23	8.04	88.81
Wholesale Trade - Durable Goods	18	6.29	95.10
Wholesale Trade - Nondurable Goods	14	4.90	100.00
Total	286	100.00	

A.5 Commodities in the resource sector

Table 29: Commodities in Resource Sector (Narrow classification)

Commodity	Freq.	Percent
Chicken	2	3.39
Coal	24	40.68
Copper	3	5.08
Corn	1	1.69
Cotton	1	1.69
Fish	2	3.39
Gas	1	1.69
Gold	5	8.47
Metal	2	3.39
Oil	8	13.56
Palm	8	13.56
Rice	1	1.69
Zinc	1	1.69
Total	59	100.00

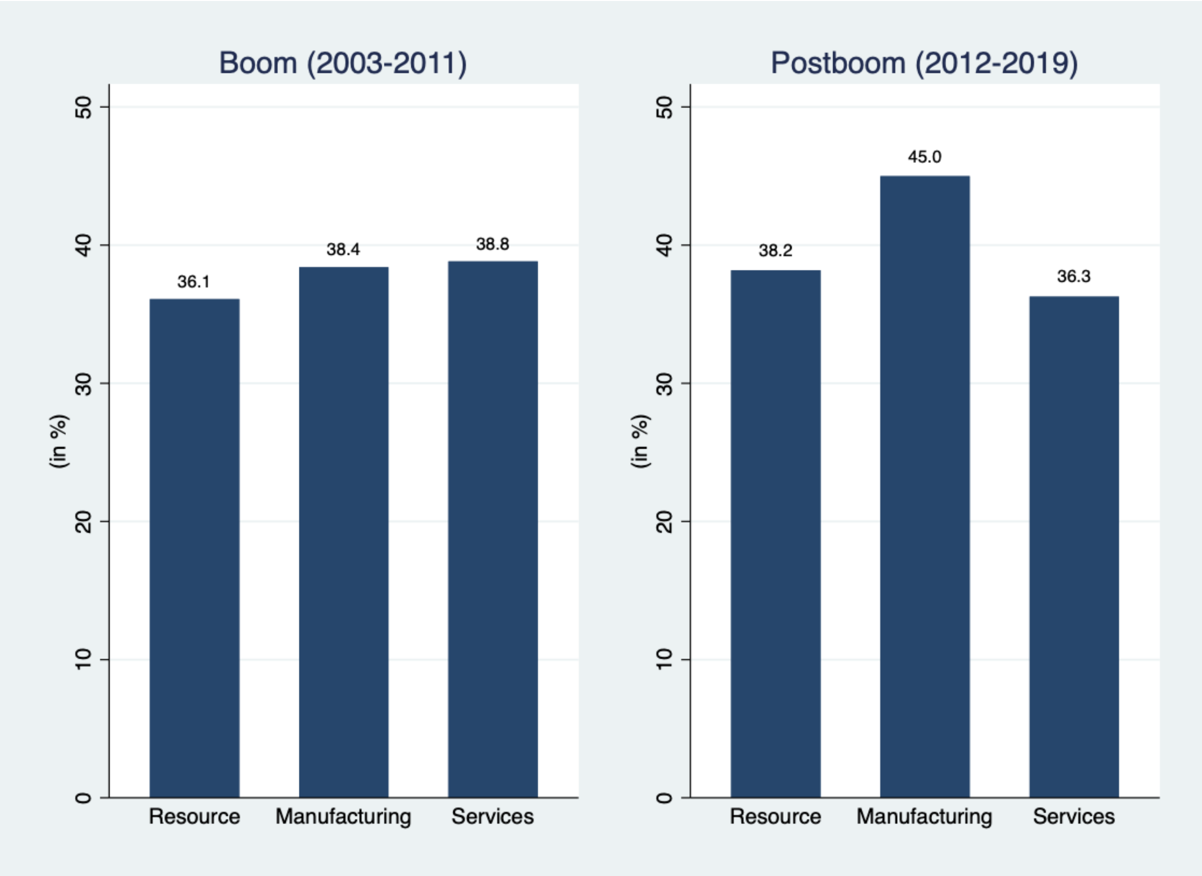
Table 30: Commodities in Resource Sector (Broad classification)

Commodity	Freq.	Percent
Chicken	5	6.41
Coal	25	32.05
Copper	3	3.85
Corn	1	1.28
Cotton	1	1.28
Fish	3	3.85
Gas	1	1.28
Gold	5	6.41
Meat	1	1.28
Metal	2	2.56
Oil	11	14.10
Palm	15	19.23
Rice	1	1.28
Timber	1	1.28
Zinc	1	1.28
wb agri	1	1.28
wb precious	1	1.28
Total	78	100.00

Note: Resource firms under the broad classification include firms which has resource sector as their output in the top three classification of their SIC code.

