Capital Reallocation and Firm-Level Productivity Under Political Uncertainty

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28 June 2021

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This Version: June 2021

Abstract

Does policy uncertainty affect productivity? Policy uncertainty creates delays as firms await new information about prices, costs and other market conditions before committing resources. Such delays can have real consequences on firms' productivity and corporate decisions. First, we find that economic policy uncertainty has a negative impact on firm-level productivity. Second, debt magnifies the adverse effects of policy uncertainty on productivity, but access to external financing during periods of significant policy uncertainty shocks has a positive impact on firm-level productivity. Third, Policy uncertainty is positively related to cash holdings but this effect is mostly driven by highly productive firms and by firms with higher levels of irreversible investments since these firms face higher opportunity costs in future states. The three findings are robust to various specifications and provide an affirmative answer to the opening question.

JEL Classifications: E22, E32, G18, G31, G32,

Keywords: Policy Uncertainty, Capital Reallocation, TFP, Leverage, Cash, Business Cycles

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‡We thank John Graham, Brandon Julio, Rohan Williamson, Ambrus Kecskeś, Goeun Choi, Yelena Larkin, Yoontae Jeon, participants at the FMA 2020, SFA 2020, SWFA 2021, GFC 2021 for including the paper in their programs and for their constructive comments and suggestions. We thank the GFC 2021 conference organizers and committee for granting this paper the "Top Paper Award". All errors remain our own.

1 Introduction

A large body of literature by Abel (1983), Bernake (1983), Abel and Eberly (1994), Baker, Bloom and Davis (2016), Gulen and Ion (2016), Julio and Yook (2012) has attempted to quantify the effects of policy uncertainty on firms' real decisions. They find that policy uncertainty shocks do have real and persistent effects. However, little attention has been devoted to the effects of policy uncertainty shocks on firm-level productivity. This paper attempts to address the following question: does policy uncertainty affect productivity? If so, what is the propagation mechanism? As pointed out by Pindyck (1991), policy uncertainty creates delays as firms await new information about prices, costs, and other market conditions before committing resources. Such otherwise cautious delays reduce not only investment, but also firms' hiring decisions. When uncertainty is high, firms reduce expansion and contraction shutting off much of the productivity-enhancing capital reallocation (Bloom, Floetotto, Jaimovich, Saporta and Terry, 2018). Therefore, we would expect that policy uncertainty shocks affect firm-level productivity through a reduction in irreversible investments, resource reallocation, which in the end leads to reduction in firm-level total factor productivity (TFP).

To carry out our investigation, we adopt the policy uncertainty measure proposed by Baker, Bloom and Davis (2016, hereafter BBD). The BBD index is specifically designed to capture political and regulatory uncertainty while filtering out other macroeconomic shocks, hence can be used as a good proxy to quantify the effects of policy uncertainty on firms' real decisions. The BBD index is constructed based on information collected from ten major U.S. newspapers. There are three components to the index. The first one is the News component which captures the intensity of political and policy related news. The second is to measure the importance of tax code changes by estimating the expected tax revenue changes. The third is to account for the discrepancy among different monetary and fiscal policy forecasting. Our results are also consistent when we use alternative policy uncertainty measures such as Jurado, Ludvigson and Ng (2015 macroeconomics uncertainty. Detailed construction of the BBD index is described in Section 2.

To measure the firm-level TFP, we utilize the procedure outlined in Olley and Pakes (1996) and Tuzel and Imrohoroglu (2014). In particular, we take capital and labor as the sole inputs in firms' production functions. We then estimate each firm's TFP using panel regressions. To ensure that each firm's TFP is free of aggregate and industry influences, we add industry-specific time dummies as control variables in the regressions. The average quarterly firm-level TFP has a mean of 0.159 and a standard deviation of 0.813, which is consistent with prior literature.

Our objective is to examine effects of policy uncertainty on firms' TFP and corporate financial decisions. To do so, we use the BBD index as an explanatory variable while controlling for aggregate states and firm specific characteristics. The GDP growth and the VXO are used as the macroeconomics control variables since GDP growth captures the general state of the economy and VXO reflects the uncertainty in the capital market. As such both GDP growth and VXO have real effects on firm's TFP. To control for firm characteristics, we include firm size, Sales Growth, Leverage, Short-Term Debt, Long-Term Debt, Capital expenditures, profitability, plant, property and equipment, Acquisitions and Sales PP&E. All our regressions include firm fixed effects and robust standard errors clustered at the firm-level.

Our first focus is to examine the impact of policy uncertainty on firm-level productivity (TFP). Intuitively, policy uncertainty creates delays as firms await new information about prices, costs and other market conditions before committing resources. Such delays result in capital reallocation, investment decline and hiring freezes. As a result, firms would experience low productivity during periods of significant policy uncertainty shocks. Based on this line of thinking, we formulate our first hypothesis that policy uncertainty has a negative effect on firm-level productivity (TFP). Our empirical analysis confirms this hypothesis. The intuition is that uncertainty shocks create a wedge and result in inefficient reallocation of capital and labor, leading to decline in firm-level productivity.

Our second objective is to examine whether there exists an impact of policy uncertainty on firms' liquidity management given its negative influence on firm-level TFP. We test whether during periods of significant policy uncertainty shocks, high productive firms behaves differently from their low productive counterparts. This is because when managers face policy uncertainty shocks, they cannot fully anticipate the length, pathways or duration of these shocks, hence they might prefer to wait for economic policy uncertainty to be resolved before fully re-committing resources to productive use.

In particular, during periods of heightened policy uncertainty shocks, firms might face financial constraints which make them unable to meet short-term and medium-term debt obligations. As such, we formulate our second hypothesis and examine whether access to external financing during periods of heightened policy uncertainty shocks has any impact on firm-level TFP. We show that, despite the fact that leverage has a negative effect on firm-level TFP, access to leverage during policy uncertainty shocks has a positive impact on productivity. We argue that this is because having access to debt financing might allow firms to continue financing ongoing investment projects and hence increases firm-level productivity during periods of heightened policy uncertainty shocks.

Our third focus is to examine whether policy uncertainty shocks induce substitution effects between the deployment of internal and external capital. In addition to utilizing the external debt as shown above, some firms may hoard cash as a hedge against policy uncertainty shocks (Beau and Jens, 2018). Therefore, we postulate our third hypothesis and investigate the impacts of policy uncertainty on firms' cash holdings. The third hypothesis is tested in two dimensions. First, we test whether policy uncertainty induces higher cash holdings especially for highly productive firms. Second, we test whether firms that have higher levels of irreversible investments tend to hold more cash during periods of heightened policy uncertainty. Our empirical results confirm this hypothesis. We find that policy uncertainty is positively related to cash holdings for firms in the top tercile of productivity distribution and for firms with more irreversible investment projects. During periods of the heightened policy uncertainty shocks, firms in the top tercile of productively distribution face higher opportunity costs in future states. This is because policy uncertainty increase adjustment costs and depressed investment opportunities (Gulen and

Ion, 2016). In order to mitigate such high opportunity costs in future states, highly productive firms tend to increase their cash holdings when policy uncertainty is high. Similarly, firms with irreversible investment projects tend to hold higher cash positions because they want to have sufficient funds to continue undertaking these projects. Our main contribution here is that the documented increase in cash holdings during periods of uncertainty shocks is mostly driven by highly productive firms. Our empirical result offers a possible explanation to the increase in cash holdings amongst U.S. firms in the past few decades.

This paper is related to two strands of literature: the role of external capital during financial uncertainty and the precautionary role of cash holdings. The first strand of literature is represented by Beck, Levine and Loayza (2000), Gatti and Love (2008), Ferrando and Ruggieri (2015), and Levine and Warusawitharana (2017). They find that higher leverage is negatively related to productivity during the period of financial uncertainty. Other studies (Julio and Yook, 2012), Jermann and Quadrini, 2012; and Falato and Liang, 2014) document that financial frictions influence capital deployment as well as on labor decisions. The second strand of literature is represented by Bates, Kahle and Stulz (2009), Duchin, Ozbas and Sensoy (2010), Campello, Graham, Giambona and Harvey (2011), Gulen and Ion (2016), and Duong, Nguyen, Nguyen and Rhee (2017). They show that firms build up their cash positions in anticipation of significant future investments. In particular, Gulen and Ion (2016) use the BBD index and show that negative effects of policy uncertainty on investment are profound amongst firms with higher degree of investment irreversibility. We show that the documented result on investment is mostly driven by lowly productive firms.

Our main contribution to the existing literature is to examine the impact of policy uncertainty on firm-level productivity, which is entirely new. We show that policy uncertainty has statistically and economically significant negative effect on firm-level productivity (TFP). Our second contribution is to show that while leverage has a negative effect on productivity, access to external financing during policy uncertainty shocks increases firm-level productivity (TFP). Access to external capital during policy uncertainty shocks allows firms to continue financing their ongoing investments and hence increase firm-level TFP. This is the second-order effect, conditional on the first-order negative effect of policy uncertainty on firm-level productivity. Our third contribution is to document that policy uncertainty induces high cash holdings for highly productive and for firms with higher irreversible investments. We attribute the result for highly productive firms to the fact that policy uncertainty induces precautionary delays in investment, which in turn leads to an increase in cash holdings. The result for firms with high levels of irreversible investment can be understood as that these firms face higher opportunity costs in future states and that the increased cash holdings will potentially be used to continue financing these investments. Our explanation is complementary to the precautionary motive of cash holdings as presented in the extant literature. The contribution here is that the documented increase in cash holdings amongst US firms is mostly driven by highly productive firms, lowly productive firms tend to reduce cash holding (stronger preference for using internal cash to refinance debt) during periods of significant policy uncertainty. We also show that the documented decline in investments during periods of significant policy uncertainty shocks is mostly pronounced amongst lowly productive firms.

The remaining paper is organized as follows. Section 2 describes the data. Sections presents the three hypotheses and the main results of our empirical analyses. Section 4 discusses various robustness tests and Section 7 concludes the paper.

2 Data, Variable Definition and Measures

For ease of exposition, in this section, we introduce the main variables and the data needed to measure each variable.

2.1 Measuring Policy Uncertainty

We adopt a policy uncertainty measure proposed by Baker, Bloom and Davis (2016), which is the BBD overall policy uncertainty index (denoted as the BBDO index). The detailed construction can be found on the following website:`http://www.policyuncertainty.com`. We provide a brief summary of the construction below. The BBDO index is a weighted average of three main components. The first component (denoted as BBDNEWS) is based on an automated search of the number of articles from 1985 to 2016 in the ten largest newspapers in the U.S. that discuss policy-related uncertainty. These ten newspapers include The New York Times, USA Today, Miami Herald, Chicago Tribune, Washington Post, L.A. Times, Boston Globe, San Francisco Chronicle, and the Dallas Morning News.

In order for an article to be included in the index, it must contain at least one term in each of the following sets: 1) the uncertainty set: at least one of the terms "uncertain" or "uncertainty"; 2) the economic set: at least one of the terms "economic" or "economy"; and 3) the policy-related set: at least one of the terms "white house," "regulation," "legislation," "federal reserve," "deficit," and "congress." Since the volume of news across newspapers and time varies, the number of policy uncertainty articles each month is normalized with the total number of articles in each of the ten newspapers, resulting in ten series. Each of the series is then adjusted monthly to a unit standard deviation and then summed, and the overall scale is normalized so that the overall index has an average of 100 throughout the entire period.

