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ABSTRACT

Initially announced Gross Domestic Product (GDP) has measurement errors since it is based on the incomplete data. Since GDP announcement affects various decisions by government and economic agents, including firm managers, I investigate the relation between the errors of GDP signals and firm R&D activities. Prior literature shows that errors in macroeconomic signals affect future aggregate activities, and that R&D has positive relation to business cycles. Consistent with those results, I find the positive relation between the error components of initial GDP estimates and subsequent R&D investment growth. I conduct further cross-sectional analyses, and find that the effect of GDP errors on firm R&D activities are less pronounced when the initial GDP estimates are negative, and are more pronounced when the capital expenditures are greater.

Keywords: Macroeconomic disclosures, GDP estimation errors, Business Cycles, R&D

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1. Introduction

The accounting literature have come to consider corporate R&D as a primary source of innovation and technological improvement in the firm (Lerner and Wulf, 2007), and as a critical component of evaluating a firm's long-run value. While the researches focus on the firm-level factors that affect firm R&D investment activities, they provide little evidence regarding the link between R&D investment activities and macro-level factors. Thus, I investigate whether the firm-level research and development (R&D) investments are associated with errors in initial announcements of gross domestic product (GDP).

As the GDP announcements convey information about the state of the economy, they affect various decisions made by economic agents, including firm managers (Nallareddy and Ogneva, 2017). However, the initial GDP figures released by the Bureau of Economic Analysis (BEA) contain measurement errors since the estimates are based on imprecise and extrapolated data from prior quarters. To improve the precision of the GDP estimates, the BEA gathers more information, and regularly restates the initially released figures during the subsequent years. Furthermore, the BEA revises all GDP figures every five years. Researchers utilize the restatement and revision process to decompose the initial GDP as true and error components. While the decomposed 'true' component approximates a period's unobservable true GDP, the remaining 'error' component represents the estimation error. The large macroeconomic literature focuses on the error component of macroeconomic signals, and predicts that the errors in publicly announced macroeconomic variables can affect future macroeconomic activities, including R&D (Lorenzoni 2009; Beaudry and Portier 2007; Jaimovich and Rebelo 2009; Cooper and John 1988; Morris and Shin 2002). It is supported by theoretical research, which assumes that the economic agents cannot filter out GDP errors, and by empirical research, which shows that GDP errors are positively associated with future investment (Mora and Schulstad, 2007).

Real GDP growths represent the business cycles. The macroeconomic literature that investigates the association between business cycles and long-run growth activities such as reorganization, reallocation, schooling, and R&D. According to Schumpeter (1939) and Aghion and Saint-Paul (1998), the recessions provide ideal conditions to improve inventive activities since the prices of inputs on R&D and the opportunity costs of R&D (e.g. forgone sales of the products) are lower in downturns, suggesting the negative relation of real GDP growth with R&D investment. However, the empirical evidences repeatedly show the positive association (Fatas, 2000; Barlevy, 2004; Comin and Gertler, 2006; and Walde and Woitek, 2004). Those studies argue that the procyclical pattern of demand and profitability of innovation, and restricted ability of credits cause the firms to invest in inventive activities following the business cycles. For example, in recessions, firms are less likely to invest in R&D since the demand and profits of commercialized R&D is lower than in booms. Furthermore, firms are not likely to do inventive activities in downturns since they are hard to finance and generate the internal cashflow in recessions.

However, as the GDP variables used in those researches are close to true components of GDP signals, it is not clear whether the error component will be positively associated with firm R&D activities. On the one hand, firm R&D investment would have positive relation with error components of GDP as the firm managers do not sufficiently filter the GDP errors (Binz et al. 2020). On the other hand, the error component would be negatively associated with R&D since the error components operate like demand shock, which temporarily increases or decreases the demand of products and services. While supply shock (e.g. arrival of new ideas or technology that increase the supply of the products and services) has direct impact on R&D, the demand shock has indirect impact through the firm outputs as opportunity costs. Ouyang (2010) shows that even though the industrial R&D is procyclical, the demand shock that indirectly affects R&D, is negatively associated with R&D, consistent with Aghion and Saint-Paul (1988).

To test the two possible predictions, I employ regression model with firm fixed effects and with standard errors clustered by firm and quarter, and use macro-level and firm-level data from Q4: 1989 to Q4: 2019. The empirical results in this paper show that firm R&D investments are positively and significantly related to the both true and error components of GDP signals, consistent with the positive relation prediction (Fatas 2000; Barlevy 2004, 2007) implying that when the two components are higher managers increase R&D investments. The results also indicate that firm managers can not sufficiently filter out the error components from macroeconomic signals by reporting that point estimates between the two components of initially announced GDP figures are statistically indifferent from one another (Binz et al. 2020).

For the better understanding, I take the further cross-sectional analyses. I investigate whether the effects of GDP errors on R&D is less pronounced when the initially announced GDP figure is negative. I find that firms are less responsive to the errors in GDP because of the increased uncertainty in recessions (Bloom, 2007). I also examine whether the effects of GDP errors on R&D is affected by the concurrent capital investments. The prior literature shows the mixed evidence that the relation between R&D and capital investments appears substituted or complementary. I find that the effects of error component in GDP signal on R&D are greater when the firms have greater concurrent capital investment, suggesting the complementary relation between R&D and capital investment. Investment projects are often bound with both capital and R&D investments. If the weights are fixed or the adjustment costs are expensive, both the capital and R&D expenditures would increase as the firm undertake more investment projects.

This paper makes several contributions. The finding in the study contributes to literature by showing that the macroeconomic disclosures are indeed important managerial investment decisions. Specifically, GDP announcements, which convey the information of demand of output, and economy's productive capacity, make firm managers to expect future state of the economy, increasing or decreasing the expense on R&D. Since R&D investment is the major component for firm long-term growth, it affects manager compensation and the firm value. Therefore, it is important to identify the factors that affect R&D investments. In this regard, I contribute to the accounting literature by showing the effects of estimation errors in macroeconomic variables as a new factor. Lastly, in macroeconomic literature, which considers the cyclicality of R&D, the researches use only the true component of GDP signals. I consider the not only the true components but also the error components in the signals. By reporting the consistent result with prior literature with error components, I expect the paper contributes to the macroeconomic literature.

2. Prior literature and Hypotheses

2.1. GDP Estimation Process

GDP signals provide the information of the state of the economy. The initial figures are released by the Bureau of Economic Analysis (BEA) three weeks after the end of a given calendar quarter. Specifically, the initial figures are typically announced at the third week of January, April, July, and October. However, the initial GDP figures have some measurement errors because of the estimation process. The initial GDP estimation is based on the imprecise and preliminary information, which comprises of 45% of full three-month survey data for a given quarter and 55% of extrapolated and trend data coming from various indicators (Grimm and Weadock, 2006).