A.6 Share of observations overinvested across sectors

Figure 16: Share of observations overinvested across sectors

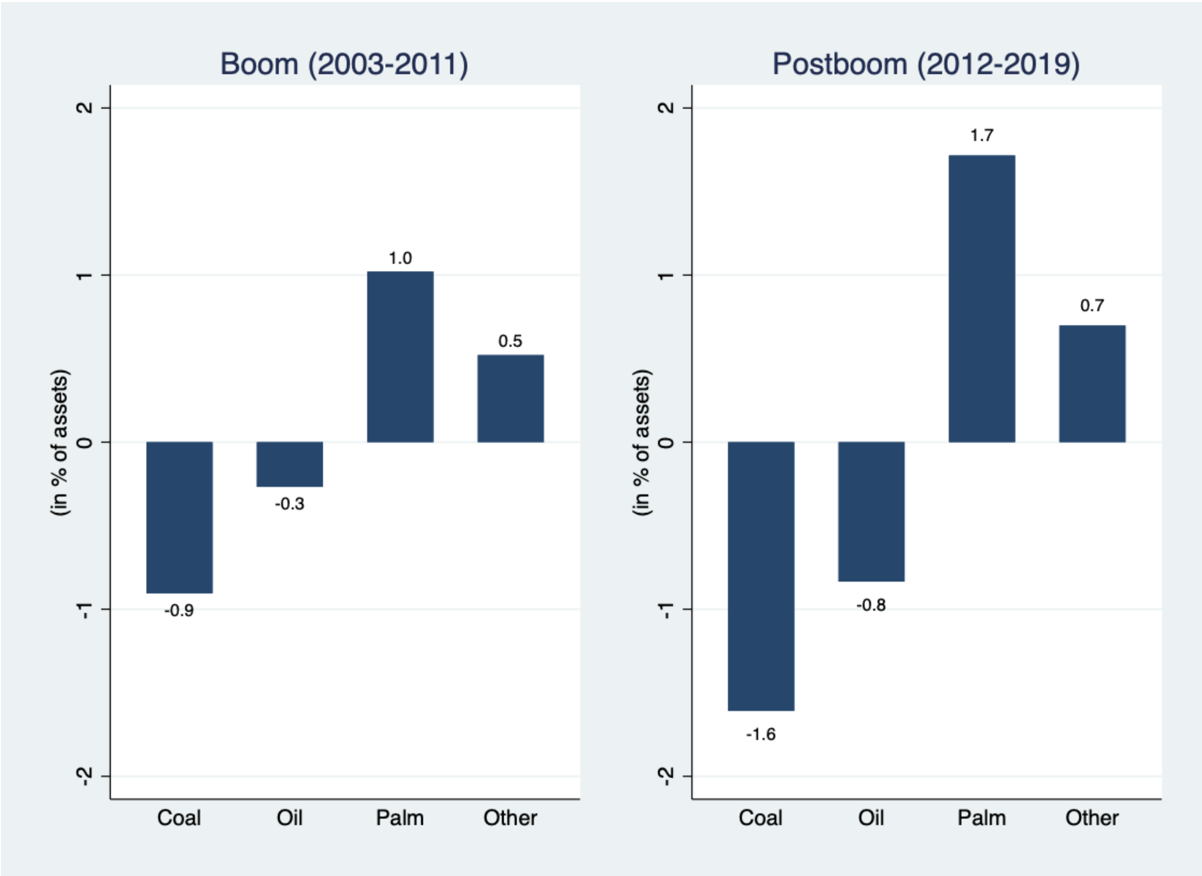


Source: Estimation result.

Note: the figure shows the share of observations with positive investment inefficiency.

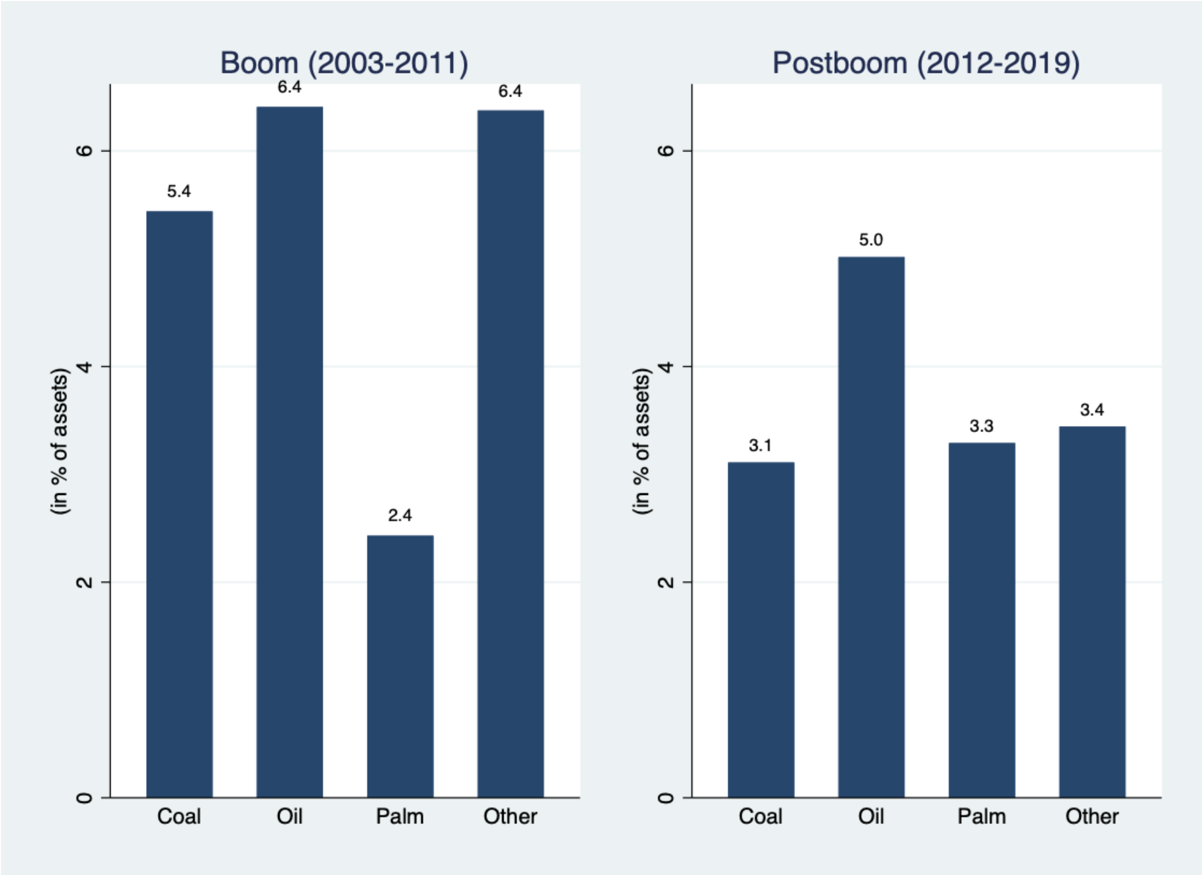
A.7 Firm's investment inefficiency within the resource sector

Figure 17: Average of firms investment inefficiencies estimates within the resource sector



Source: Estimation result.