The second component (denoted as BBDTAX) accounts for levels of uncertainty related to expected changes in the tax code. Using data from the Congressional Budget Office, Baker, Bloom and Davis (2016) estimate the level of tax-related uncertainty on a yearly basis by discounting the expected value of tax revenue due to tax provisions that are to expire in the following decade.

The third component (denoted as BBDFS) consists of forecasters' disagreement regarding future monetary and fiscal policies. The Federal Reserve Board (Philadelphia) survey of professional forecasters, the forecasts of the Consumer price index (CPI), as well as the forecasts of purchases of goods and services by federal, state, and local government are the ingredients for the third component of the BBD index. The forecasters' disagreement index is proxied by the average of the interquartile range between the two forecasts.

The BBDO index is then computed as a weighted average of the three components: (1/2)(BBDNEWS)+(1/6)(BBDTAX)+(1/3)(BBDFS). Panel A of Table 1 presents the summary statistics of the four BBD indices. The overall index BBDO has an average of 105.6736 with a standard deviation of 31.6134 for the period of 1985 to 2016. While BBDNEWS and BBDFS have a comparable average and standard deviation, the counterparts for the BBDTAX index are much larger, indicating a wider dispersion and a longer right-tail in tax revenues. Insofar as the BBDTAX component receives the lowest weight in the overall index, the profile of BBDO resembles those of the other two components. Panel A of Table 2 presents the correlations among the BBD indices. While the largest weight of BBDNEWS does lead to the highest correlation with the overall index (viz. 0.8890), the second largest weight of BBDFS fails to result in the second highest correlation. A smaller weight notwithstanding, the BBDTAX component enjoys a higher correlation with the overall index (viz. 0.5750), chiefly due to its higher variability. Finally, Figure 1 presents the time series of the BBDO index. The vertical dotted lines represent periods of extraordinary events: the first Gulf war, 9/11, the Great Financial crisis and the 2013 government shut down. The figure clearly indicates a heightened uncertainty during these periods, suggesting more intense debates about economic policies.

2.2 Measuring the Macroeconomics Environment: GDP Growth and VXO

To examine the impact of the policy uncertainty on firms' productivity, it is necessary to control for the effects of macro environment. To this end, we use the GPD growth rate to proxy for the aggregate economic state, with a high growth rate indicating a booming economy while a low growth rate indicating a depressed economy. For all empirical tests in this study, GDP growth rates are retrieved from the website of the Bureau of Economic

Analysis. For the sample period of 1985 to 2016, the average GDP growth rate is 1.24%, with a standard deviation of 1.022%, indicating significant fluctuation (please see Panel B of Table 1). In order to investigate the impact of the policy uncertainty on firms' corporate financial decisions, it is important for us to control for the effect of the uncertainty of the capital market. We use the stock market VXO index to capture the expected volatility or uncertainty in the capital market. The VXO index, the implied volatility derived from S&P 100 index option prices, is a well-known measure that captures the expected volatility of the stock market. The higher the VXO, the more uncertain the stock market. We obtain the historical VXO data from the Chicago Board Options Exchange. Panel B of Table 1 shows that the average VXO is 20.6857% and the standard deviation of VXO is 8.6656%. This suggests significant movements in the stock market for the sample period of 1985 to 2016.

2.3 Firm-Level Control Variables

The main sample consists of COMPUSTAT firms incorporated in the U.S for the period of 1985 to 2016. Following the literature, we exclude financial firms whose SIC codes ranging from 6000 to 6999 as well as utility firms whose SIC codes ranging from 4900 to 4999. The former firms are excluded due to the difficulty in assessing liquidity levels and the latter due to heavy regulations. We also eliminate firms whose total assets are reported as zero or negative. We exclude observations with negative sales or employment, which are essentially measurement errors. The final sample consists of 458,339 firm-quarter observations with 15,106 unique firms. Panel C of Table 1 presents the summary statistics for firm level control variables.

The average firm in the sample has an average quarterly sales growth of 2.05%, which ranges from -8.26% in the 25^{th} per centile to 12.55% in the 75^{th} per centile. Cash is measured as quarterly short-term cash and short-term investment (CHEQ) normalized by total quarterly assets. The average quarterly cash holding is about 18.23%, which is consistent with prior literature (Bates et al. 2009). Short-term debt (DLCQ) and Long-Term debt (DLTTQ) are reported as the percentage of the total debt. The average quarterly Short-term debt is 0.3393 while the average quarterly long-term debt is 0.6606. This suggests that, on average, firms tend to borrow with longer terms and about 2/3 of total debt is long term debt. The standard deviations of the short-term and long-term debts are 0.3041 and 0.3468. This suggests that long-term borrowing shows more variations than short-term debt. Total debt is reported as per centage of total asset.

The average quarterly total debt is 0.2349, which implies that total debt is roughly a quarter of the total asset. Average firms in the sample are financially sound. The standard deviation of total debt is 0.2252, suggesting only a modest variation in total debt among firms. The capital expenditure, acquisitions, sales of plants, properties and equipment are reported in million dollars. The average quarterly capital expenditure and acquisitions are 25.2849 and 2.8054 million dollars, with standard deviations being 138.8706 and 61.0159 million dollars. These figures are consistent with the existing literature. The mean and standard deviation of sales of plants, properties and equipment are 2.2651 and 50.6882 million dollars, slightly lower than those of acquisitions.

[INSERT Table 1 ABOUT HERE]

2.4 Measuring Firm-Level Total Factor Productivity (TFP)

Our empirical measure of firm-level total factor productivity (TFP) is based on the methodology presented in Olley and Pakes (1996), Dwyer (1998), Syverson (2004), and Tuzel and Imrohoroglu (2014) with firms' labor and physical capital as the sole inputs in the production function. The adoption of the technical model for our work is outlined in the Appendix. We use the COMPUSTAT accounting measure of gross property, plant and equipment (PPEGTQ) to approximate for capital stock. To account for depreciation of capital stock (k_{it}); we compute age of capital as accumulated depreciation, depletion and amortization (DPACTQ) adjusted by total depreciation and amortization (DPQ). The current quarter beginning capital stock is then assumed as the lagged quarter capital stock. The value added y_{it} is estimated as COMPUSTAT variable net sales (SALEQ) less materials, where materials are estimated as total expense net labor expense.

Total labor expense is the product of wages (extracted from social security administration) and COMPUSTAT stock of labor (EMP). Value added is then deflated using a GDP price deflator and both investment and capital stock are deflated using a non-residential fixed investment price index (Brynjolfson and Hitt 2003, Hall 1990, Hulten 2001). To obtain TFP, we estimate a panel regression in Equation [A1] controlling for industry-specific time dummies, ensuring that firm specific TFP is free of aggregate and industry level TFP. Panel C of Table 1 shows that the average quarterly TFP is about 0.159 with a standard deviation of 0.813 and ranges from a negative value of 0.102 in the 25^{th} percentile to a positive value of 0.316 in the 75^{th} per centile

Table 2 presents the correlations among the BBDO index, macro control variables and the firm-level control variables. As expected, there is a positive correlation between firms' TFP and GDP growth (0.0418) while a negative correlation between TFP and the VXO (-0.0077). Also, firms' sales or assets exhibit similar pattern with GDP growth and the VXO index. In particular, the correlations of firms' size and sales with GDP growth are 0.0748 and 0.0907 while their correlations with VXO are -0.0027 and -0.0068. It is important to note that the correlations between GDP growth/the VXO and all firm-level control variables are less than 0.01, ensuring the absence of potential multicollinearity problems.

3 Hypothesis Development and Empirical Analyses

3.1 The Impact of Policy Uncertainty on Firm-Level Productivity

Our primary empirical question is whether policy uncertainty affects firms' productivity. Specifically: How is firm productivity affected when firms face high levels of policy uncertainty shocks? As expected, policy uncertainty tends to heighten during recessions and abate during booms. Gulen and Ion (2016) indicate that policy uncertainty is inversely related to output and firms' investment decision. Managers not only react to policy uncertainty shocks but also incorporate uncertainty effects into long-term investment decisions, capital deployment and hiring decisions.This is paritally because managers can not fully anticipate the length or duration of policy uncertainty shocks. In addition, policy uncertainty creates delays as firms await for uncertainty to be fully resolved before committing additional resources. The overall result would be that policy uncertainty shocks have a long-lasting right tail. Thus, the adverse effects of policy uncertainty shocks on productivity effectively amplify the investment problem. Therefore, we would expect a negative relationship between firm-level TFP and policy uncertainty. This is the first hypothesis that we will examine in this paper.

Hypothesis 1:

Policy uncertainty has a negative impact on firm-level total factor productivity (TFP).

To test the above hypothesis, we run the baseline panel regression as follows:

$$TFP_{it} = \beta_0 + \beta_1 PU_t + \psi \mathbf{X_{it}} + \gamma \mathbf{M_t} + \eta_i + \epsilon_{it} \tag{1}$$

In this model, TFP_{it} is the dependent variable measuring firm i's productivity at time t. The policy uncertainty (PU_t) measure is the main explanatory variable, and it is proxied by the natural logarithm of the quarterly BBD indices. In addition, we include two macro measures ($\mathbf{M_t}$), namely the GDP growth and the VXO, as control variables. Moreover, we include a set of firm specific control variables (X_{it}): Ln(Sales), Sales Growth, Short-Term Debt, Long-Term Debt, Capex, Acquisitions and Sales PP&E. Finally, we employ firm fixed effects (η_i) to control for time-invariant differences across firms. Following Petersen (2009), the error term ϵ_{it}, it is clustered at firm-quarter level so as to correct for potential cross-sectional and serial correlations.

As suggested by Bloom (2009), and Bloom, Floetotto, Jaimovich, Saporta and Terry (2018), policy uncertainty is countercyclical because politicians and regulatory bodies are more likely to intervene during recessions. Before we run the panel regression (1), we need to filter out the cyclical component. The Hodrick-Prescott (HP) filter is used for this purpose. We perform the same filter to GDP growth rate and some firm-level control variables. Figures 2[a,b] plot the HP filtered cyclical part of the BBDO index, GDP growth and capital reallocation. Capital reallocation is defined as the sum of sales of property, plant and equipment and acquisitions. In other words, capital reallocation can be understood as the exchange or the transfer of capital across firms. This interpretation is similar to Eisfeldt and Rampini (2006), and Cao and Shi (2017). The correlation between the cyclical components of GDP and the BBDO is -0.3679, suggesting that policy uncertainty is countercyclical.

[INSERT FIGURES 2[a-d] ABOUT HERE]

Furthermore, the series plotted in Figure [2c] below suggest that the correlation between the cross-sectional standard deviation of TFP growth over the GDP cycle is -0.177. The evidence suggests that the benefit of capital reallocation are countercyclical[1]. Note that the cross-sectional standard deviation of productivity serves as a proxy for the benefits of capital reallocation.