Since the GDP figures affect the decision makings of various economic agents such as firm managers, investors, politicians, regulators, and financial experts, the precision of the GDP estimates is critical. Thus, the BEA restates the GDP figures for the previous quarter when it announces the new initial GDP estimates. For the restatement process, the BEA collects additional data, including the delayed responses from the initial surveys, corporate tax filings from the Internal Revenue Services, and annual surveys based on the large samples. The annual surveys are mandatory to the 150,000 business units while the initial GDP estimates are based on the voluntary surveys of 35,500 business units. With the additional sources for updating the initial GDP estimates, the BEA restates its GDP figures (Grimm and Weadock 2006; Landefeld et al. 2008). In addition to the restatement process of GDP figures, the past figures are revised for every five years to incorporate the any new information coming from mandatory census surveys based on more than 7 million business units (Landefeldet et al. 2008).

2.2. Macroeconomic Estimation Errors and Future Economic Activities

The initially announced GDP estimates are sensitive to the extrapolated information and trend data and are restated and revised regularly, indicating the presence of measurement errors in the GDP figures. Following the restatement process, researchers decompose the initially announced GDP estimates into two parts, 'true' and 'error' components. According to prior literature, the 'true' component of GDP signals represents the unobservable true state of the economy while the 'error' component is the remaining part, measurement error.

Like GDP estimates, other macroeconomic estimates, initially announced, contains some measurement errors. Thus, some macroeconomic papers empirically investigated the relation between initial estimates of macroeconomic variables and future macroeconomic activities. The related papers document that future economic activities are positively associated with both the true and error components of the initial macroeconomic estimates. Specifically, Oh and Waldman (1990) shows that the future growth rates of industrial production are positively related to the both components of economic leading indicators. Oh and Waldman (2005) develops the prior work, and confirms the argument that error components affect the future activities by investigating that the macroeconomists' forecasts are influenced by error components of the National Bureau of Economic Research's (NBER) index of leading indicator.

Furthermore, Mora and Schulstad (2007) follows the investigation of Oh and Waldman (1990) by examining the effects of the initial errors of GNP estimates. They report that the error components have the positive impact on future industrial productions, and that the investment, a major component of the GNP figures, is mostly responsive to the errors of the

GNP estimates while other components such as consumption and government spending are not responsive to the GNP estimation errors for the previous quarter. In addition to the work of Mora and Schulstad (2007), other studies investigate the effects of estimation errors on real economy. Orphanides (2001) reports the significant relation between monetary policies and GDP estimation errors, and suggests that policy makers do consider the GDP announcements when they make the rules for monetary policies. Kaukoranta (2010) examines the effects of errors in macroeconomic estimations using the data from Finland, the United Kingdom, and Sweden. It shows that the measurement errors in GDP estimation have the relation with business fluctuations by affecting the future production and investment.

The two explanations support the empirical results. The first explanation is from Lorenzoni (2009)'s model, which suggests that estimation errors affect the economic agents' expectation of the demand. Lorenzoni (2009)'s model assumes that economic agents know the perfect information for their own conditions while having imprecise information for the overall state of the economy. Thus, they search for extra information about the economy, and receive some public signals like real GDP figures that contain not only the news about the whole economy but also the measurement errors while the agents cannot filter out the true and error components in the initial announcements. With these assumptions, agents would increase (decrease) their expectation of productive ability of the economy relative to the true state when the estimation errors are positive (negative). Subsequently, the increased (decreased) expectation makes the agents overreact to the signals and leads to product more (less).

The second explanation is related to the notion of strategic complementarity. The model that exhibits strategic complementarity assumes that agents' decision making is affected by their expectations based on the beliefs of other agents' expectations (Cooper and John 1988;

Morris and Shin 2002). As the production of one firm increase the marginal revenue of the others in strategic complements, the higher is aggregate production, the larger is the incentive for any particular agent to produce. Thus, if the macroeconomic signals indicate the optimal condition to increase the production, all agents will produce, given that the agents cannot filter out the errors in the signals. Specifically, when the agents update their expectations upward with announced signals, remaining agents will follow them, increasing the overall production in economy and vice versa. In this situation, as the agents cannot distinguish the components in the signals, the estimation errors have the influence as well as the true components.

Overall, the point that two theoretical explanations suggest is that economic agents cannot classify the two components in the public signals. As the GDP estimation process implies that the information of the true economy state is incorporated only in the true component of the macroeconomic indicators. Even though the error components of the signals do not include the true story of the economy, they affect the expectations of the audiences, in turn, resulting in the future activities. The empirical evidences based on the aggregate data confirm the theoretical explanations (Oh and Waldman, 1990; Oh and Waldman, 2005; Orphanides, 2001; Kaukoranta, 2010; Mora and Schulstad, 2007)

2.3. Business Fluctuations and R&D investments

In accounting literature, firm R&D activities are a major topic for the various researches as the R&D investments are related to the firm long-term growth. Those papers use GDP level or growth as a proxy for investment opportunities, and predict the positive relation between GDP figures and firm R&D investments (Berger, 1993; Brown and Krull, 2008; HUANG et al. 2020; Ma et al. 2020). However, according to macroeconomic literatures, aggregate, and firm R&D could be either positive or negative association with business fluctuations.

2.3.1. Negative relation with business cycles and long-run growth

There is a view that downturn of the business cycles is the period for the long-run growth of the economy. It was firstly argued by Joseph Schumpeter (1939). He argues that the recessions provide the ideal conditions for the investment for long-term growth, such as investments in reorganization, reallocation, schooling, and research and developments, which would generate the new technology for the firm profits. The base of the argument is that since the inputs of the R&D activities are less expensive in the downturn, the resources can be reallocated to the R&D investments at a lower cost than at any other point in the cycle. Schumpeter's argument has been emphasized with Aghion and Saint-Paul (1998), which supports the idea that recessions provide the excellent conditions to invest in inventive activities. Aghion and Saint-Paul (1998) argument, called opportunity cost hypothesis, is that the opportunity costs of investing in activities that improve long-term growth are lower in the period of recessions. The lower outputs and sales that have to be sacrificed when the resources are invested in R&D activities give incentives to the innovators to undertake activities for long-term growth in downturn. In short, those two reasons support the view that R&D activities show the countercyclical patterns because of the lower input prices and opportunity costs.

2.3.2. Positive relation with business cycles and long-run growth

While some papers show that improving long-term growth activities such as schooling, reorganization, and reallocation have negative relation with business cycles, the aggregate data empirically and repeatedly show that researches and developments have procyclical patterns. The positive relation of R&D with business fluctuations is supported by some explanations.

One explanation involves financial constraints. The related hypothesis is developed by Aghion et al. (2005), which proposes a model to imply that constraints on the availability of credit make the R&D follow the business cycles. The logic is simple: as the firms are hard to finance more in recessions, it makes the firms not to invest in R&D activities even though the periods provide the good conditions. This view is supported by empirical evidence of Aghion et al. (2008), which reports that private R&D is actually countercyclical with absent credit constraints. It also reports that even allowing for credit constraints, R&D responses to economic conditions are asymmetric: in recessions firms reduce the R&D expenditures while do not increase immediately in the periods of recovery. The results of Aghion et al. (2008) is consistent with Ouyang (2010), which shows the same asymmetric R&D responses with demand shocks. Those papers show that despite the excellent conditions to undertake R&D activities in R&D, financial constraints affect to respond differently.