Figure 18: Average of firms overinvestment estimates within the resource sector



Source: Estimation result.

A.8 Firm's financial performance three-periods ahead

Table 31: Firms performance (Current Ratio) three-periods ahead across sectors

	(1) All sector	(2) Resource	(3) Manufacturing	(4) Services
Current ratio (t-1)	0.674***	0.600*	0.703***	0.744***
	(0.065)	(0.314)	(0.070)	(0.066)
Investment (t-1)	0.032**	0.106	0.050	0.036
	(0.014)	(0.105)	(0.032)	(0.037)
Investment (t-2)	0.018*	-0.018	-0.023	0.027
	(0.011)	(0.251)	(0.056)	(0.025)
Investment (t-3)	0.004	-0.042	-0.019	-0.019
	(0.009)	(0.156)	(0.033)	(0.028)
OVER (t-1)	-0.148**	-0.483	-0.190**	-0.108
	(0.064)	(0.638)	(0.087)	(0.151)
OVER (t-2)	-0.166***	-0.244	-0.227***	-0.154
	(0.062)	(1.708)	(0.078)	(0.138)
OVER (t-3)	-0.027	-0.154	-0.173	0.207
	(0.045)	(0.910)	(0.111)	(0.160)
InvestOVER (t-1)	-0.024**	-0.069	-0.040	-0.037
	(0.012)	(0.091)	(0.026)	(0.037)
InvestOVER (t-2)	-0.012	0.038	0.028	-0.008
	(0.010)	(0.219)	(0.052)	(0.025)
InvestOVER (t-3)	-0.014	0.010	0.026	-0.017
	(0.010)	(0.204)	(0.033)	(0.028)
Size (t-1)	-0.060***	-0.089	0.072	-0.120**
	(0.021)	(0.220)	(0.064)	(0.053)
Age (t-1)	0.007	-0.003	-0.030	0.002
	(0.005)	(0.044)	(0.065)	(0.008)
Observations	3595	407	1715	1473

Note: *** p<0.01, ** p<0.05, * p<0.10.

Table 32: Firms performance (Debt-to-capital ratio) three-periods ahead across sectors

	(1) All sector	(2) Resource	(3) Manufacturing	(4) Services
Debt-to-capital ratio (t-1)	0.737***	0.877***	0.695***	0.695***
	(0.058)	(0.193)	(0.076)	(0.079)
Investment (t-1)	-0.444	1.322	-0.922	-0.687*
	(0.313)	(1.518)	(0.654)	(0.410)
Investment (t-2)	-0.499**	-0.959	-0.632*	-0.382
	(0.228)	(0.776)	(0.338)	(0.332)
Investment (t-3)	-0.209	-0.251	-0.756	-0.211
	(0.200)	(0.728)	(0.479)	(0.305)
OVER (t-1)	1.581	-7.540	3.231	3.644**
	(1.019)	(13.502)	(1.993)	(1.503)
OVER (t-2)	2.126**	1.001	1.533	3.761***
	(1.042)	(5.498)	(1.425)	(1.426)
OVER (t-3)	1.308	9.441	1.125	1.024
	(1.002)	(6.215)	(1.634)	(1.526)
InvestOVER (t-1)	0.412	-0.478	0.701	0.452
	(0.318)	(1.002)	(0.584)	(0.431)
InvestOVER (t-2)	0.358	0.082	0.711	0.182
	(0.240)	(1.672)	(0.444)	(0.296)
InvestOVER (t-3)	0.299	-0.192	0.779*	0.402
	(0.215)	(0.817)	(0.463)	(0.266)
Size (t-1)	1.155***	-2.362	1.963***	1.364**
	(0.383)	(4.561)	(0.748)	(0.618)
Age (t-1)	-0.102	-0.253	-0.129	-0.167
	(0.105)	(0.747)	(0.181)	(0.116)
Observations	3759	412	1671	1676

Note: *** p<0.01, ** p<0.05, * p<0.10.

Table 33: Firms performance (total asset turnover ratio) three-periods ahead across sectors

	(1) All sector	(2) Resource	(3) Manufacturing	(4) Services
Asset turnover (t-1)	0.785***	0.390**	0.838***	1.016***
	(0.065)	(0.171)	(0.045)	(0.044)
Investment (t-1)	0.006**	0.043	0.004	0.006
	(0.003)	(0.044)	(0.004)	(0.005)
Investment (t-2)	-0.002	-0.019	-0.001	-0.005
	(0.002)	(0.037)	(0.004)	(0.003)
Investment (t-3)	-0.002	0.016	-0.002	-0.004
	(0.002)	(.)	(0.004)	(0.003)
OVER (t-1)	0.003	-0.146	0.019	-0.011
	(0.011)	(0.205)	(0.017)	(0.016)
OVER (t-2)	0.011	0.310	-0.007	-0.015
	(0.011)	(.)	(0.017)	(0.011)
OVER (t-3)	0.016	0.511	0.036**	-0.014
	(0.010)	(0.703)	(0.016)	(0.012)
InvestOVER (t-1)	-0.008***	-0.052	-0.006	-0.005
	(0.003)	(0.056)	(0.004)	(0.005)
InvestOVER (t-2)	0.002	-0.012	0.002	0.006*
	(0.003)	(0.059)	(0.004)	(0.003)
InvestOVER (t-3)	0.000	-0.078	-0.001	0.004
	(0.002)	(0.153)	(0.005)	(0.003)
Size (t-1)	-0.010	-0.010	-0.008	0.016**
	(0.008)	(0.092)	(0.008)	(0.006)
Age (t-1)	0.002	-0.011	0.002	0.000
	(0.002)	(0.013)	(0.002)	(0.001)
Observations	3825	413	1716	1696

Note: *** p<0.01, ** p<0.05, * p<0.10.