Figure [2d] plots the cyclical components (HP filtered) of GDP and the cross-sectional standard deviation of TFP. The evidence in Figure [5] indicates that the correlation between policy uncertainty and the cross-section of dispersion in firm-level TFP growth is positive. In the data, this correlation is approximately 0.308. The combined results suggest that the benefits of reallocation and policy uncertainty measure are indeed countercyclical. The results confirm some empirical findings supporting the notion that firms' cross-sectional heterogeneity drives capital reallocation (Maksimovic and Phillips, 2001, Andrade et al. 2001, Schoar, 2002, Jovanovic and Rousseau, 2002), and that capital flows from the least productive firms to the more productive firms. The overall graphical results in Figure [2a-d] suggest that an increase in productivity dispersion during periods of heightened policy uncertainty shocks is positively related to the reallocation of productive capital.

After taking the cyclical components for the BBD indices and GDP growth into account, we run the panel regressions and present our results in Table 3. The coefficients of the BBD indices are negative and statistically significant, after controlling for macroeconomics and

[1]This result is consistent with Eisfeldt and Rampini (2006) and Kehrig (2015) finding that the benefits to capital reallocation appears to be countercyclical.

firm-specific factors. In particular, the BBDO overall index has a coefficient of -0.0429 and a t-value of -4.63 , suggesting that firm-level TFP is negatively related to policy uncertainty shocks. This result strongly supports our first hypothesis that on average uncertainty shocks depress productivity. Table 3 also indicates that the firm-level TFP, on average, is positively related to firm size, sales growth, cash and GDP growth, all consistent with intuition.

[INSERT TABLE 3 ABOUT HERE]

3.2 Policy Uncertainty, Debt Financing and Firm Level Productivity

In the previous subsection, we show that policy uncertainty has a negative impact on firm-level productivity. Now we turn our attention to the medium to long-term effects of policy uncertainty on firms' financing decisions. When managers face policy uncertainties, they cannot fully anticipate the length or duration of such uncertainties, inducing them to wait out and postpone major decisions. In particular, during periods of heightened policy uncertainty, firms might face financial constraints which impede meeting short-term and medium-term debt obligations. Having access to debt during periods of heightened policy uncertainty would allow firms to mitigate financial distress, notwithstanding the negative impact of a higher leverage on firm-level productivity. That is, we would expect that while high levels of book leverage would negatively impact firm-level productivity, access to debt financing during periods of heightened uncertainty would at minimum mitigate some of the negative impacts of uncertainty on productivity. The above conjecture can be tested with the following hypothesis.

Hypothesis 2:

The negative impact of financial leverage on firm-level TFP notwithstanding, the ability to use debt financing during periods of heightened policy uncertainty shocks could increase firm-level productivity (TFP).

This hypothesis is tested with the following panel regression:

$$TFP_{it} = \beta_0 + \beta_1 PU_t + \beta_2 Leverage_{it} + \beta_3 PU_t * Leverage_{it} + \psi \mathbf{X_{it}} + \gamma \mathbf{M_t} + \eta_i + \epsilon_{it} \quad (2)$$

Where the leverage variable is firm's leverage ratio: debt divided by firm's total asset. Firm's debt is measured with total debt, short-term debt or long-term debt, resulting in three versions of debt ratios. This regression is a variant of our baseline model, by adding leverage variable we can examine the cross effect of policy uncertainty measure and leverage on firms' TFP.

The results are presented in Table 4 with four panels. In Panel A, the policy uncertainty variable is the BBDO overall index. The results with the three components of the BBDO index as the policy uncertainty variable are shown in Panels B, C and D. In all four panels, the leverage is defined as the total debt divided by total assets. The results in Panel A confirm our second hypothesis. That is, leverage is negatively related to firm-level productivity and that the interaction of leverage and policy uncertainty is positively related to productivity. While the coefficients of the leverage variable and the interactive term have the right sign when the uncertainty is measured by BBDTAX and BBDFS, the corresponding t-values are only close to being significant at the 10%. Therefore, the financing effect of polciy uncertainty manifests itself more prominently when the uncertainty measure is the overall index ((viz. BBDNEWS).) and the general news index (viz. BBDNEWS). The above conclusions also hold when the debt ratio is calculated using either short-term or long-term debt only.

Moreover, judging by the coefficient of the BBDO variable, the impact is economically significant. A one standard deviation increase in total debt is associated with a statistically significant 1.4 per centage point decline in productivity. The interaction of leverage and policy uncertainty measure is positive, a result which is consistent across all three measures of leverage. The observation suggests that access to debt financing might allow firms to continue financing ongoing investment projects and hence increase firm-level productivity even during periods of heightened policy uncertainty.

The channel for the overall positive effect of debt financing is straighforward. Intuitively, access to external debt financing during periods of uncertainty shocks could allow firms to overcome financial constraints and hence absorb the potential negative shocks on productivity. Our finding that access to external capital during policy uncertainty is positively related to productivity implies that the negative impact of a higher leverage is, to some extent, offset by the benefit of avoiding the operational disruptions due to policy uncertainty shocks.

[INSERT TABLE 4 ABOUT HERE]

3.3 Cash Holdings, Productivity and Policy Uncertainty

Bernanke (1983), and Julio and Yook (2012) suggest that an increase in uncertainty leads to delays in investment as firms awaits for the effects of uncertainty to be fully resolved before committing internal resources. Pastor and Veronesi (2012), Duong, Nguyen, Nguyen and Rhee (2017), and Gungoraydinoglu, Colak and Oztekin (2017) show that policy uncertainty induces additional financing costs which might incentivize firms to hold more cash to avoid such costs. Bordo, Duca and Koch (2016) confirm that higher levels of policy uncertainty increase the cost of commercial and industrial loans. However, firms' demands for cash are heterogeneous depending on each firm's productivity. In particular, firms with high productivity might face significant opportunity costs in future states relative to firms with low productivity. These costs would also increase with the amount of irreversible investment. The above observations lead us to the following hypothesis.

Hypothesis 3: *(a) Policy uncertainty leads to an increase in cash holdings that is most pronounced amongst highly productive firms; (b) During periods of heightened policy uncertainty, firms that have higher levels of irreversible investment tend to hold more cash.*

This hypothesis is tested with the following panel regression model:

$$Cash_{it} = \beta_0 + \beta_1 PU_t + \beta_2 Leverage_{it} + \beta_3 PU_t * Leverage_{it} + \beta_4 OCF_{it} + \gamma \mathbf{M_{it}} + \psi \mathbf{X_{it}} + \eta_i + \epsilon_{it} \quad (3)$$

The dependent variable is the cash holdings for each firm at time t. We include the operating cash flow (OCF) and the leverage ratio as explanatory variables since they directly impact the cash holding.

The results in Panel A of Table 5 pertain to Hypothesis 3a. Column 1 of Panel A is for the overall sample, and Columns 2, 3 and 4 are for low, medium and high productivity firms respectively. The results in Columns 1 (full sample), 3 (medium) and 4 (high) suggest that there is a positive relationship between policy uncertainty and cash holdings. This is consistent with the findings in Gulen and Ion (2016) reflects the fact that firms are less likely to invest and will instead stockpile cash. That is, during periods of heightened policy uncertainty, firms opt for precautionary delays in the deployment of internal capital, resulting in a temporary accumulation of cash. In particular, firms with high productivity face higher opportunity costs in future states because without a ready cash holding built up amidst the uncertainty, the firm might have to forgo profitable investments or use costly external financing.

Therefore, during periods of heightened policy uncertainty, we would expect highly productive firms to increase their cash holdings in anticipation of positive net present value projects in future states, which is borne out in Column 4. In contrast, for firms in the bottom tercile of productivity distribution shown in Column 2, the coefficient of policy uncertainty measure is negative, albeit insignificant. This is in part because policy uncertainty induces external financing constraints and firms in the bottom tercile of productivity distribution might prefer to either pay down pre-existing debt or finance their ongoing investment projects with internal capital.

To test Hypothesis 3b, we add a dummy variable for irreversible investment into the previous regression:

$$Cash_{it} = \beta_0 + \beta_1 PU_t + \beta_2 Leverage_{it} + \beta_3 PU_t * Leverage_{it} + \beta_4 OCF_{it} + \beta_5 Irrev_{it} + \gamma \mathbf{M_{it}} + \psi \mathbf{X_{it}} + \eta_i + \epsilon_{it} \quad (4)$$

"Irrev" is a dummy variable that equals to "1" if a firm, relative to the sample, has an above-median level of irreversible investment, and zero otherwise. Irreversible investment is estimated as the ratio between net quarterly property, plant and equipment (PPENTQ) adjusted by quarterly total assets (ATQ). The coefficient of interest is the interaction term between policy uncertainty and the irreversible investment dummy. A positive coefficient would suggest that firms with significant irreversible investment tend to hold higher level of cash during periods of heightened policy uncertainty shocks. Panel B of Table 5 presents the testing results. The coefficient estimate for the interaction term generally supports the hypothesis in that a higher level of irreversible investment elevates precautionary motive of cash but that this effect mostly manifests itself for highly productivity, as shown in Columns 3 and 4.

[INSERT TABLE 5 ABOUT HERE]

3.4 Productivity, Speed of Cash Holding's Adjustment

Panel A of Table 5 indicates that the interaction term between leverage and policy-specific uncertainty is negatively related to cash holdings for firms in the top tercile of productivity distribution, reflecting significantly induced policy uncertainty financing frictions. This suggests that a proportional increase in the level of policy-specific uncertainty and total leverage is associated with a decline in cash holdings and that this effect is stronger for highly productive firms. This can be observed from the fact that the coefficient of the interaction term in Column 4 is greater than the coefficient in Columns 2 and 3. The results also imply that policy uncertainty invariably affects the speed of cash holding's adjustment. To investigate the speed of cash holding's adjustment, we follow Dittmar and Duchin (2011), Venkiteshwaran (2011), Tut (2019) and Jiang and Lie (2016) and run the following simultaneous equations:

$$Cash_{it} - Cash_{it-1} = \lambda Cash^*_{it} - \lambda Cash_{it-1} + \delta_{it} \tag{5}$$

Where λ serves as a proxy for the proportion of gap between actual cash level and target cash level, that is, the adjustment speed towards target. $Cash^*_{it}$ is the target cash level determined as follows:

$$Cash^*_{it} = \beta \mathbf{X_{it}} + \eta_i \tag{6}$$

Such that $\mathbf{X_{it}}$ is a vector of firm specific variables and η_i are firm specific fixed effects.