The second explanation is based on the patterns of profits. As it is true that economic demands and profits are larger in booms and are lower in recessions, this pattern affects the value of research and development. In recessions, the commercialized results of R&D would have lower value than the one in the booms, since the aggregate demand and profits are different. Barlevy (2007) propose a related model to explain the procyclical pattern of R&D. He assumes that innovators immediately implement the new ideas, and that they care about the short-term profits of the innovations because of the rival firms who can imitate the results of innovation. As the results of innovation is announced in public, other firms can copy the results while there are some lags to copy the results. Thus, innovators are concentrated to make profits with the new ideas during the lags, focusing on the market demand of the new ideas and the profits. With the assumption of immediate implementation, even though the recessions are the optimal time to take inventive activities, firm managers do not undertake inventive activities in recessions, since the productivity of the new idea is lower. Fabrizio and Tsolmon (2015) empirically investigates the Barlevy (2007)'s view by examining whether firm R&D investments and innovation outcomes are procyclical, and whether the procyclical patterns are more pronounced in industries where the rates of product obsolescence are faster. The results support that firms' inventive activities in industries where the productions are changing faster are stronger and appears to be procyclical, implying that firm managers consider the value of the research and development with its profits and demand. In short, since the profits that come from the results of the innovations are affected by the demand and business conditions, the value of the R&D increase as the business conditions get better, implying the positive relation of R&D activities and business cycles.

2.4. GDP Estimation Errors and R&D investments

The prior literature, which investigates the pattern of R&D investment, uses GDP figures as a proxy for business cycles. However, those researches do not examine the relation between estimation errors and R&D investments to the error components. In this paper, I focus on the GDP estimation errors and firm R&D investments for some reasons. First, as the error components serve as demand shock, which affects firm managers expectation of the demand, firm R&D activities could be related to the error components. Since the R&D investments are all expensed, it makes firm managers underinvest in R&D activities. If the managers' incentives are measured by the firm net income, then the managers have incentive to reduce the R&D expenditures. However, R&D activities are the source of long-term growth of the firm productivity. Thus, it is important to investigate the factors that could affect firm managers' decision to invest in inventive activities. Second, most of the researches that study GDP, a proxy for business conditions, and R&D do not consider the initial GDP estimations, which contain error components. The GDP figures used in those researches are similar with true component of GDP because the researchers regard the true GDP as the lastly announced figure and database that provides GDP figures uses the revised ones. That's why firm R&D investments could respond differently to the GDP estimation errors.

In the case of macroeconomic estimation error, the key point is that as both explanations assume, the economic agents do not sufficiently distinguish the true and error in the GDP signals. Binz et al. (2020) finds that firm managers cannot find the difference between true and error components when the initial GDP estimation errors are announced. Therefore, in my first hypothesis, I expect that GDP estimation errors are positively related to the firm R&D.

H1a: The GDP estimation errors are positively related to the firm R&D investments.

On the contrary, the estimation errors could be negatively associated with firm R&D investment. Based on the opportunity cost hypothesis, as the greater demand in booms affect firms to provide more outputs, it increases the opportunity costs of R&D. The reasoning of the opportunity cost hypothesis is that demand of the firm outputs does not have direct impact on firm R&D but affects R&D indirectly through the impact on firm production. While the increased demand has the indirect impact on R&D, new technology or idea, which increase the supply of the outputs, has direct impact on R&D. For example, the arrival of new ideas and new technology can boost productivity and raise the return to innovation by helping a given level of R&D to generate more ideas and technologies, increasing the R&D. Furthermore, the arrival of new technology can drive firms to perform more R&D for the purpose of developing the new technology into further productivity gains since the most of R&D spending is spent on development. In short, the positive relation between business cycle and firm R&D can be driven by mixed effects of demand and supply. Ouyang (2010) investigates the effect of demand shock, which suddenly increases or decrease demand for a product, on firm R&D, and shows the negative relation between demand shock and firm R&D. Since the macroeconomic estimation errors of the macroeconomic signals operate like demand shock (Lorenzoni, 2009) to the economic agents, firm managers would be affected by the effects of demand shocks on R&D. Thus, a competing hypothesis can be presented.

H1b: The GDP estimation errors are negatively related to the firm R&D investments.

3. Data and Research Design

3.1. Data

The sample data comprises macro-level and firm-level data. The data span is from Q4: 1989 to Q4: 2019. The data to calculate GDP estimation errors are based on the Real-Time Data Set for Macroeconomists maintained by Federal Reserve Bank of Philadelphia. The initial real GDP growth estimates and final vintage values are all seasonally adjusted percentage changes. Other macroeconomic variables are from the database: Federal Reserve Economic Data (FRED). The final sample of Macro-level observations is 121.

I obtain the firm-level data from the merged database from Compustat and CRSP. The quarterly R&D expenditures are available from Q3: 1988. Since I need data to calculate R&D expense growth over the 4 quarters and require the presence of 2 quarters consecutive lagged observations, the sample period starts from Q4: 1999. Table 1 reports the sample selection process of firm-level variables First, I exclude the regulated financial (SIC codes 6000-6999) and utilities firms (SIC codes 4900-4999) because they have different operating and reporting environments. Then, I replace the missing R&D values to zero. I also excluded observations with not enough information that was needed to construct the variables[1]. Lastly, I require the firms to have at least 30 quarterly observations and a stock price larger than one. Since initial GDP growth estimates are announced three weeks after the end of the quarter, the firms with

[1] Koh and Reeb (2015) shows that missing value of R&D would not mean that those firms do not have inventive activities. Since missing value can be a strategical choice, I exclude the missing and zero R&D firms, and test the analyses again, following the Zhong et al. (2018). The results also hold when the sample only includes the positive R%D firms.

fiscal year-ends in March, June, September, or December are included in the sample. Every quarter, I winsorize the variables at the 1st and 99th percentiles to reduce the influence of the outliers. The final sample of firm-quarter observations is 71,289.

[Insert Table 1 about here]

3.2. Measurement of GDP Estimation Errors

Since GDP figures are restated and revised for a long time, researchers use the revision process to calculate the GDP estimation errors. They decompose initial GDP estimates into two components: true component and error component as follows:

$$Initial\_GDP_t = True\_GDP_t + GDP\_Error_t \tag{1}$$

Initial GDP$_t$ in equation (1) is the initially announced real GDP figure for the quarter t. The Bureau of Economic Analysis (BEA) announces the first GDP figure three weeks after the end of the quarter t. $True\_GDP_t$, the most recently updated real GDP estimates for quarter t, is a proxy for the unobservable 'true' GDP of the quarter t. The remaining part, GDP_Error_t, is the measurement error of the initial GDP estimates. The GDP estimation errors are calculated as $Initial\_GDP_t$ minus $True\_GDP_t$.