A.9 Determinants of overinvestment by using World Bank commodity price index

Table 34: Determinants of overinvestments in resource sector (All Period)- by using World Bank commodity price index

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.014	0.016	0.021**	0.006*
	(0.010)	(0.010)	(0.010)	(0.004)
CP SD (t-1)	0.097	0.088	0.023	0.019
	(0.128)	(0.126)	(0.122)	(0.049)
CP growth x CP SD	-0.007*	-0.008*	-0.011**	-0.003**
	(0.004)	(0.004)	(0.004)	(0.001)
Observations	566	566	566	566

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependant variable: Overinvestment dummy.

Table 35: Determinants of overinvestments in resource sector (Boom period)- by using World Bank commodity price index

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.030**	0.031**	0.030**	0.010*
	(0.014)	(0.014)	(0.014)	(0.006)
CP SD (t-1)	-0.088	-0.093	0.110	-0.042
	(0.253)	(0.271)	(0.224)	(0.096)
CP growth x CP SD	-0.014**	-0.014**	-0.015***	-0.005**
	(0.006)	(0.006)	(0.005)	(0.002)
Observations	169	169	169	169

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependant variable: Overinvestment dummy.

Table 36: Determinants of overinvestments across sectors (All Period)- by using World Bank commodity price index

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	0.052	-0.053	-0.209
	(0.277)	(0.139)	(0.161)
Commodity price growth (t-1)	0.072	-0.019	0.036
	(0.119)	(0.147)	(0.025)
Commodity price SD (t-1)	-1.031	-1.362*	0.752*
	(1.411)	(0.706)	(0.440)
SENS x Commodity price growth	0.016	-0.000	0.035*
	(0.041)	(0.020)	(0.019)
SENS x Commodity price SD	0.049	-0.008	0.077
	(0.240)	(0.121)	(0.142)
SENS x CP growth x CP SD	0.000	-0.001	-0.021
	(0.028)	(0.013)	(0.013)
Observations	566	2110	2272

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependant variable: Overinvestment dummy.

A.10 Determinants of overinvestment by using IMF commodity price index

Table 37: Determinants of overinvestments across sectors (Boom period)- by using World Bank commodity price index

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-3.349	-1.145	-1.086
	(2.052)	(1.353)	(1.107)
Commodity price growth (t-1)	0.000	-0.001	-0.004
	(0.009)	(0.003)	(0.004)
Commodity price SD (t-1)	-0.011	0.147	-0.257*
	(0.359)	(0.140)	(0.143)
SENS x Commodity price growth	0.186	0.053	0.118*
	(0.134)	(0.088)	(0.071)
SENS x Commodity price SD	1.933	0.303	0.555
	(1.388)	(0.701)	(0.667)
SENS x CP growth x CP SD	-0.089	-0.013	-0.073*
	(0.081)	(0.043)	(0.039)
Observations	169	724	698

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependant variable: Overinvestment dummy.

Table 38: Determinants of overinvestments in resource sector (All Period)- by using IMF commodity index

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.014	0.015	0.020**	0.006*
	(0.010)	(0.010)	(0.010)	(0.004)
CP SD (t-1)	-0.038	-0.049	-0.066	-0.026
	(0.148)	(0.127)	(0.122)	(0.057)
CP growth x CP SD	-0.007**	-0.008**	-0.011***	-0.003**
	(0.004)	(0.004)	(0.004)	(0.001)
Observations	566	566	566	566

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependant variable: Overinvestment dummy.

Table 39: Determinants of overinvestments in resource sector (Boom period)- by using IMF commodity index

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.035**	0.037**	0.033**	0.012**
	(0.015)	(0.016)	(0.014)	(0.006)
CP SD (t-1)	-0.242	-0.268	-0.002	-0.097
	(0.224)	(0.272)	(0.231)	(0.073)
CP growth x CP SD	-0.016***	-0.017***	-0.017***	-0.005**
	(0.006)	(0.006)	(0.006)	(0.002)
Observations	169	169	169	169

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependant variable: Overinvestment dummy.

Table 40: Determinants of overinvestments across sectors (All Period)- by using IMF commodity index

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	0.517	0.171	-0.235
	(0.474)	(0.214)	(0.233)
Commodity price growth (t-1)	0.059	0.023	-0.022*
	(0.085)	(0.044)	(0.013)
Commodity price SD (t-1)	-1.773	2.087	-0.643
	(2.760)	(2.659)	(0.443)
SENS x Commodity price growth	0.002	-0.004	0.047*
	(0.053)	(0.023)	(0.024)
SENS x Commodity price SD	-0.377	-0.220	0.083
	(0.351)	(0.177)	(0.182)
SENS x CP growth x CP SD	0.016	0.006	-0.031*
	(0.036)	(0.016)	(0.017)
Observations	566	2110	2272

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependant variable: Overinvestment dummy.