Substituting Equation (5) into Equation (6)[2] and controlling for policy uncertainty (PU_t.), yields the following equation:[3]

$$Cash_{it} = [\underbrace{\psi \mathbf{X_{it}} + (1-\lambda)Cash_{it-1} + \eta_{it} + \epsilon_{it}}_{\textbf{Part (i):5=>6}}] + \beta PU_t + \varphi(Cash_{it-1}XPU_t) \quad (7)$$

The results in Panel A of Table 5 indicate that such costs of adjustment are higher for highly productive firms as they face higher opportunity costs in future states. In terms of economic significance, an increase in policy uncertainty index is associated with a 1.1% increase in cash holdings for firms in the top productivity tercile, while it is only associated with an increase of 25 basis points for the overall sample in Panel A of Table 5. The regression results in Panel B of Table 5 indicate that the increase in cash holdings due to a high level of irreversible investments is mostly driven by highly productive firms. A doubling of policy uncertainty for firms with high level of irreversible investments is associated with a 1.3% increase in cash holdings for highly productive firms, but there is no evidence that it is statistically significant for firms in the bottom tercile of productive distribution. [INSERT TABLE 6 ABOUT HERE]

3.5 Productivity, Cash Holding and Investments

Baker, Bloom and Davis (2016), Gulen and Ion (2016) suggest that policy uncertainty depresses investment and firms might use internally generated cash to mitigate the effects of uncertainty on investment. To test whether the moderating effect of cash holdings on investment is heterogeneous conditional on productivity, we run the following panel regression:

$$Investment_{it} = \beta_0 + \beta_1 PU_t + \beta_2 Leverage_{it} + \beta_3 PU_t * Leverage_{it} + \beta_4 Cash_{it} + \gamma \mathbf{M_t} + \psi X_{it} + \eta_i + \epsilon_{it} \quad (8)$$

[2] Equals part (i)

[3] Note that the coefficient ψ equals $\lambda\beta$.

Table 7 reports the regression results. Column 1 is for the overall sample while Columns 2, 3 and 4 are for low, medium and high productivity firms respectively. The results suggest that cash holdings mitigate the well-documented[4] underinvestment problem during periods of heightened policy uncertainty. Note that the interaction term is significantly positive across all four models. Model (2) presents the results for firms in the lowest tercile of productivity distribution while model (4) presents the results for firms in the top tercile of productivity distribution. Firstly, we can observe that the coefficient of the interaction term in model (2) is greater than in the coefficient of the same term in model (4). These results suggest that on the margin and as uncertainty heightens, firms in the lower tercile of productivity distribution benefit more from having higher internal capital. That is, the moderating role of cash holdings in mitigating the effects of policy uncertainty on investment is much stronger for firms in the bottom tercile of productivity distribution. Overall, the results in Table [7] indicate that internal capital mitigates the adverse effects of policy uncertainty on investment. The results strongly support precautionary motive of cash holdings (Doung et al. 2017, Duchin et al. 2017, Harford et al. 2008); that is, firms hoard cash to mitigate the effects of policy uncertainty. The results suggest that policy uncertainty partially explains the recent rise in cash holdings amongst the U.S. firms. [INSERT TABLE 7 ABOUT HERE]

4 Robustness Tests

In this section, we carry out four robustness checks. First, we employ an alternative measure to proxy for macroeconomic uncertainty so as to run a horse-race with the BBDO index for all three hypotheses. Second, we test our hypotheses within specific industries. For the last two robustness tests, we control for the effects of demand shocks and the effects of financial flexibility. Overall, the evidence confirms our main hypotheses that policy uncertainty adversely affects firm-level productivity.

[4]Ref: Gulen and Ion 2016.

4.1 Competing Measures of Macroeconomic Uncertainty

One may wonder whether the effects of policy uncertainty on firm productivity (TFP) from our baseline model are responses to the general macroeconomics uncertainty. To address this question, we employ a macroeconomic uncertainty measure proposed by Jurado, Ludvigson and Ng (2015). We run a horse-race test by adding this measure into our regression analysis. We adopt their monthly, quarterly and yearly macroeconomic uncertainty measures and denote them as the JLN_M, JLN_Q and JLN_Y, respectively.

Figure 3 depicts the time series of the JLN measures. The vertical dotted lines represent periods of heightened policy-related uncertainty: the first Gulf war, 9/11, the Great Financial crisis and the 2013 government shut down. Figure 3 indicates that there is a positive co-movement between this measure and the BBDO index. Moreover, Figures 1 and 3 indicate that the BBDO and this macro uncertainty measure are countercyclical, supporting the general belief that policymakers feel more compelled to intervene during recessions as opposed to during booms.

The summary statistics for JLN measures are presented Panel A of Table 1. The averages of JLN measures are 0.6441, 0.7761 and 0.9051 for monthly, quarterly and yearly frequency, increases with the measure frequency. The standard deviations are 0.0785, 0.0779 and 0.0436 respectively, decrease with measure frequency. JLN measures have positive correlations with the BBDO index as expected. The precise correlations shown in Table 2 are 0.3595, 0.3506 and 0.3134 for monthly, quarterly and yearly JLN measures.

[INSERT FIGURE 3 ABOUT HERE]

To show that policy uncertainty does have real effects on firms' productivity and investment decisions in the presence of other macroeconomic uncertainties, we run a horse-race test for all hypotheses. The results are summarized in Table 8. Columns 1 to 3 present the results for the first hypothesis. As expected, the JLN measures have negative and significant impact on firm-level productivity. However, the JLN measures does not take away the negative and significant impact of the BBDO measure. This confirms that policy uncertainty has a strong negative effect on firm-level productivity after controlling for other macro uncertainties. Columns 4 to 6 show the results for the second hypothesis. Again, the impact of the BBDO measure on firm-level productivity is negative and significant after controlling for the JLN macro measure. More importantly, the interaction between the BBDO measure and firms' leverages remains positive, reaffirming the second hypothesis.

Columns 7 to 10 pertain to the third hypothesis. Although the JLN measures have positive and significant impacts on firms' cash holding, they do not diminish the positive and significant effect of the BBDO measure on firms' cash holdings. To recap, the horse-race tests for all hypotheses suggest that policy uncertainty is still a significant factor and is negatively related to firm-level TFP even after controlling for general macroeconomic uncertainties. [INSERT TABLE 8 ABOUT HERE]

4.2 Policy Uncertainty, Productivity at Specific Industry-Level

We now conduct the robustness test within each industry at the two-digit SIC level. The industries include Manufacturing, Metal Mining, Oil and Gas, Wholesale-Retail Trades, Services and Non-Classified. It turns out that all the hypotheses also hold within each industry. To save space, we only report in Table 9 the baseline model results for Hypothesis 1. It is evident that the policy uncertainty index has a negative effect on productivity for all industries except for the Oil and Gas industry. The positive effect of policy uncertainty on the productivity of oil and gas firms is due to the special feature of energy products. As shown in Kilian (2009), oil and gas prices are mostly driven by both aggregate global demand shocks and precautionary demand shocks. It is likely that policy uncertainty induces an upward pressure on oil and gas prices. To meet the demand, oil and gas companies would increase their productivity during the periods of heightened policy uncertainty shocks.

[INSERT TABLE 9 ABOUT HERE]

4.3 Accounting for Demand Shocks

Positive demand shocks might mitigate the adverse effects of policy-related uncertainty on productivity (TFP). In this subsection, we examine whether the effects of demand shocks override policy uncertainty effects. Following Bloom, Bond and Reenen (2007), we use sales growth as a proxy for demand shocks and estimate their effects on uncertainty using the following specification:

$$TFP_{it} = \beta_0 + \beta_1 PU_t + \beta_2 Leverage_{it} + \beta_3 PU_t * SaleGowth_{it} + \gamma M_t + \psi X_{it} + \eta_{it} + \epsilon_{it} \quad (9)$$

The coefficient of interest is the interaction term between sales growth and uncertainty. The sign of this interaction term can be either positive or negative. When demand shocks are negative, the sign is negative in the presences of policy uncertainty since negative demand shocks would further exacerbate the policy uncertainty effects on productivity. However, when demands shocks are positive, the interaction term will have a positive effect only if the impact of the positive demand shocks strictly dominates the negative effect of policy uncertainty.

Table 10 reports the results. Columns 1, 2 and 3 present the results for our three hypotheses in sequence. Two observations are in order. First, all three hypotheses still hold. Second, the coefficients of the interaction term are positive. The interpretation of these two observations is as follows. After controlling for demand shocks, the effects of policy uncertainty on firm level productivity are negative while the effects on firm cash holding are positive, suggesting that the effects of policy uncertainty are statistically significant and are not fully offset by demand effects. The positive coefficient for the interaction term between demand shocks and policy uncertainty suggests that demand shocks during periods of heightened policy uncertainty are associated with higher levels of productivity. Firms that experience higher sales during periods of heightened policy uncertainty tend to have higher levels of productivity. The results confirm that the interaction of policy uncertainty and demand shocks partially drives the cautious response of firms' real decisions to demand conditions as in Bloom (2007).

[INSERT TABLE 10 ABOUT HERE]

4.4 Accounting for Financial Flexibility

We now examine whether policy uncertainty still affects firms' productivity after controlling for firms' financial flexibility. This investigation is important because we need to ascertain whether a greater financial flexibility would obliterate the impact of policy uncertainty on productivity. To this end, and consistent with prior literature, we define financial flexibility as the current-period assets divided by the difference between current-period assets and total debt. In this case, financial flexibility serves as a proxy for the ability of a firm to take on additional debt. Such additional debt would allow firms to override the adverse effects of policy-uncertainty as suggested by Khwaja and Mian (2005), Bloom (2007), Claessens, Fejen and Laeven (2008) and Akey and Lewellen (2016). We run the panel regression for our baseline model by adding the financial flexibility (FL) variable and its interactive term with policy uncertainty as follows:

$$TFP_{it} = \beta_0 + \beta_1 PU_t + \beta_2 FL_{it} + \beta_3 PU_t * FL_{it} + \gamma M_t + \psi X_{it} + \eta_{it} + \epsilon_{it} \qquad (10)$$

The results are summarized in Table 11. The coefficient of the interaction term between policy uncertainty and financial flexibility is positive and statistically significant, conditional on confirming the three hypotheses. This evidence suggests that firms with higher financial flexibility are, to some extent, able to absorb the adverse effects of policy specific uncertainty on productivity. Nevertheless, accounting for financial flexibility does not fully override the adverse effect of policy uncertainty on firm-level TFP.

[INSERT TABLE 11 ABOUT HERE]

5 Conclusion

This paper investigates the effects of policy uncertainty on firms' productivity and investment decisions. We postulate three hypotheses. First, we argue that policy uncertainty has a negative impact on firm-level TFP. Second, we argue that although leverage has a negative impact on productivity, access to external financing during periods of significant policy uncertainty shocks, has a positive impact on firm-level productivity. Last, we conjecture that policy uncertainty leads to an increase in cash holdings, but that this effect is mostly pronounced amongst highly productive firms. And that this effect is further magnified as the proportion of irreversible investment increases.

We run different panel regression models to examine each hypothesis. We show that policy uncertainty has a negative effect on firms' productivity. This adverse effect is partly due to the fact that policy uncertainty induces investment delays which in turn leads to a reduction in firms' productivity. This effect is robust to various specifications.

Next, we examine the impact of policy uncertainty on firms' financing decisions. It is known that managers, when faced with policy uncertainty shocks, tend to wait for the uncertainty to be resolved before making further decisions. Higher levels of uncertainty result in postponement of business activities as firms awaits for uncertainty to be fully resolved before fully committing resources. In particular, during periods of significant policy uncertainty shocks, firms might face financial constraints which make them unable to meet short-term and medium-term debt obligations. Having access to debt financing during these periods would allow firms to continue to operate. We show that access debt financing during periods of significant policy uncertainty shocks potentially mitigates some of the negative impacts of uncertainty on productivity.