3.3. Empirical Model

To examine whether GDP estimation errors are associated with firm R&D investments, I construct the regression model following the Binz et al. (2020):

$$R\&D\_Growth_{i,t+1} = \beta_1 True\_GDP_t + \beta_2 GDP\_Error_t + \beta_K Macro\text{-}level\ Controls_t + \beta_J Firm\text{-}level\ Controls_{i,t} + Firm\ FE_i + \varepsilon_{i,t+1} \quad (2)$$

The dependent Variable, $R\&D\_Growth_{i,t+1}$, is a R&D investment proxy, defined as seasonally adjusted firm's R&D expenditures for firm *i* and quarter *t+1* deflated by beginning of year total assets. I include 6 macroeconomic variables (*Macro-level Controls)* in the model. First, since the effects of GDP signal on firm R&D investment can be influenced by macroeconomists' forecasts of GDP, I include the forecast errors ($Forecast\_Error_t$). Second, I include market returns on the GDP announcement day (Ann_Ret_t), because Gilbert (2011) reports that stock market return on the day of GDP announcement can identify errors in the initial estimates. Third, Orphanides 2001 finds that error components of initial GDP estimates are associated with monetary policies. Thus, the managers' R&D investments could be influenced by the relation between GDP estimation errors and the Fed's policy decisions ($T\text{-}bill_t$). Forth, consumer sentiment index ($Consumer\_Sent_t$) is included, since consumer sentiment is related to the aggregate demand, which, in turn, affect the manager's investment activities. Lastly, I included the aggregate-level credit spreads ($\Delta Credit\ Spread_t$), and the economic policy uncertainty index ($\Delta EPUI_t$) from Baker et al. (2016) to control the effects of the market conditions, which could be related to the GDP estimations and firm R&D investments.[2]

[2] I obtain the Economic Policy Uncertainty Index data from http://www.policyuncertainty.com. The data are available beginning in 1985.

In addition to the country-level control variables, I also control for firm- investment variables (*Firm-level Controls*). Following Binz et al.(2020), I include the firm's stock return ($Return_t$), the firm Tobin's Q ($TobinsQ_{i,t}$) at the beginning of the quarter, the firm book-to-market ratio (BM_t) at the beginning of the quarter, the firm's earnings growth ($Earnings\ Growth_t$), the firm's capital expenditures growth ($CAPEX_t$), the firm's return volatility ($\Delta Return\_Vol_t$), the firm's asset growth over the previous quarter ($Asset\_Growth_t$), the firm age ($Firm\_age_t$) to control the investment opportunities and firm profitability; the firm leverage ratio (Lev_t) and internally generated cash ($Cash_t$) to capture the effect of capital structure; and lastly two lags of the dependent variable due to the autocorrelation. Finally, I include firm fixed effects ($FIRM\_FE_i$) to capture firm specific characteristics that may influence the firm R&D investments. Standard errors of the equation (2) are clustered by firm and quarter.

4. Empirical Results

4.1. Descriptive Statistics and Correlations

[Insert Table 2 about here]

Panel A of Table 1 presents descriptive statistics for all macroeconomic variables used in the analyses. The main variable of interest is the quarterly GDP estimation error (*$Error_t$*). Prior literature finds that GDP estimation errors are not mean zero, can be both positive and negative, and are highly variable over time (Aruoba 2008; Nallareddy and Ogneva 2016). We confirm these empirical results in the sample. The mean (median) estimation error is -0.125 (-0.220), implying that, on average, the initial GDP estimate is lower than the true GDP that will be subsequently revealed through upward revisions by the BEA.

Panel B of Table 1 presents the firm-level descriptive statistics. The means (medians) of R&D growth and capital expenditure growth, are 0.189 (0.024) and 0.068 (0.024).

[Insert Table 3 about here]

Table 3 presents the Pearson and Spearman correlation coefficients. Panel A shows the correlation coefficients of macroeconomic variables. True components of GDP signals are positively correlated with macroeconomists forecast errors and consumer sentiment index, while negatively correlated with error components of GDP signals and Economic Policy index. The error component of GDP signals is significantly related to the macroeconomists forecast errors.

Panel B of table 3 shows the correlation coefficients of firm-level variables. The dependent variable, $R\&D\_growth_t$, is significantly related to the variables to capture investment opportunities and capital structures. Specifically, R&D expenditures are significantly and positively correlated with internally generated cash, showing that cash availability is an important resource for the R&D investments (Ouyang, 2010).

4.2. Main results

[Insert Table 4 about here]

Table 4 presents that regression results of the equation (2). I begin by examining the effect of estimation errors with macroeconomic control variables and firm fixed effects in column (1). The coefficients on both true and error components of GDP signals, $True\_GDP_t$ and GDP_Error_t, are all positive and significant ($\beta_1 = 0.039$, t-value = 4.285; $B_2 = 0.031$, t-value = 2.541). Both coefficients are not statistically different based on the p-value of F-test (p = 0.149), which examines whether the two coefficients are different each other or not. The column (2) reports the regression results both with the macroeconomic control variables and with firm fixed effects. I observe the positive and statistically significant coefficient on $True\_GDP_t$ ($\beta_1 = 0.026$, t-value = 3.143) and on GDP_Error_t, ($B_2 = 0.022$, t-value = 2.004). As the results in column (1), the coefficients on both true and error components of GDP signals are indistinguishable (p = 0.385). For the firm specific investment controls, the coefficients on the variables present the consistent results with Gennaioli et al. (2016).

Overall, the positive and significant results in both columns suggest that firm future R&D investments are positively related to the GDP estimation errors, consistent with H1a. Specifically, since the firm level analysis reports the consistent procyclical pattern of R&D,

and the p-value of F-test shows that firm managers cannot sufficiently filter out the true GDP signals and measurement errors in initial GDP estimates, the error component of GDP estimates are positively associated with subsequent firm R&D expenditures.

4.3. Cross-sectional Analysis

The results in table 4 indicate that firm managers consider the initial GDP announcement in their R&D activities while they cannot filter out the true and error components of the initial GDP estimates, and that firm R&D investments are positively related to the GDP signals as the empirical analyses. However, some prior researches argue that while the ideal time to invest in R&D activities is still in recessions, some restrictions such as demand and profit of R&D (Fatas, 2000) and cash or credit constraints (Aghion et al. 2010) make the procyclical pattern of firm R&D. In other words, there are some potential factors that make the effects of GDP estimation error on firm R&D investments more or less pronounced. Thus, the further tests are held to analyze the potential situations when relation between GDP estimation errors and R&D investments might be more or less pronounced.

4.3.1. Periods of negative initial GDP estimates

The investment on knowledge stock incurs large adjustment costs, which are characterized by fixed and sunk costs. For example, payments for scientists and engineers are large parts of R&D expenditures. Since they know a lot of proprietary information of the firm and are hard to replace with others, it is difficult to lay them off. Because of the large adjustment costs, firms are less likely to responses to the temporal demand shock (Hall and Reenen, 1999). During recessions, uncertainty about future firm productivity, profitability and demand conditions becomes greater. The uncertainty or volatility over future industrial production and stock market, when GDP estimates are negative, increases by 50 percent to 100 percent (Schwert, 1989; Bloom, 2006). Because of the increased uncertainty, firm managers hesitate to invest in human resources, productivity (Bloom, 2006) and research and development and wait for uncertainty to resolve (Bloom, 2007). Based on the prior literature, it is predictable that the effects of GDP estimation errors on GDP might be lower in the period of downturn.