Table 41: Determinants of overinvestments across sectors (Boom period)- by using IMF commodity index

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-5.021	-1.594	-1.230
	(4.636)	(2.369)	(2.168)
Commodity price growth (t-1)	-0.000	0.003	-0.012**
	(0.013)	(0.005)	(0.005)
Commodity price SD (t-1)	-0.013	0.406	-0.808*
	(1.070)	(0.417)	(0.421)
SENS x Commodity price growth	0.269	0.078	0.153
	(0.275)	(0.132)	(0.118)
SENS x Commodity price SD	2.734	0.579	0.501
	(2.502)	(1.176)	(1.167)
SENS x CP growth x CP SD	-0.127	-0.029	-0.091
	(0.143)	(0.061)	(0.061)
Observations	169	724	698

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependant variable: Overinvestment dummy.

A.11 Using multinomial investment inefficiency in equation 11

Table 42: Determinants of overinvestments of resource firms across different specifications (All and Boom period) by using ordered probit method

	(1) All Period	(2) Boom Period
Commodity price growth (t-1)	0.034**	0.050**
	(0.013)	(0.021)
Commodity price SD (t-1)	0.142	0.026
	(0.090)	(0.224)
CP growth x CP SD	-0.010**	-0.014**
	(0.004)	(0.006)
Observations	566	169

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment estimates (multinomial of residuals of investment function in equation 11). The value ranges from 1 (underinvest) to 5 (overinvest) Estimations use ordered probit and controls for year. Robust standard error is used.

Table 43: Determinants of overinvestments across sectors (All Period) by using ordered probit method

	(1) Resource	(2) Manufacturing
SENS (t-1)	0.454	0.246
	(0.737)	(0.401)
Commodity price growth (t-1)	0.067	0.081
	(0.082)	(0.418)
Commodity price SD (t-1)	-1.290	-1.451
	(1.368)	(3.599)
SENS x Commodity price growth	0.100	-0.010
	(0.068)	(0.030)
SENS x Commodity price SD	-0.171	-0.095
	(0.242)	(0.140)
SENS x CP growth x CP SD	-0.020	0.004
	(0.021)	(0.010)
Observations	566	2110

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment estimates (multinomial of residuals of investment function in equation 11). The value ranges from 1 (underinvest) to 5 (overinvest) Estimations use ordered probit and controls for year. Robust standard error is used.

Table 44: Determinants of overinvestments across sectors (Boom Period) by using ordered probit method

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-1.301	-0.891	-0.101
	(3.243)	(2.156)	(1.966)
Commodity price growth (t-1)	0.000	0.002	-0.011***
	(0.007)	(0.003)	(0.003)
Commodity price SD (t-1)	0.047	0.208	-0.377**
	(0.442)	(0.178)	(0.175)
SENS x Commodity price growth	0.160	0.060	0.159
	(0.191)	(0.108)	(0.105)
SENS x Commodity price SD	0.349	0.183	-0.007
	(0.987)	(0.562)	(0.529)
SENS x CP growth x CP SD	-0.036	-0.010	-0.042
	(0.053)	(0.027)	(0.027)
Observations	169	724	698

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment estimates (multinomial of residuals of investment function in equation 11). The value ranges from 1 (underinvest) to 5 (overinvest) Estimations use ordered probit and controls for year. Robust standard error is used.

A.12 Using investment inefficiency residuals (intensive margin) in equation 11

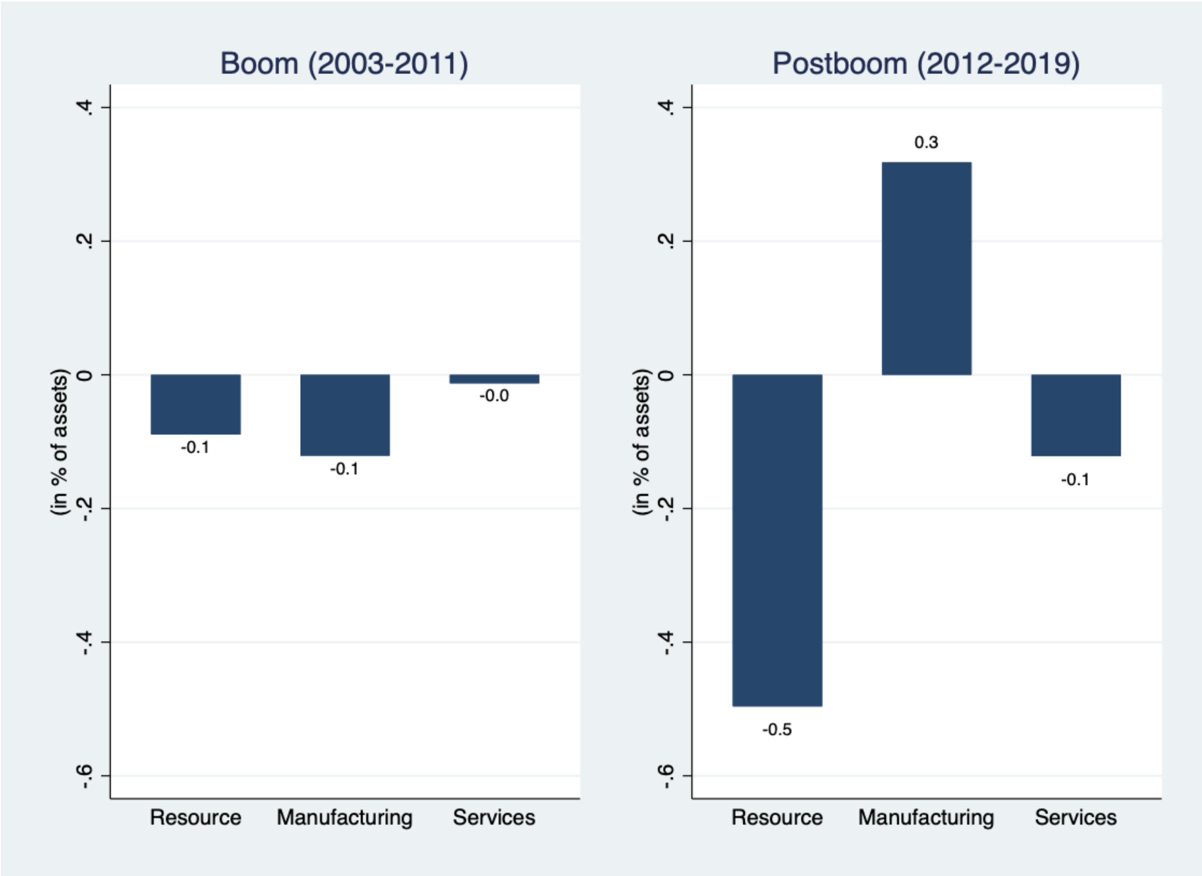
Table 45: Determinants of overinvestments of resource firms across different specifications (All and Boom period) by using overinvestment residuals in Equation 11