Lastly, we investigate the impact of policy uncertainty on firms' cash holdings. We show that policy uncertainty is positively related to cash holdings but that the effect is mostly pronounced amongst highly productive firms. This result suggests that highly productive firms hoard cash in anticipation of positive net present value projects in future states. This is because policy uncertainty increases adjustment costs and such costs are more pronounced for highly productive firms as they face higher opportunity costs in future states. This effect is further magnified as the proportion of irreversible investment increases. Also, policy uncertainty leads to an increase in the cost of external financing. To avoid this consequence, highly productive firms tend to hold more cash. This rational supports the precautionary motive of cash holdings and can offer partial explanation to the recent rise in cash holdings amongst U.S. firms.

Of particular importance, our findings suggest that the adverse effects of policy uncertainty are not only limited to first-order effects such as decline in investment but that policy uncertainty also generates fluctuations that lead to second-order effects such as a decline in productivity (TFP).

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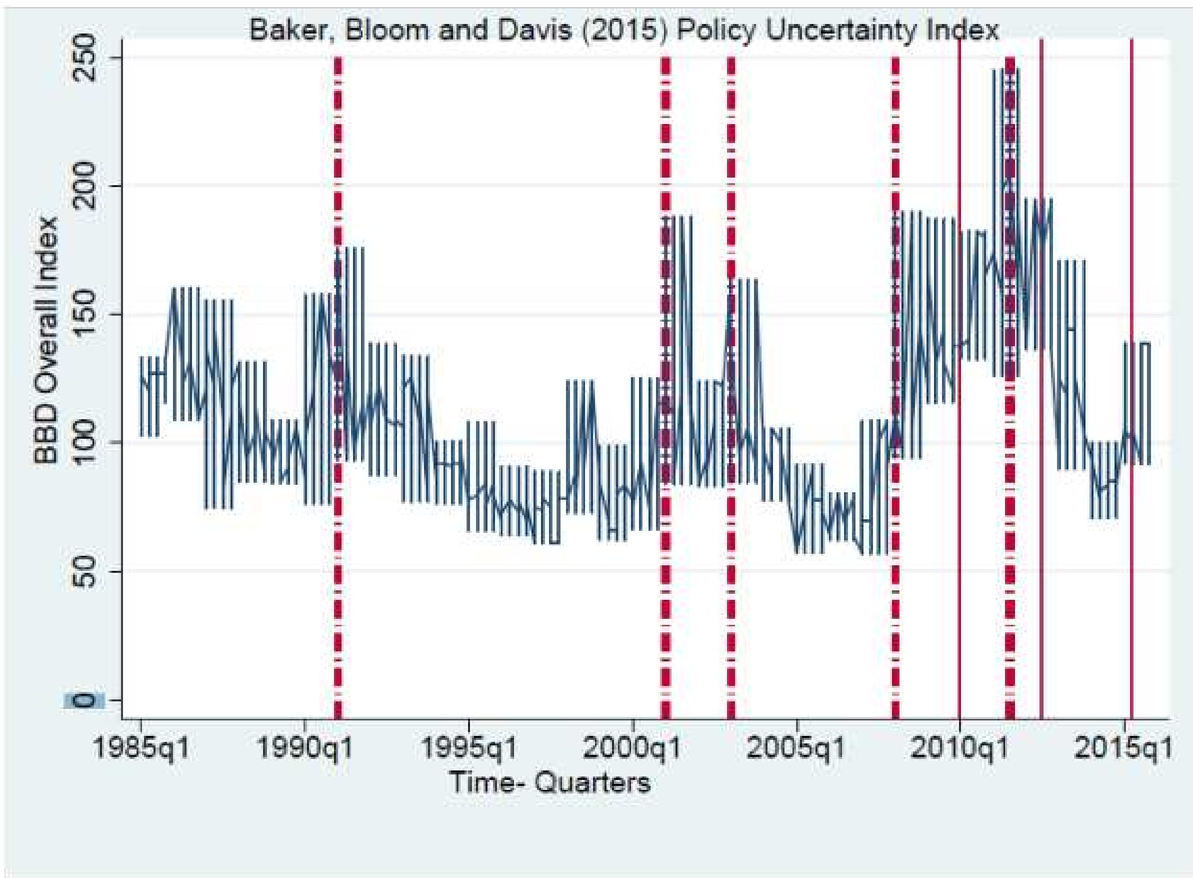
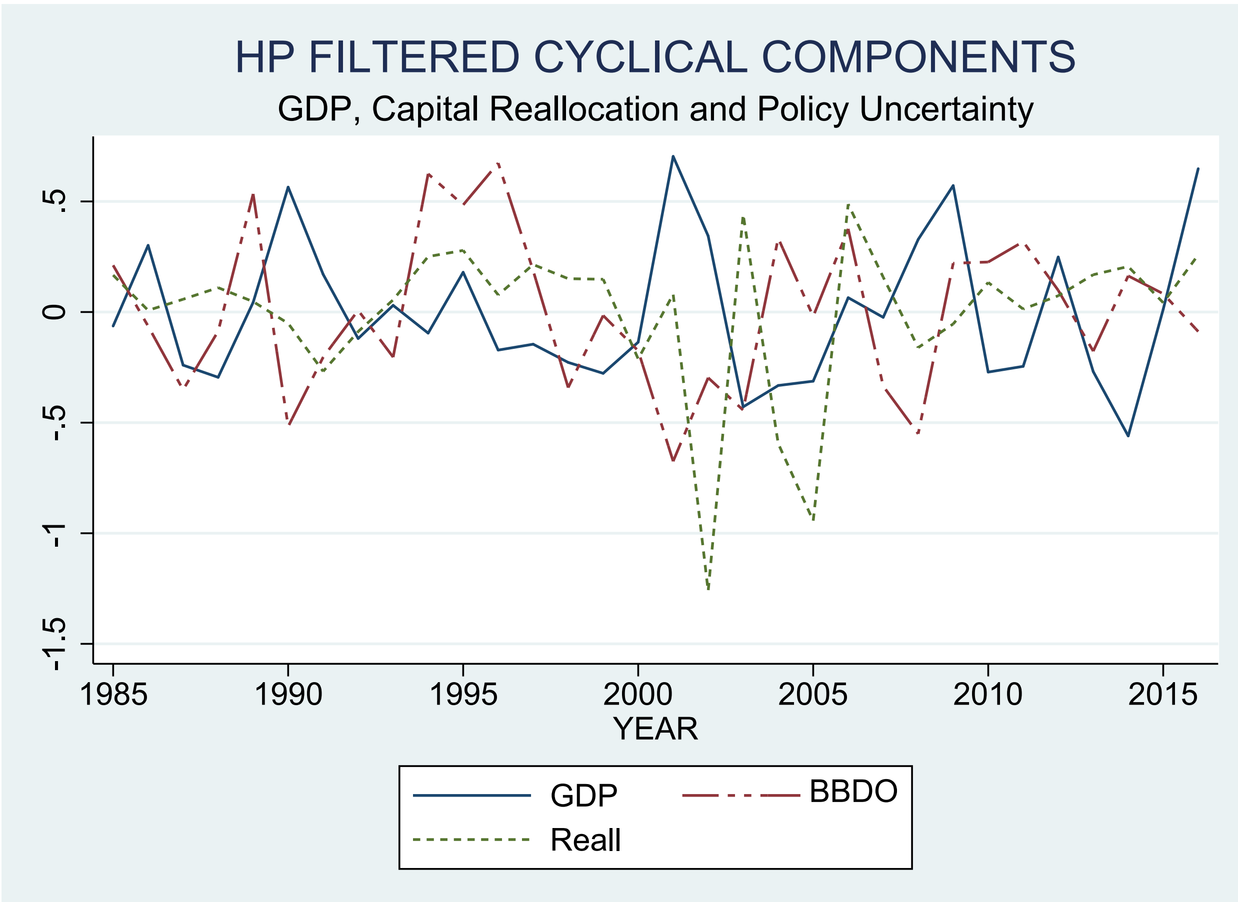


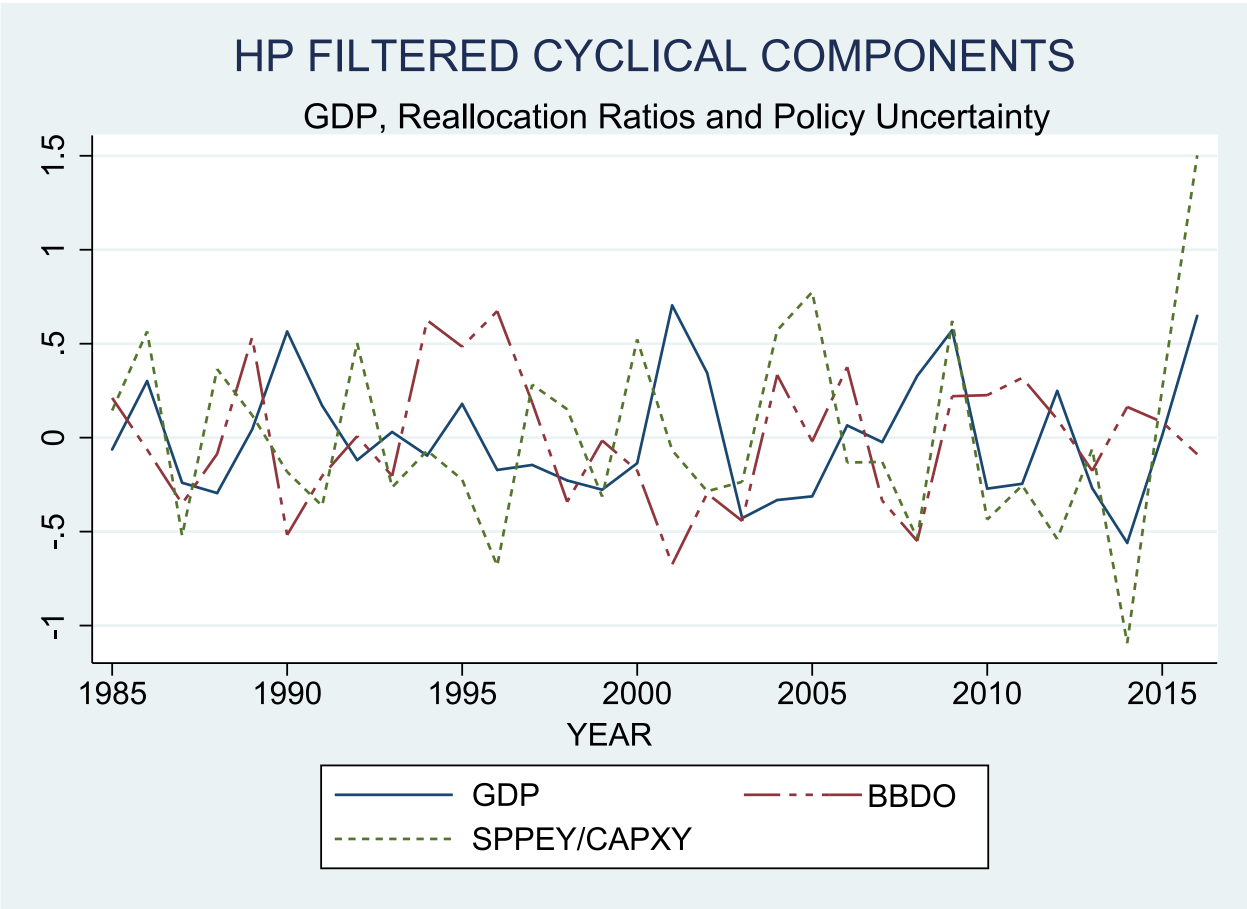
Figure 1: ***Policy uncertainty Index***

Figure 1: Plots Baker, Bloom and Davis (2016) Overall uncertainty index. The vertical dotted lines represent periods of heightened policy-related uncertainty.