To investigate the whether the effects of GDP estimation errors on firm R&D investments are less pronounced when the initially announced GDP signal is negative, I add the interaction terms in equation (2) as follows:

$$\begin{aligned} R\&D\_Growth_{i,t+1} = \; & \gamma_1 True\_GDP_t + \gamma_2 True\_GDP_t \times D_t \\ & + \gamma_3 GDP\_Error_t + \gamma 4\ GDP\_Error_t \times D_t \\ & + \gamma_K Macro\text{-}level\ Controls_t + \gamma_J Firm\text{-}level\ Controls_{i,t} \\ & + Firm\ FE_i + \theta_{i,t+1} \end{aligned} \tag{3}$$

where D_t is an indicator that initially announced GDP estimates are negative, $True\_GDP_t \times D_t$ is an interaction term of $True\_GDP_t$ *with* D_t, and $GDP\_Error_t \times D_t$ is an interaction term of GDP_Error_t with D_t. Since the recessions are the periods when real GDP growth are negative, I construct an indicator variable that equals one when initially announced GDP estimates are negative, otherwise zero. The reason why I use the initial GDP estimates is that recession data are also revised as the revision of GDP figures, and that the only observable GDP estimates for quarter t is the initial one when the mangers make decisions.

I predict that the value of γ_4 would be negative to show that the effects of GDP estimation errors would be less likely to affect firm managers relative to the period of booms.

The specific definitions of variables in equation (3) are provided in appendix A. All the test statistics and significance levels are based on the standard errors, which are clustered at the firm and quarter levels.

[Insert Table 5 about here]

Table 5 presents the regression results of equation (3). Consistent with the prediction, the coefficients on both interaction terms, $True\_GDP_t$ *with* D_t, and $GDP\_Error_t \times D_t$, in column (1) are negative and significant (γ_3 = -0.02, t-value = - 1.358; γ_4 = -0.35, t-value = -1.731). The coefficients of both interaction terms do not statistically differ from each other (p = 0.128), consistent with Binz et al. (2020). In column (2), when the regression model includes the firm specific investment control variables, the estimated coefficients on interaction terms are all negative and significant (γ_3 = -0.039, t-value =-2.811; γ_4 = -0.35, t-value = - 2.059), and are significantly indistinguishable from one another (p = 0.775). It indicates that association between GDP estimation errors and subsequent R&D investments are less pronounced in the periods of negative initial GDP estimates, and firm managers do not filter out the true and error components in released GDP signals.

Overall, the negative and significant coefficients on γ_3 in table 4 column (1) and (2) shows that the positive relation between GDP estimation errors and firm R&D investments are less likely to be pronounced when the initial GDP estimates are negative, consistent with the prediction. It implies that in recession the firm managers do not invest or devest in subsequent R&D, but they are likely to wait for the for uncertainty to be resolved (Bloom, 2007).

4.3.2 Relation of R&D expenditures to capital expenditures

Under GAAP, all R&D investments are expensed. In 1974, the FASB issued Statement of Financial Accounting Standard No. 2: Accounting for Research and Development Costs. Based on the SFAS No.2, companies have to expense R&D investments when the investment incur (Elliott et al. 1984). However, some specific R&Ds are expensed somewhat later, not in the year incurred. The R&D investments that are obtained or built for R&D activities and that have alternative future uses can be treated as the capital investment. It means that some R&D investments can be depreciated and the expenses are recognized on a delayed basis in income statement. Specifically, the R&D expenses are firstly included on the balance sheet as part of PP&E, and then they are depreciated. The depreciated R&D investments are required to be reported as R&D expenditures in income statements. Since managers have flexibility to decide and change the R&D investment to capital investment, firms can report zero or missing R&D values in income statement (Koh and Reeb, 2015). Thus, R&D and capital expenditures are partial substitutes for one another (Canace et al. 2018).

R&D investments need longer time periods than capital investments to take the results of the investments. Thus, it is riskier for firm managers to take lots of R&D investments. However, it is true that R&D investments are related to the long-term growth of the firm productivity and profitability. Since the R&D investment are all expensed, firm managers have incentives to reduce the R&D expenditures when their performance measures are related to the earnings of the firms. To reduce the incentives to reduce the R&D investments, some compensation committees are likely to incorporate terms that makes the positive association between R&D expenditures and the compensations (Cheng, 2004). As the managers have motivations to increase or decrease the R&D expenditures, they could use SFAS No.2 to moderate their compensation risks. Based on the prior literature, it is predictable that the effects of GDP estimation errors on firm R&D expenditures would be more pronounced when the firm capital expenditures are greater. Furthermore, Binz et al. (2020) reports the positive GDP estimation errors and subsequent firm capital expenditures. Since the firms have limited resources to allocate in investments, there could be a possibility to have negative relation between firm capital expenditures and R&D investments.

On the contrary, firm R&D expense can be positively related to concurrent capital expenditures. Investments in R&D and physical assets often bind each other in investment projects. If the weights of them are fixed or difficult to be adjusted in the short run, the increased investment in physical assets likely raise the expenditures of R&D, and vice versa (Berstein and Nadiri, 1984; Chiao, 2001). For example, when the firms decide to invest a new technology, they have to build a facility or buy a new equipment, increasing the capital expenditures. At the same time, they have to hire new engineers, scientists, and other people to support the new project, increasing the R&D expenditures. Therefore, it can be possible to predict the positive relation between capital expenditures and R&D expenditures. To test the prediction, I add the indicator variable and interaction terms in the model below.

$$\begin{aligned} R\&D\_Growth_{i,t+1} = {} & \delta_1 True\_GDP_t + \delta_2 GDP\_Error_t + \delta_3 Q_{1,t+1} \\ & + \delta_4 True\_GDP_t \times Q_{1,t+1} + \delta_4 GDP\_Error_t \times Q_{1,t+1} \\ & + \delta_K Macro\text{-}level\ Controls_t + \delta_J Firm\text{-}level\ Controls_{i,t} \\ & + Firm\ FE_i + \eta_{i,t+1} \end{aligned} \tag{4a}$$

$$\begin{aligned} R\&D\_Growth_{i,t+1} = {} & \omega_1 True\_GDP_t + \omega_2 GDP\_Error_t + \omega_3 Q_{4,t+1} \\ & + \omega_4 True\_GDP_t \times Q_{4,t+1} + \omega_4 GDP\_Error_t \times Q_{4,t+1} \\ & + \omega_K Macro\text{-}level\ Controls_t + \omega_J Firm\text{-}level\ Controls_{i,t} \\ & + Firm\ FE_i + \psi_{i,t+1} \end{aligned} \tag{4b}$$

where $Q_{j,t}$ is the indicator variables that equals one when the firms have the value of $CAPEX_{t+1}$ in j_{th} quintile of the sample, and $True\_GDP_t \times Q_{j,t}$ and $GDP\_Error_t \times Q_{j,t}$ are the interaction terms of GDP components with first quartile indicator of capital expenditures at the quarter t+1. The specific definitions of variables are provided in Appendix A. All the test statistics and significance levels are based on the standard errors, which are clustered at the firm and quarter levels.