	(1) All Period	(2) Boom Period
Commodity price growth (t-1)	0.138	0.153
	(0.088)	(0.139)
Commodity price SD (t-1)	0.335	-0.234
	(0.386)	(1.019)
CP growth x CP SD	-0.037	-0.044
	(0.029)	(0.044)
Observations	566	169

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment estimates (residuals of investment function in equation 11). Estimations use Random-effects GLS regression and include firm and year fixed effects. Robust standard error is used.

A.13 Limiting observation to post-2000

Figure 19: Average of firms investment inefficiencies estimates across sectors (Post-2000 period)



Source: Estimation result.

Table 46: Determinants of the degree of overinvestments (intensive margin) across sectors (All Period) – Post-2000 sample

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	3.002	4.709*	1.137
	(7.637)	(2.498)	(3.305)
Commodity price growth (t-1)	-0.172***	-0.024	0.044**
	(0.051)	(0.025)	(0.022)
Commodity price SD (t-1)	-0.979	-1.912	1.597
	(2.916)	(1.453)	(1.399)
SENS x Commodity price growth	0.650	-0.427**	0.153
	(0.426)	(0.169)	(0.183)
SENS x Commodity price SD	-0.891	-1.283*	-0.153
	(2.267)	(0.735)	(0.959)
SENS x CP growth x CP SD	-0.165	0.118**	-0.050
	(0.128)	(0.049)	(0.052)
Observations	519	1761	2024

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Dependent variable: Overinvestment estimates (residuals of investment function in equation 11). Estimations use Random-effects GLS regression and include firm and year fixed effects. Robust standard error is used.

Table 47: Determinants of overinvestments across sectors (All Period) by using ordered probit method – Post-2000 sample

	(1) Resource	(2) Manufacturing
SENS (t-1)	0.304	1.960**
	(1.903)	(0.852)
Commodity price growth (t-1)	-0.048***	-0.014*
	(0.018)	(0.007)
Commodity price SD (t-1)	-0.327	-0.548
	(0.697)	(0.347)
SENS x Commodity price growth	0.108	-0.115**
	(0.123)	(0.049)
SENS x Commodity price SD	-0.122	-0.555**
	(0.562)	(0.246)
SENS x CP growth x CP SD	-0.022	0.032**
	(0.035)	(0.014)
Observations	519	1761

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment estimates (multinomial of residuals of investment function in equation 11). The value ranges from 1 (underinvest) to 5 (overinvest) Estimations use ordered probit and controls for year. Robust standard error is used.

A.14 Splitting the boom period into 2003-2008 and 2010-2013

Table 48: Determinants of overinvestments in resource sector (Boom period 2003-2008)

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.132***	0.132**	0.082*	0.028**
	(0.046)	(0.053)	(0.047)	(0.011)
CP SD (t-1)	0.433	0.433	0.534	0.158*
	(0.300)	(0.434)	(0.372)	(0.083)
CP growth x CP SD	-0.033**	-0.033**	-0.022	-0.007**
	(0.015)	(0.016)	(0.014)	(0.003)
Observations	96	96	96	96

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

Table 49: Determinants of overinvestments in resource sector (Boom period 2010-2013)

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.016	0.016	0.023	0.006
	(0.046)	(0.049)	(0.045)	(0.018)
CP SD (t-1)	0.405	0.408	0.171	0.220
	(0.275)	(0.321)	(0.270)	(0.140)
CP growth x CP SD	-0.008	-0.008	-0.007	-0.002
	(0.011)	(0.013)	(0.012)	(0.005)
Observations	118	118	118	118

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

Table 50: Determinants of overinvestments across sectors (Boom period 2003-2008)

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-43.194***	-2.788	-1.336
	(10.796)	(4.014)	(4.368)
Commodity price growth (t-1)	-0.026	0.006	-0.020
	(0.030)	(0.012)	(0.013)
Commodity price SD (t-1)	-0.047	-0.031	0.101
	(0.542)	(0.147)	(0.176)
SENS x Commodity price growth	3.563***	0.012	0.323
	(0.600)	(0.267)	(0.265)
SENS x Commodity price SD	14.149***	0.719	0.274
	(3.429)	(1.234)	(1.415)
SENS x CP growth x CP SD	-1.126***	0.001	-0.090
	(0.190)	(0.082)	(0.084)
Observations	96	469	431