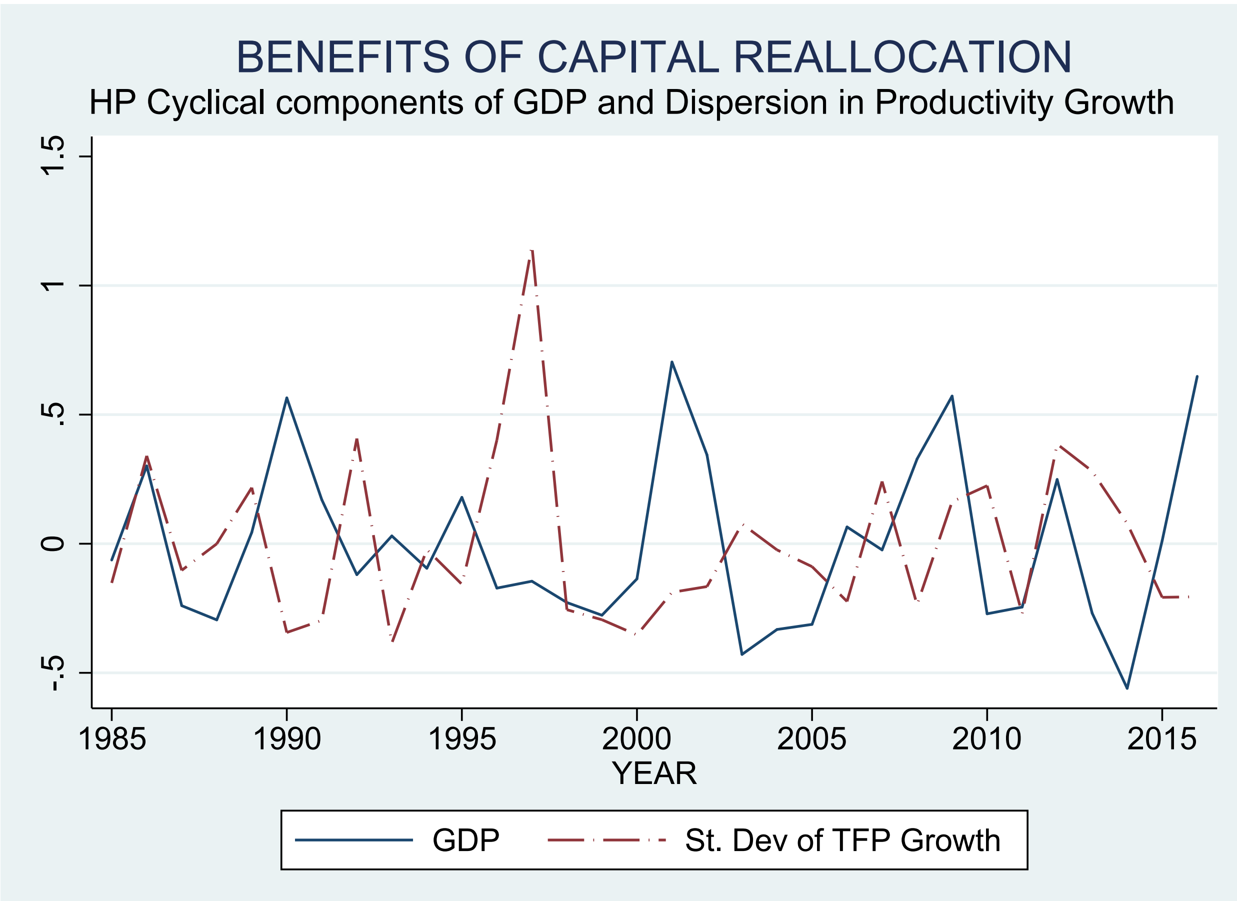
Policy uncertainty and Capital Reallocation

Figure 2a: The plotted series are the cyclical components of the Hodrick-Prescott filtered data normalized by standard deviation. The solid line denotes GDP, dotted-dash line denotes the BBD (2016) overall policy uncertainty index and the dotted line denotes capital reallocation. Note that capital reallocation is computed as the sum of sales of PP&E.



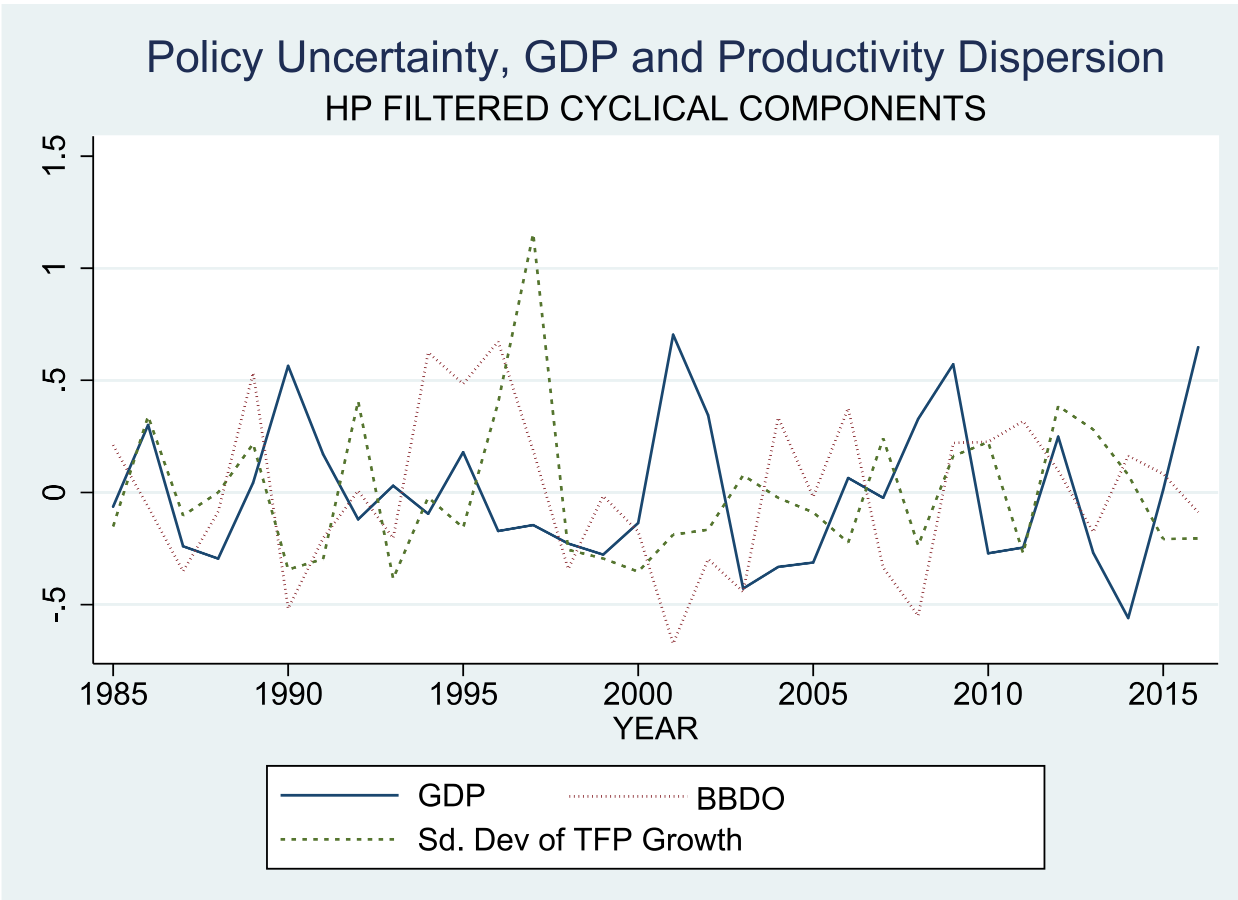
Policy Uncertainty and Capital Reallocation Ratio

Figure 2b: The plotted series are the cyclical components of the Hodrick-Prescott filtered data normalized by standard deviation. The solid line denotes GDP, dotted-dash line denotes BBD(2016) overall uncertainty policy index and the dotted line denotes the reallocation ratio. Reallocation ratio is estimated as the sales of property, plant and equipment to capital expenditure.



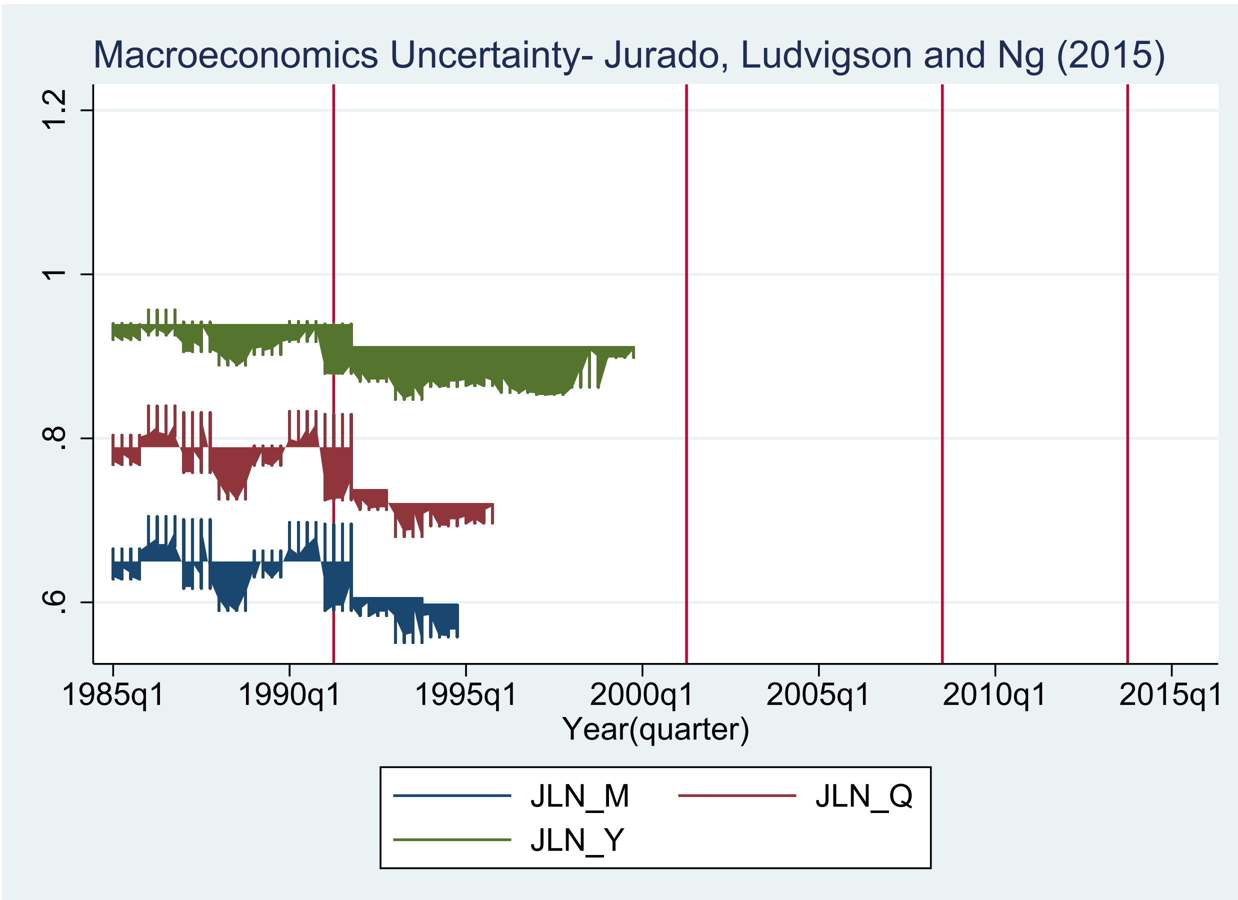
Benefits of Capital Reallocation

Figure 2c: The plotted series are the cyclical components of Hodrick-Prescott filtered data normalized by standard deviation. The solid line denotes GDP, dotted lines denote dispersion in productivity growth (TFP)



Policy Uncertainty and Productivity Dispersion

Figure 2d: The plotted series are the cyclical components of Hodrick-Prescott filtered data normalized by standard deviation. The solid line denotes GDP, thin dotted lines denote the BBD(2016) overall policy uncertainty index and the bolder dotted line denotes the Benefit of Capital Reallocation.