[Insert Table 6 about here]

Table 6 reports the regression results of equation (4). The column (1) and (2) shows the results with the lowest quintile indicator variables based on the value of capital expenditure in quarter t+1 and with the interaction terms, $True\_GDP_t \times Q_{1,t}$ and $GDP\_Error_t \times Q_{1,t}$. The coefficients on both interaction terms in column (1) are negative and significant (δ_4 = -0.019 t-value = - 2.676; δ_5 =-0.026, t-value = 2.142), and the terms in column (2) are also negative and significant (δ_4 = -0.011 t-value = - 1.844; δ_5 =-0.019, t-value = 1.762). The results of (1) and (2) indicate that when the firms' capital investments are in the first quintile of the sample, the concurrent R&D investments of the firms are less likely to be associated with GDP estimation errors. The column (3) and (4) show the results with the highest quintile indicator variable and its interaction terms with true and error components of the GDP signals. The coefficients on both interaction terms in column (3) and (4) are positive and significant, indicating that when firm has greater capital expenditures, the effects of GDP estimation errors are increasing, consistent with Canace et al. (2018).

Overall, the results of table 6 presents the positive relation between R&D investments and capital investments, consistent with Berstein and Nadiri (1984), and Chiao (2001). When the firms in the lowest capital expenditure groups, the effects of GDP estimation errors on firm R&D investments reduce, while the effects of the estimation errors are more likely pronounced when the firms have higher capital expenditures. The correlation shown in table 2 between R&D expenditures and capital expenditures is positive and significant, supporting the results in table 6.

Chapter 5. **Conclusion**

In this study, I examine the association between macroeconomic estimation errors, GDP signals, and firm R&D expenditures. Because of the estimation process of GDP announcement, the initial GDP estimates contain unobservable true GDP figures with measurement errors. As the macroeconomic literature assumes that economic agents do not sufficiently distinguish the true and error components of GDP signals, so do firm managers while the managers have rich information environment. Thus, the estimation errors affect firm managers' decision makings such as a decision for future R&D investments. As GDP, a measure of business conditions, is positively associated with R&D, the results in this paper show that GDP estimation errors also have positive and significant relation with R&D expenditures. Through the further analyses, I investigate the factors that the effects of GDP estimation errors are more or less pronounced. I report that when the initial GDP is negative, firm R&D is less likely to respond to estimation errors, and that when firms have greater capital expenditures, the effects of GDP errors on R&D investment reduce. The latter finding suggest that firm R&D is positively correlated to the firm investment in physical assets.

The finding in the study contributes to accounting literature by shows that the macroeconomic disclosures are indeed important managerial R&D investment decisions. I report that initial GDP announcements with measurement errors affect firms to investment in R&D. It is also important to identify the factors that affect R&D investments. In this regard, I contribute to literature by showing the estimation errors in macroeconomic variables as a new factor. As the role of macroeconomic disclosures have received little attention, the examination of the effects of other disclosures, including unemployment rate, employment rate, and exchange rate, on firm responses might be helpful to understand the role of macroeconomic signals in the economy.

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Appendix A
Variable Definitions

Variables	Description
Macroeconomic Variables	
$True\_GDP_{i,t}$	Final vintage (as of October 2020) value of real GDP growth for quarter t.
$GDP\_Error_{i,t}$	Real GDP estimation error computed as initially announced value minus final restated value for quarter t.
$\Delta Credit\ Spread_{i,t}$	Change in spread of seasoned Baa corporate bond yield and constant maturity 10-Year treasury bond yield in quarter t relative to quarter t-4.
$\Delta EPUI_{i,t}$	Change in Baker et al.'s (2016) Economic Policy Uncertainty Index in quarter t relative to quarter t-4.
$T\text{-}bill_{i,t}$	Annualized average daily one-year maturity T-bill yield during quarter t
$Forecast\_Error_{i,t}$	Initial real GDP estimate minus median real GDP macroeconomist forecast for quarter t
$Ann\_Ret_{i,t}$	S&P 500 index return on the day of the initial GDP announcement for quarter t
$Consumer\_Senti_{i,t}$	Change in consumer sentiment according to the University of Michigan Consumer Sentiment Index for quarter t relative to quarter t-4.
Firm Variables	
$R\&D\_Growth_{i,t}$	Change in R&D expenditures in quarter t relative to quarter t-4 scaled by beginning-of-year total assets
$Return_{i,t}$	Firm's stock return over the quarter t.
$TobinsQ_{i,t}$	Tobin's Q for firm i at the beginning of quarter t scaled by 100
$BM_{i,t}$	Book value of equity scaled by market value of equity scaled by 100
$Earnings\_Growth_{i,t}$	Seasonally adjusted earnings before extraordinary items scaled by beginning-of-year total assets
$CAPEX_{i,t}$	Seasonally adjusted capital expenditures scaled by beginning-of-year total assets
$\Delta Return\_Vol_{i,t}$	Change in daily-return standard deviation of firm i in quarter t relative to quarter t-4
$Asset\_Growth_{i,t}$	Seasonally adjusted assets scaled by beginning-of-year total assets
$Lev_{i,t}$	Total liabilities scaled by total assets
$Firm\_Age_{i,t}$	Natural log of one plus the number of years listed in CRSP
$Cash_{i,t}$	Internally generated cash computed as earnings before extraordinary items plus depreciation and amortization plus R&D expense scaled by total asset

Table 1
Sample Selection

Primary sample:	# Obs.
2020 Compustat quarterly file covering firm-quarter observations from Q3: 1988 to Q1 2020	575,918
(-) firm-quarter observations in financial (SIC codes 6000-6999) and utility (SIC codes 4900-4999) industries	497,874
(-) firm-quarter observations with fiscal year-ends not in March, June, September, or December	339,060
(-) firm-quarters observations with stock price less than one and to have less than 30 quarterly observations	241,624
(-) firm-quarters observations with at least one missing variables	71,289
Final sample:	71,289

Table 2
Descriptive Statistics

Panel A: Descriptive Statistics of Macro level Variables

	N	Mean	STD	P25	Median	P75
True_GDP$_t$	121	2.493	2.325	1.455	2.549	3.840
GDP_Error$_t$	121	-0.125	1.569	-1.355	-0.220	1.078
ΔCredit Spread$_t$	121	0.017	0.754	-0.330	-0.010	0.360
T-bill$_t$	121	0.017	0.592	0.145	0.759	1.266
Forecast_Error$_t$	121	0.140	1.319	-0.868	0.006	0.982
Ann_Ret$_t$	121	0.060	1.115	-0.562	0.033	0.672
Consumer_Senti$_t$	121	0.045	8.915	-3.800	1.300	5.200
ΔEPUI$_t$	121	1.520	33.408	-17.927	2.360	21.260