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

Table 51: Determinants of overinvestments across sectors (Boom period 2010-2013)

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-100.600	-38.688	88.249
	(134.096)	(54.787)	(54.319)
Commodity price growth (t-1)	0.013	0.005	0.002
	(0.009)	(0.004)	(0.005)
Commodity price SD (t-1)	0.524	0.318	0.263
	(0.731)	(0.371)	(0.396)
SENS x Commodity price growth	-4.900	-2.281	4.253*
	(5.822)	(2.348)	(2.337)
SENS x Commodity price SD	28.850	11.266	-25.435
	(38.437)	(15.667)	(15.581)
SENS x CP growth x CP SD	1.320	0.616	-1.154*
	(1.583)	(0.640)	(0.635)
Observations	118	362	400

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

A.15 Taking into account stock liquidity in estimating firm's sensitivity

Table 52: Determinants of overinvestments across sectors (All Period) by using alternative firm sensitivity estimates

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	0.651	-0.010	-0.005
	(0.751)	(0.409)	(0.510)
Commodity price growth (t-1)	0.050	-0.076	0.007
	(0.097)	(0.261)	(0.006)
Commodity price SD (t-1)	-1.079	-0.460	0.611*
	(1.654)	(2.300)	(0.343)
SENS x Commodity price growth	0.083	-0.023	0.097**
	(0.088)	(0.038)	(0.047)
SENS x Commodity price SD	-0.193	-0.024	-0.035
	(0.264)	(0.147)	(0.173)
SENS x CP growth x CP volatility	-0.019	0.007	-0.029**
	(0.027)	(0.012)	(0.015)
Observations	566	2110	2272

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

Table 53: Determinants of overinvestments across sectors (Boom Period) by using alternative firm sensitivity estimates

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-4.619	-1.543	-2.160
	(4.451)	(2.265)	(2.258)
Commodity price growth (t-1)	0.002	0.001	-0.007**
	(0.008)	(0.003)	(0.003)
Commodity price SD (t-1)	0.061	0.195	-0.357*
	(0.498)	(0.196)	(0.207)
SENS x Commodity price growth	0.341	0.034	0.338***
	(0.286)	(0.126)	(0.123)
SENS x Commodity price SD	1.256	0.321	0.504
	(1.219)	(0.582)	(0.630)
SENS x CP growth x CP volatility	-0.092	-0.005	-0.092***
	(0.078)	(0.031)	(0.033)
Observations	169	724	698

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

A.16 Taking into account the heterogeneity of Tobin's Q effect across sectors

Table 54: Determinants of overinvestments of resource firms across different specifications (All Period) by taking into account the heterogeneity of Tobin's Q

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.049***	0.050***	0.040**	0.016***
	(0.016)	(0.019)	(0.019)	(0.005)
CP SD (t-1)	0.414***	0.401***	0.266**	0.095**
	(0.103)	(0.133)	(0.122)	(0.042)
CP growth x CP SD	-0.015***	-0.015***	-0.013**	-0.005***
	(0.005)	(0.005)	(0.005)	(0.002)
Observations	566	566	566	566

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

Table 55: Determinants of overinvestments of resource firm across different specifications (Boom period) by taking into account the heterogeneity of Tobin's Q

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.099***	0.099***	0.075**	0.030**
	(0.031)	(0.032)	(0.032)	(0.011)
CP SD (t-1)	0.372	0.371	0.279	0.102
	(0.235)	(0.248)	(0.213)	(0.075)
CP growth x CP SD	-0.028***	-0.028***	-0.022**	-0.008***
	(0.009)	(0.009)	(0.008)	(0.003)
Observations	169	169	169	169

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

Table 56: Determinants of overinvestments across sectors (All Period) by taking into account the heterogeneity of Tobin's Q

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	0.900	0.218	0.069
	(0.838)	(0.402)	(0.491)
Commodity price growth (t-1)	0.068	-0.084	0.009
	(0.108)	(0.260)	(0.006)
Commodity price SD (t-1)	-1.288	-0.154	0.643*
	(1.812)	(2.295)	(0.346)
SENS x Commodity price growth	0.071	0.017	0.102**
	(0.090)	(0.036)	(0.043)
SENS x Commodity price SD	-0.300	-0.099	-0.076
	(0.277)	(0.146)	(0.168)
SENS x CP growth x CP SD	-0.013	-0.004	-0.031**
	(0.028)	(0.011)	(0.013)
Observations	566	2110	2272

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

Table 57: Determinants of overinvestments across sectors (Boom Period) by taking into account the heterogeneity of Tobin's Q

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-1.247	-2.097	-1.074
	(4.234)	(2.401)	(2.132)
Commodity price growth (t-1)	-0.000	0.002	-0.008**
	(0.009)	(0.003)	(0.003)
Commodity price SD (t-1)	-0.140	0.225	-0.405**
	(0.498)	(0.203)	(0.201)
SENS x Commodity price growth	0.233	0.092	0.280**
	(0.277)	(0.129)	(0.121)
SENS x Commodity price SD	0.509	0.454	0.160
	(1.142)	(0.619)	(0.597)
SENS x CP growth x CP SD	-0.066	-0.019	-0.077**
	(0.074)	(0.032)	(0.032)
Observations	169	724	698

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

A.17 Using alternative measure of firm's growth opportunities

Table 58: Determinants of overinvestments of resource firms across different specifications (All Period) by using alternative measure of firm's growth opportunities

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.039***	0.040**	0.027	0.012**
	(0.014)	(0.018)	(0.018)	(0.005)
CP SD (t-1)	0.230*	0.205	0.127	0.044
	(0.120)	(0.126)	(0.116)	(0.050)
CP growth x CP SD	-0.012***	-0.013**	-0.009*	-0.004***
	(0.004)	(0.005)	(0.005)	(0.001)
Observations	617	617	617	617