Policy uncertainty Index

Figure 3: Plots Jurado, Ludvigson and Ng (2015) Macroeconomics uncertainty index. JLN_M is one-month, JLN_Q three-month, JLN_Y Twelve-Month macroeconomics uncertainty index respectively

TABLE 1: Summary Statistics

This table presents the descriptive statistics for the sample. All firm specific variables are extracted from COMPUSTAT. The sample period is from 1985 to 2016. All dollar values are in millions. The final sample consists of 458,339 firm-quarter observations with 15,106 unique firms.

	Obs	**Mean**	**Std. Dev**	**25^{th}**	**75^{th}**
PANEL A:		Policy Uncertainty Variables			
BBDO	458,339	105.6736	31.6134	79.8131	122.3492
BBDNEWS	458,339	107.7437	39.7846	81.3894	122.2935
BBDTAX	458,339	194.7976	375.7423	13.4948	223.6065
BBDFS	458,339	98.9093	48.7451	61.9940	121.6537
JLN_M	458,339	0.6441	0.0785	0.5906	0.6727
JLN_Q	458,339	0.7761	0.0779	0.7192	0.8061
JLN_Y	458,339	0.9051	0.0436	0.8717	0.9240
PANEL B:		Macroeconomics Variables			
GDP Growth(%)	456,049	12.4401	1.2282	0.9224	1.6226
VXO(%)	444,788	20.6857	8.6656	14.2406	23.8500
PANEL C:		Firm-Level Variables			
Ln(Size)	458,339	4.5686	2.1533	3.0314	6.1216
Sale Growth(%)	400,955	2.0507	43.8238	-8.2760	12.5565
Cash(%)	457,834	18.2309	22.2832	2.2161	26.5227
Short-Term Debt(%)	442,866	0.3393	0.3041	0.04150	0.5836
Long-Term Debt(%)	454,247	0.6606	0.3468	0.4164	0.9585
Total Debt/Asset(%)	458,265	0.2349	0.2252	0.0265	0.3713
Capex($)	458,339	25.2849	138.8706	0.2950	11.9120
Acquisitions($)	458,339	2.8054	61.0159	0.0000	0.0000
Sales PP&E($)	377,512	2.2651	50.6882	0.0000	0.0330
PPENTQ($)	458,167	228.4539	961.4344	2.7820	110.1770
TFP	458,339	0.1594	0.8013	-0.1024	0.3161

TABLE 2: Correlations Table

This table presents correlations for variables of interest. Policy uncertainty measures are based on Baker, Bloom and Davis (2016) Indices. BBDO is the Overall Index, BBDNEWS is the news-based component of the index, BBDFS is the fiscal spending component of the index, BBDTAX is the tax component of the index.

	BBDO	BBDNEWS	BBDTAX	BBDFS	GDPGrowth	VXO	Size	Sales	Cash	StDebt	LtDebt	ACQ	SPPE	TotDebt	PPENTQ	TFP
Correlations:																
BBDO	1															
BBDNEWS	0.8890	1														
BBDTAX	0.5750	0.3852	1													
BBDFS	0.4411	0.1280	0.0408	1												
GDP Growth	-0.3679	-0.3625	-0.2745	-0.3943	1											
VXO	0.2927	0.2955	0.0325	0.00481		1										
Size	0.0531	0.0630	0.1686	-0.1030	0.0748	-0.0027	1									
Sales	00.0272	0.0262	0.0668	-0.0268	0.0907	-0.0068	0.4109	1								
Cash	0.0439	0.0189	0.0845	-0.0882	-0.0391	-0.0010	-0.1803	0.5465	1							
St Debt	0.0021	0.0036	0.0055	-0.0057	-0.0063	-0.0013	0.1056	0.3633	-0.0289	1						
Lt Debt	0.0195	0.0207	0.0409	-0.0176	-0.0265	-0.0012	0.5797	0.2309	-0.0644	0.7660	1					
ACQ	0.0041	0.0058	0.0150	-0.0131	-0.0005	-0.0004	0.1120	0.0446	0.0217	0.0121	0.0187	1				
SPPE	0.0034	0.0048	-0.0017	-0.0004	-0.0022	0.0083	0.0789	0.3157	-0.0223	0.3349	0.5326	0.0039	1			
Total Debt	0.0217	0.0215	0.0458	-0.0171	-0.0033	-0.0006	0.2562	0.5026	-0.0730	0.9008	0.9692	0.0230	0.4041	1		
PPENTQ	0.0265	0.0248	0.0458	-0.0072	-0.0004	0.0526	0.3920	0.0.6553	-0.1175	0.4282	0.7114	0.0220	0.3870	0.6391	1	
TFP	-0.0218	-0.0270	-0.0803	-0.0218	0.0418	-0.0077	0.2276	0.1566	0.1174	0.0326	0.1211	0.0487	0.0320	0.1321	0.2284	1
	BBDO	Uncertainty_1	Uncertainty_3	Uncertainty_12												
Macroeconomic Uncertainty:																
BBDO	1.0000															
JLN_M	0.3595	1.0000														
JLN_Q	0.3506	0.9974	1.0000													
JLN_Y	0.3134	0.9654	0.9785	1.0000												

TABLE 3: Total Factor Productivity (TFP) and Policy Uncertainty

This table reports baseline cross-sectional panel regression estimates with firm total factor productivity(TFP) as the dependent variable. All standard errors are clustered at the firm-level. Robust t-stats are reported in the brackets. BBDO is the Overall index, BBDNEWS is the news-based component of the index, BBDFS is the fiscal component of the index and BBDTAX is the tax component of the index. All index components are based on Baker, Bloom and Davis (2015) policy-uncertainty index measures. TFP computation is based on Olley and Pakes (1996), Imrohoroglu and Tuzel (2014).

	(1)	(2)	(3)	(4)
	TFP	TFP	TFP	TFP
BBDO	-0.0429***			
	(-4.63)			
BBDNEWS		-0.0164***		
		(-2.94)		
BBDTAX			-0.0224***	
			(-2.92)	
BBDFS				0.0072
				(0.84)
GDP Growth	1.3081***	1.6244***	1.6420***	1.8928***
	(4.93)	(6.17)	(5.20)	(6.04)
VXO	0.0975***	0.0797***	0.0644***	0.0577***
	(3.91)	(3.29)	(2.99)	(2.71)
Size	0.0487***	0.0489***	0.0479***	0.0494***
	(7.16)	(7.2)	(7.02)	(7.2)
Sale Growth	0.0391***	0.0390***	0.0393***	0.0390***
	(15.30)	(15.30)	(15.33)	(15.27)
Cash	0.0369*	0.0358*	0.0370*	0.0359*
	(1.77)	(1.72)	(1.77)	(1.71)
Constant	0.0933	-0.0314	0.0033	-0.1312**
	(1.64)	(-0.73)	(0.07)	(-2.50)
Firm Controls	YES	YES	YES	YES
Firm F.E	YES	YES	YES	YES
Clustered Std Errors	YES	YES	YES	YES
N	394310	394310	394310	394310
R^2	0.0560	0.0563	0.0544	0.0568

NOTE: t-statistics in parentheses * p:0.10, ** p:0.05, *** p:0.01

TABLE 4: Policy Uncertainty, Leverage and Firm-level Productivity

This table reports panel regression estimates with TFP as the dependent variable. Table 4 Panel [A] presents the results for the overall index. Panel [B] presents the results with the news component of the index as the policy uncertainty measure, Panel [C] presents the results with Tax policy component as the policy uncertainty measure and Panel [D] presents the results with the Fiscal Policy as the measure of policy uncertainty. All regressioncs include fixed effects, firm-level controls and robust standard errors clustered at the firm-level

Table 4:	(1)	(2)	(3)
	TFP	TFP	TFP
BBD Overall Index:		**Panel** A	
BBDO	-0.0364***	-0.0471***	-0.0347***
	(-4.23)	(-4.96)	(-4.02)
Leverage	-0.0061**		
	(-2.00)		
LeverageXBBDO	0.0012**		
	(2.01)		
LT Debt		-0.2550**	
		(-2.50)	
LT DebtXBBDO		0.0576**	
		(2.57)	
ST Debt			-0.0144***
			(-2.76)
ST DebtXBBDO			0.0027***
			(2.75)
Constant	0.3122***	0.3596***	0.3011***
	(7.86)	(8.23)	(7.55)
BBD News Index:		**Panel** B	
BBDNEWS	-0.0084	-0.0143**	-0.0078
	(-1.64)	(-2.47)	(-1.51)
Leverage	-0.0049**		
	(-2.21)		
LeverageXBBDNEWS	0.0010**		
	(2.21)		
LT Debt		-0.1403**	
		(-2.10)	
LT DebtXBBDNEWS		0.0322**	
		(2.23)	
ST Debt			-0.0147***
			(-3.11)
ST DebtXBBDNEWS			0.0028***
			(3.10)
Constant	0.1781***	0.2046***	0.1723***
	(7.68)	(7.71)	(7.37)
BBD Tax Policy Index:		**Panel** C	
BBDTAX	-0.0332***	-0.0346***	-0.0314***
	(-4.25)	(-4.26)	(-3.97)
Leverage	-0.0050		
	(-1.55)		
LeveragetXBBDTAX	0.0010		
	(1.55)		
LT Debt		-0.0273	
		(-0.47)	
LT DebtXBBDTAX		0.0081	
		(0.62)	
ST Debt			-0.0036
			(-0.40)
ST DebtXBBDTAX			0.0007
			(0.38)
Constant	0.2919***	0.2962***	0.2805***
	(7.84)	(7.70)	(7.45)
BBD Fiscal Policy Index:		**Panel** D	
BBDFS	-0.0115	-0.0138	-0.0111
	(-1.30)	(-1.55)	(-1.26)
Leverage	-0.0086		
	(-1.29)		
LeverageXBBDFS	0.0018		
	(1.27)		
LT Debt		-0.00367	
		(-0.07)	
LT Debtx BBDFS		0.0028	
		(0.23)	
ST Debt			-0.0169**
			(-2.10)
ST DebtX BBDFS			0.0036**
			(2.09)
Constant	0.1736***	0.1853***	0.1714***
	(4.33)	(4.60)	(4.28)
Firm Controls	YES	YES	YES
Firm F.E	YES	YES	YES
Clustered Std Errors	YES	YES	YES
N	379793	390798	381506
R^2	0.0134	0.0137	0.0126

NOTE: t-statistics in parentheses * p: 0.10, ** p:0.05, *** p:0.01

TABLE 5: Policy Uncertainty, Productivity and Cash Holdings

This table reports panel regression estimates with cash holdings(CHEQ/ATQ) as the dependent (TFP). Column [1] presents the results for all firms, columns [2, 3, 4] presents the results for low, medium and high level productivity firms. Panel [B] presents results with irreversible investments as an additional control.