Panel B: Descriptive Statistics of Firm level Variables

	N	Mean	STD	P25	Median	P75
R&D_Growth$_{i,t}$	72,165	0.189	1.909	-0.035	0.024	0.352
TobinsQ$_{i,t}$	72,165	2.631	2.323	1.296	1.877	3.064
BM$_{i,t}$	72,165	0.477	0.460	0.198	0.361	0.622
Return$_{i,t}$	72,165	4.582	29.314	-11.327	2.212	16.026
Earnings_Growth$_{i,t}$	72,165	0.176	6.543	-1.021	0.151	1.157
CAPEX$_{i,t}$	72,165	0.068	1.253	-0.240	0.024	0.341
ΔReturn_Vol$_{i,t}$	72,165	-0.061	1.861	-0.804	-0.048	0.695

Asset_Growth$_{i,t}$	72,165	7.131	28.928	-3.981	5.653	17.526
Lev$_{i,t}$	72,165	45.644	27.433	23.991	43.643	61.763
Firm_Age$_{i,t}$	72,165	260.594	87.555	194.591	263.906	317.805
Cash$_{i,t}$	72,165	2.205	5.951	0.963	3.013	5.016

Note: This table presents descriptive statistics for variables used in the analyses. All the values are multiplied by 100. Appendix A provides detailed variable definitions. The sample includes 71,289 firm-quarter observations from Q:4 1989 to Q4: 2019.

Table3
Pearson/Spearman Correlation Matrix

Panel A: Macro Variables

Variables	1	2	3	4	5	6	7	8
1. True_GDP$_{i,t}$	1	**-0.573**	**-0.320**	**0.109**	**0.361**	**-0.030**	**0.109**	**-0.325**
2. GDP_Error$_{i,t}$	**-0.574**	1	**-0.009**	**0.064**	**0.258**	**0.002**	**-0.113**	**-0.014**
3. ΔCredit Spread$_{i,t}$	**-0.467**	0.055	1	**0.172**	**-0.125**	**0.106**	**-0.447**	**0.598**
4. T-bill$_{i,t}$	**0.153**	-0.084	0.107	1	**0.162**	**0.057**	**-0.215**	**0.124**
5. Forecast_Error$_{i,t}$	**0.417**	**0.219**	**-0.201**	0.149	1	**0.029**	**0.0149**	**-0.162**
6. Ann_Ret$_{i,t}$	-0.054	0.057	0.100	**0.011**	0.017	1	**-0.121**	**0.103**
7. Consumer_Senti$_{i,t}$	**0.4108**	-0.068	**-0.546**	-0.138	0.0926	-0.079	1	**-0.353**
8. ΔEPUI$_{i,t}$	**-0.433**	0.084	**0.613**	**0.037**	**-0.184**	0.114	**-0.527**	1

Panel B: Firm level Variables

Variables	1	2	3	4	5	6	7	8	9	10	11
1. R&D_Growth$_{i,t}$	1	**0.290**	**-0.196**	0.001	**-0.240**	**0.173**	-0.014	**0.307**	**-0.104**	**-0.141**	**0.110**
2. TobinsQ$_{i,t}$	**0.155**	1	**-0.835**	**-0.065**	**0.049**	**0.130**	**-0.036**	**0.302**	**-0.073**	**-0.175**	**0.142**
3. BM$_{i,t}$	**-0.088**	**-0.511**	1	**-0.187**	**-0.067**	**-0.093**	**0.040**	**-0.181**	**-0.252**	**0.103**	**-0.079**
4. Return$_{i,t}$	-0.006	**-0.053**	**-0.181**	1	**0.099**	0.007	**-0.066**	**0.058**	**0.048**	**0.031**	**0.109**
5. Earnings_Growth$_{i,t}$	**-0.382**	0.005	**-0.011**	**0.042**	1	**0.027**	**-0.054**	**0.048**	**0.051**	**0.033**	**0.400**
6. CAPEX$_{i,t}$	**0.098**	**0.097**	**-0.076**	-0.004	**-0.010**	1	**-0.023**	**0.246**	**-0.003**	**-0.006**	**0.114**
7. ΔReturn_Vol$_{i,t}$	**-0.030**	**-0.017**	**0.063**	**0.024**	**-0.045**	**-0.030**	1	**-0.040**	**0.038**	**0.025**	**-0.030**
8. Asset_Growth$_{i,t}$	**0.234**	**0.213**	**-0.131**	**0.046**	**-0.032**	**0.200**	**-0.047**	1	**-0.003**	**-0.069**	**0.253**
9. Lev$_{i,t}$	**-0.045**	**0.033**	**-0.262**	**0.042**	**0.035**	**-0.011**	**0.039**	**0.036**	1	**0.190**	**-0.004**

10. Firm_Age$_{i,t}$	**-0.079**	**-0.179**	**0.048**	**-0.017**	**0.018**	**-0.013**	**0.010**	**-0.054**	**0.142**	1	**0.180**
11. Cash$_{i,t}$	**0.039**	**-0.101**	-0.007	**0.024**	**0.399**	**0.078**	**-0.054**	**0.184**	**-0.068**	**0.184**	1

Note: This table reports Pearson and spearman correlations of variables from the main models. Bold coefficients indicate statistical significance at 1 percent level. Variable definitions are in Appendix A.

Table4

GDP Announcements and Subsequent R&D investments

Dependent Variable	**$R\&D\_Growth_{i,t+1}$**			
	(1)		**(2)**	
$True\_GDP_t$	0.039	***	0.026	***
	(4.285)		(3.143)	
GDP_Error_t	0.031	***	0.022	**
	(2.541)		(2.004)	
$Return_{i,t}$			0.002	***
			(5.073)	
$TobinsQ_{i,t}$			0.026	***
			(3.017)	
$BM_{i,t}$			0.006	
			(0.191)	
$Earnings\_Growth_{i,t}$			-0.011	***
			(-4.078)	
$CAPEX_{i,t}$			0.032	***
			(4.202)	
$\Delta Return\_Vol_{i,t}$			-0.058	***
			(-8.296)	
$Asset\_Growth_{i,t}$			0.006	***
			(9.407)	
$Lev_{i,t}$			-0.004	***
			(-6.251)	
$Firm\_Age_{i,t}$			0.000	
			(0.326)	
$Cash_{i,t}$			0.012	***
			(4.099)	
$Dep\_Var_{i,t}$	0.379	***	0.342	***
	(19.257)		(18.470)	
$Dep\_Var_{i,t-1}$	0.124	***	0.116	***
	(9.258)		(9.097)	
Macro Controls	YES		YES	
Firm FE	YES		YES	
Obs.	72,165		72,165	
Adj.R^2	0.262		0.281	
$True\_GDP_t = GDP\_Error_t$	0.149		0.385	

Note: This table reports the results of OLS regressions with fixed firm effects and with standard errors clustered by firm quarter. ***, **, * statistical significance at 1, 5, 10 % levels, respectively, and t statistics are in parentheses. The last row of the panel reports the p-values of F-tests for whether the coefficients of GDP and Error are equal.