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

Table 59: Determinants of overinvestments of resource firm across different specifications (Boom period) by using alternative measure of firm's growth opportunities

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.070**	0.070**	0.043	0.019*
	(0.030)	(0.030)	(0.029)	(0.010)
CP SD (t-1)	0.331	0.331	0.244	0.083
	(0.253)	(0.229)	(0.199)	(0.095)
CP growth x CP SD	-0.022**	-0.022***	-0.015**	-0.006**
	(0.009)	(0.008)	(0.008)	(0.003)
Observations	203	203	203	203

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

Table 60: Determinants of overinvestments across sectors (All Period) by using alternative measure of firm's growth opportunities

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	1.270	0.446	-0.211
	(1.480)	(0.383)	(0.437)
Commodity price growth (t-1)	0.389	0.064	0.005
	(0.346)	(0.071)	(0.006)
Commodity price SD (t-1)	-4.150	-1.699*	0.303
	(3.765)	(0.925)	(0.333)
SENS x Commodity price growth	0.059	-0.001	0.082**
	(0.096)	(0.036)	(0.039)
SENS x Commodity price SD	-0.351	-0.180	0.056
	(0.438)	(0.129)	(0.144)
SENS x CP growth x CP SD	-0.017	0.002	-0.025**
	(0.028)	(0.010)	(0.012)
Observations	564	2070	2264

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

Table 61: Determinants of overinvestments across sectors (Boom Period) by using alternative measure of firm's growth opportunities

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	5.265	-0.925	-2.086
	(4.280)	(2.070)	(1.998)
Commodity price growth (t-1)	0.002	0.004	-0.006*
	(0.008)	(0.003)	(0.004)
Commodity price SD (t-1)	-0.063	0.246	-0.359*
	(0.489)	(0.190)	(0.190)
SENS x Commodity price growth	-0.074	0.031	0.277**
	(0.217)	(0.121)	(0.112)
SENS x Commodity price SD	-1.463	0.184	0.487
	(1.125)	(0.528)	(0.538)
SENS x CP growth x CP SD	0.014	-0.006	-0.077***
	(0.061)	(0.030)	(0.030)
Observations	176	727	707

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

A.18 Using alternative sector classification

Table 62: Determinants of overinvestments of resource firms across different specifications (All Period) by using alternative sector classification

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.038***	0.039**	0.030*	0.013***
	(0.014)	(0.016)	(0.016)	(0.005)
CP SD (t-1)	0.117	0.104	0.023	0.021
	(0.106)	(0.101)	(0.098)	(0.037)
CP growth x CP SD	-0.012***	-0.013***	-0.010**	-0.004***
	(0.004)	(0.005)	(0.005)	(0.001)
Observations	810	810	810	810

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

Table 63: Determinants of overinvestments of resource firm across different specifications (Boom period) by using alternative sector classification

	(1) CRE Pooled Probit	(2) CRE MLE Probit	(3) MLE Probit	(4) Linear FE
CP growth (t-1)	0.062**	0.063**	0.043	0.019**
	(0.026)	(0.028)	(0.028)	(0.009)
CP SD (t-1)	-0.045	-0.078	-0.135	-0.028
	(0.171)	(0.194)	(0.180)	(0.062)
CP growth x CP SD	-0.017**	-0.018**	-0.013*	-0.005**
	(0.007)	(0.007)	(0.007)	(0.002)
Observations	243	243	243	243

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation. The first column shows result for Correlated Random Effect (CRE) pooled probit, the second is CRE Maximum Likelihood Estimator (MLE), the third is the standard MLE probit, and the fourth is linear model (within-estimator fixed effect model). Estimations controls for year and use robust standard error.

Table 64: Determinants of overinvestments across sectors (All Period) by using alternative sector classification

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	0.797	0.136	-0.165
	(0.625)	(0.416)	(0.508)
Commodity price growth (t-1)	0.125	-0.085	0.007
	(0.078)	(0.260)	(0.006)
Commodity price SD (t-1)	-2.161*	-0.136	0.592*
	(1.287)	(2.303)	(0.349)
SENS x Commodity price growth	0.004	0.000	0.110**
	(0.076)	(0.040)	(0.044)
SENS x Commodity price SD	-0.300	-0.069	0.018
	(0.201)	(0.153)	(0.174)
SENS x CP growth x CP SD	0.002	0.001	-0.033**
	(0.023)	(0.012)	(0.014)
Observations	810	1910	2228

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.

Table 65: Determinants of overinvestments across sectors (Boom Period) by using alternative sector classification

	(1) Resource	(2) Manufacturing	(3) Services
SENS (t-1)	-5.227	-1.217	-0.630
	(3.761)	(2.400)	(2.142)
Commodity price growth (t-1)	0.001	0.001	-0.007**
	(0.006)	(0.004)	(0.003)
Commodity price SD (t-1)	-0.130	0.184	-0.334
	(0.403)	(0.210)	(0.205)
SENS x Commodity price growth	0.320	0.022	0.248**
	(0.223)	(0.132)	(0.119)
SENS x Commodity price SD	1.553	0.189	0.068
	(0.999)	(0.631)	(0.599)
SENS x CP growth x CP SD	-0.090	-0.001	-0.068**
	(0.059)	(0.033)	(0.032)
Observations	243	660	688

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: Overinvestment dummy. CP = Commodity price; SD = Standard deviation; SENS = estimates of firm sensitivity. The estimation uses Correlated Random Effect (CRE) pooled probit. Estimations controls for year and use robust standard error.