Table5

GDP Announcements, Subsequent R&D investments, and Signs of GDP

Dependent Variable	**$R\&D\_Growth_{i,t+1}$**			
	(1)		**(2)**	
$True\_GDP_t$	0.041	***	0.034	***
	(3.268)		(3.190)	
$True\_GDP_t \times D_t$	-0.031	**	-0.052	***
	(-2.333)		(-4.074)	
GDP_Error_t	0.036	**	0.030	**
	(2.237)		(2.194)	
$GDP\_Error_t \times D_t$	-0.038	**	-0.043	**
	(-2.075)		(-2.602)	
D_t	-0.085	**	-0.110	***
	(-2.054)		(-3.077)	
$Return_{i,t}$			0.002	***
			(5.183)	
$TobinsQ_{i,t}$			0.026	**
			(2.985)	
$BM_{i,t}$			0.004	
			(0.143)	
$Earnings\_Growth_{i,t}$			-0.011	***
			(-4.103)	
$CAPEX_{i,t}$			0.032	***
			(4.199)	
$\Delta Return\_Vol_{i,t}$			-0.059	***
			(-8.400)	
$Asset\_Growth_{i,t}$			0.000	***
			(9.409)	
$Lev_{i,t}$			-0.004	***
			(-6.246)	
$Firm\_Age_{i,t}$			0.000	
			(0.443)	
$Cash_{i,t}$			0.012	***

			(4.136)	
$Dep\_Var_{i,t}$	0.379	***	0.342	***
	(19.258)		(18.473)	
$Dep\_Var_{i,t-1}$	0.124	***	0.116	***
	(9.264)		(9.105)	
Macro Controls	YES		YES	
Firm FE	YES		YES	
Obs.	72,165		72,165	
Adj.R^2	0.262		0.281	
$True\_GDP_t = GDP\_Error_t$	0.389		0.356	
Interaction terms	0.128		0.775	

Note: This table reports the results of OLS regressions with fixed firm effects and with standard errors clustered by firm quarter. ***, **, * statistical significance at 1, 5, 10 % levels, respectively, and t statistics are in parentheses. The last two rows of the panel report the p-values of F-tests for whether the coefficients of GDP and Error or coefficients of two interaction terms are equal.

Table6

GDP Announcements, R&D investments and Capital investments

Dependent Variable	**$R\&D\_Growth_{i,t+1}$ ($Q_{1,t+1}$)**				**$R\&D\_Growth_{i,t+1}$ ($Q_{5,t+1}$)**			
	(1)		**(2)**		**(3)**		**(4)**	
$True\_GDP_t$	0.040	***	0.033	**	0.039	***	0.028	***
	(4.284)		(2.562)		(4.206)		(3.224)	
GDP_Error_t	0.035	***	0.028	*	0.032	***	0.024	**
	(2.809)		(1.740)		(2.454)		(2.030)	
Q_{t+1}	-0.065	***	-0.035	***	0.194	***	0.108	***
	(-6.362)		(-3.446)		(7.729)		(4.245)	
$True\_GDP_t \times Q_{t+1}$	-0.019	***	-0.011	*	0.018	*	0.016	*
	(-2.676)		(-1.844)		(1.748)		(1.849)	
$GDP\_Error_t \times Q_{t+1}$	-0.026	**	-0.019	*	0.015	*	0.023	*
	(-2.142)		(-1.762)		(1.887)		(1.662)	
$Return_{i,t}$			0.002	***			0.002	***
			(4.639)				(4.697)	
$TobinsQ_{i,t}$			0.025	**			0.025	**
			(2.868)				(2.913)	
$BM_{i,t}$			0.008				0.006	
			(0.262)				(0.213)	

$Earnings\_Growth_{i,t}$			-0.011	***			-0.011	***
			(-4.163)				(-4.122)	
$CAPEX_{i,t}$			0.019	**			0.027	**
			(2.404)				(3.584)	
$\Delta Return\_Vol_{i,t}$			-0.058	***			-0.058	***
			(-8.282)				(-8.323)	
$Asset\_Growth_{i,t}$			0.006	***			0.006	***
			(9.178)				(9.384)	
$Lev_{i,t}$			-0.004	***			-0.004	***
			(-6.241)				(-6.232)	
$Firm\_Age_{i,t}$			0.000				0.000	
			(0.279)				(0.487)	
$Cash_{i,t}$			0.012	***			0.012	***
			(4.082)				(4.107)	
$Dep\_Var_{i,t}$	0.377	***	0.342	***	0.378	***	0.342	***
	(19.190)		(18.479)		19.164		(18.449)	
$Dep\_Var_{i,t-1}$	0.124	***	0.117	***	0.123	***	0.116	***
	9.275		(9.145)		9.235		(9.121)	
Macro Controls	YES		YES		YES		YES	
Firm FE	YES		YES		YES		YES	
Obs.	72,165		72,165		72,165		72,165	
Adj.R^2	0.246		0.281		0.238		0.279	
$True\_GDP_t$=GDP_Error_t	0.307		0.647		0.244		0.598	
Interaction terms	0.739		0.391		0.663		0.306	

Note: This table reports the results of OLS regressions with fixed firm effects and with standard errors clustered by firm quarter. ***, **, * statistical significance at 1, 5, 10 % levels, respectively, and t statistics are in parentheses. The last two rows of the panel report the p-values of F-tests for whether the coefficients of GDP and Error or coefficients of two interaction terms are equal.

국문 초록

거시경제변수 측정오류와 기업의 연구개발 활동

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경영학과 회계학 전공

김 휘 동

분기 마감 이후, 처음으로 공시되는 국내총생산 예측치는 일부 불완전한 정보를 사용하기 때문에 측정오류를 내포하고 있다. 본 연구는 국내총생산 측정치의 측정오류와 기업의 연구개발 활동의 연관성에 대해 조사하여, 거시경제에 대한 정보 공시가 기업 활동에 미치는 영향에 대한 이해를 높이는 것을 목표로 한다. 기존의 연구에서는 거시경제 지표들의 측정오류와 미래 경제활동들의 양(+)의 관계를, 연구개발 활동과 경기순환의 양(+)의 관계를 이론과 실증분석으로 설명하였다. 본 연구 결과에 따르면, 초기 국내총생산 성장률 예측치에 포함된 측정오류는 다음 기 연구개발 투자의 성장률과 양(+)의 관계를 보였다. 또한 측정오류와 연구개발 투자와의 관계는 초기 국내총생산 성장률의 측정치가 음(−)수 일수록 약화되고, 다음 기 자본적 지출이 클수록 강화되는 것으로 나타났다.

주요어: 거시경제지표 공시, 국내총생산 측정오류, 경기순환, 연구개발

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