	(1)	(2)	(3)	(4)
	Cash	**Cash**	**Cash**	**Cash**
PANEL A:				
PRODUCTIVITY	All Firms	LOW	MEDIUM	HIGH
BBDO	0.0052***	-0.0024	0.0058***	0.0138***
	(3.51)	(-0.87)	(2.61)	(7.64)
Leverage	-0.0602***	-0.0664***	-0.0495***	-0.0086
	(-8.46)	(-6.65)	(-4.79)	(-0.59)
LeverageXBBDO	-0.0034**	-0.0002	-0.0069***	-0.0121***
	(-2.22)	(-0.10)	(-3.12)	(-3.98)
Cashflow	-0.0339	-0.0391	0.0175	0.0113
	(-0.85)	(-0.82)	(1.35)	(0.59)
GDP Growth	0.1421***	0.1852**	0.3981***	0.0909
	(3.04)	(2.30)	(5.48)	(1.61)
VXO	-0.0033***	-0.0053***	-0.0012	-0.0028***
	(-6.03)	(-5.63)	(-1.30)	(-4.23)
Constant	0.1340***	0.2552***	0.0819***	0.0583***
	(14.84)	(14.63)	(6.37)	(5.08)
Firm Controls	YES	YES	YES	YES
Firm F.E	YES	YES	YES	YES
Clustered Std Errors	YES	YES	YES	YES
N	394113	134473	130291	129349
R^2	0.223	0.256	0.197	0.273
PANEL B:				
PRODUCTIVITY	All Firms	LOW	MEDIUM	HIGH
BBDOXIrrev	0.0031*	-0.0136***	0.0102***	0.0160***
	(1.68)	(-4.24)	(3.66)	(7.32)
Irrev	-0.0922***	-0.1053***	-0.0825***	-0.0729***
	(-35.08)	(-25.11)	(-23.69)	(-16.77)
Leverage	-0.0004	-0.0003	-0.0423***	-0.0508***
	(-1.08)	(-0.91)	(-3.78)	(-6.52)
Cash flow	-0.0278	-0.0403	-0.0163	-0.0081
	(-0.66)	(-0.78)	(-1.12)	(-0.46)
VXO	-0.0002***	-0.0001	-0.0002	-0.0002***
	(-3.45)	(-0.51)	(-1.64)	(-3.01)
GDP Growth	0.4342***	0.5335***	0.5940***	0.1266**
	(8.92)	(6.41)	(7.95)	(2.26)
Constant	0.2420***	0.3474***	0.1760***	0.1811***
	(23.24)	(18.14)	(11.56)	(12.03)
Firm Controls	YES	YES	YES	YES
Firm F.E	YES	YES	YES	YES
Clustered Std Errors	YES	YES	YES	YES
N	379697	129918	125635	124144
R^2	0.137	0.149	0.139	0.173

NOTE: t- statistics in parentheses * p:0.10, ** p:0.05, *** p:0.01

TABLE 6: Policy Uncertainty and Cash Holdings Speed of Adjustment

This table reports panel regression estimates with cash holdings (CHEQ/ATQ) as the dependent variable and policy uncertainty measures plus a set of firm controls as the independent variables. All regressions include firm F.E and standard errors are clustered at the firm level. Robust t-stats are reported in the brackets. The policy uncertainty measure used is the Overall index (BBDO) based on Baker, Bloom and Davis (2016).

	(1)	(2)	(3)	(4)
	Cash	Cash	Cash	Cash
$Cash_{t,t-1}$	0.7362***	0.6683***	0.7362***	0.6954***
	(168.12)	(39.46)	(167.87)	(33.71)
BBDO			0.0035***	0.0021***
			(6.02)	(3.11)
$Cash_{t,t-1}$XBBDO		0.0149***		0.0090**
		(4.18)		(2.03)
Constant	0.0414***	0.0417***	0.0256***	0.0321***
	(16.88)	(17.07)	(6.84)	(8.36)
Firm Controls	YES	YES	YES	YES
Firm F.E.	YES	YES	YES	YES
Clustered Std. Errors	YES	YES	YES	YES
N	244,480	244,480	244,480	244,480
R^2	0.908	0.907	0.907	0.907

Note: t- stats in parentheses * p:0.10, ** p:0.05, *** p:0.01

TABLE 7: Policy Uncertainty, Investment and Productivity

This table reports panel regression estimates with Investment as the dependent variable and policy uncertainty measure(s) plus a set of firm controls as the independent variables. All regressions include firm F.E and standard errors are clustered at the firm level. Robust t-stats are reported in the brackets. The policy-uncertainty measure used is the Overall index (BBDO) based on Baker, Bloom and Davis (2015). Firms are sorted into terciles based on their productivity levels (TFP). Columns 2, 3,4 reports estimates for firms in the bottom, middle and top terciles of productivity distribution

	(1)	(2)	(3)	(4)
	Investment	**Investment**	**Investment**	**Investment**
PRODUCTIVITY	ALL	LOW	MEDIUM	HIGH
BBDO	-0.0136	-0.0682***	0.0866***	-0.0017
	(-1.11)	(-3.38)	(4.19)	(-0.09)
Cash	-0.8003***	-0.6161***	-0.9176***	-0.9622***
	(-6.29)	(-3.73)	(-13.42)	(-12.02)
CashxBBDO	0.0086***	0.0089***	0.0131***	0.0083***
	(4.59)	(2.81)	(9.70)	(5.55)
Leverage	-0.2724***	-0.2791***	-0.2354***	-0.2449***
	(-27.53)	(-18.45)	(-14.86)	(-11.28)
LeverageXBBDO	0.0263***	0.0403***	0.0205***	0.0118**
	(8.91)	(9.24)	(5.03)	(2.38)
GDP Growth	0.1041***	0.9774***	0.1133***	0.6778***
	(28.49)	(16.47)	(17.58)	(12.05)
VXO	0.0090***	0.0126***	0.0065***	0.0079***
	(3.45)	(3.51)	(3.64)	(3.16)
Constant	-3.5571***	-3.8952***	-4.1162***	-3.2074***
	(-50.33)	(-32.45)	(-38.62)	(-28.74)
Firm Controls	YES	YES	YES	YES
Firm F.E.	YES	YES	YES	YES
Clustered Std. Errors	YES	YES	YES	YES
N	389277	133309	128383	127585
R^2	0.0245	0.0242	0.0182	0.0229

NOTE: statistics in parentheses * p:0.10, ** p:0.05, *** p:0.01

Table 8 Total Factor Productivity and Macro_Uncertainty

This table reports panel regression estimates with firm-level total factor productivity (TFP) as the dependent variable and policy uncertainty measures plus a set of firm controls, with firm F.E. All standard errors are clustered at the firm level. Robust t-stats are reported in the brackets. BBDO is the overall index, Uncertainty_1, Uncertainty_3 and Uncertainty_12 are Macroeconomics uncertainty measures based on Jurado,Ludvigson and Ng (2015). TFP computation is based on Olley and Pakes (1996), Tuzel and Imrohoroglu (2014).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	TFP	TFP	TFP	TFP	TFP	TFP	Cash	Cash	Cash	Cash
JLN_M	-0.1194***			-0.1162***				0.0289***		
	(-3.51)			(-3.44)				(4.25)		
JLN_Q		-0.1252***			-0.1238***				0.0276***	
		(-3.64)			(-3.57)				(3.96)	
JLN_Y			-0.1875***				0.0294**			
			(-3.24)				(2.42)			
BBDOXLeverage				0.0111*	0.0111*	0.0110*				
				(1.76)	(1.76)	(1.76)				
BBDO	-0.0402***	-0.0406***	-0.0419***	-0.0392***	-0.0396***	-0.0409***	0.0117***	0.0109***	0.0111***	0.0114***
	(-4.29)	(-4.35)	(-4.50)	(-4.17)	(-4.22)	(-4.37)	(8.02)	(7.35)	(7.45)	(7.75)
GDP Growth	0.7551***	0.7373***	0.8820***	0.4281***	0.5172***	0.6724***	0.0385	0.1624***	0.1540***	0.1017**
	(3.33)	(3.20)	(3.56)	(3.63)	(3.06)	(3.20)	(0.80)	(3.41)	(3.20)	(2.05)
VXO	0.0013***	0.0014***	0.0014***	0.0014***	0.0014***	0.0014***	-0.0283***	-0.0374***	-0.0376***	-0.0345***
	(5.47)	(5.63)	(5.51)	(5.56)	(5.72)	(5.62)	(-5.19)	(-6.64)	(-6.63)	(-6.04)
Constant	0.1392**	0.1616***	0.2405***	0.1423**	0.1644***	0.2431***	0.106***	0.0928***	0.0894***	0.0816***
	(2.35)	(2.64)	(3.23)	(2.38)	(2.66)	(3.26)	(10.54)	(8.84)	(8.23)	(5.72)
Firm Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Clustered Std. Errors	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	394310	394310	394310	394199	394199	394199	240400	240400	240400	240400
R^2	0.0584	0.0584	0.0576	0.0566	0.0566	0.0559	0.160	0.162	0.162	0.161

TABLE 9: Industry Level: Policy Uncertainty and Firm-Level Productivity

This table reports panel regression estimates with firm-level total factor productivity as the dependent variable and policy uncertainty measures plus a set of firm controls, with F.E. Column [1] presents estimates for Metal Mining and Column [2] presents estimates for oil & Gas Sector. Column [3] presents estimates of firms in the manufacturing industry. Column[4] represents firms in the Wholesale and Retail industry. Column [5] presents estimates of firms in the Services industry. Column [6] present estimates of firms in the non-classified. All industries are at the two-digit SIC level. Robust standard errors and t-stats are reported. TFP computation is based on Olley and Pakes (1996), Imrohoroglu and Tuzel (2014).

	(1)	(2)	(3)	(4)	(5)	(6)
	TFP	TFP	TFP	TFP	TFP	TFP
INDUSTRY:	Metal_Mining	Oil&Gas	Manufac.	Wholesale-Retail Trade	Services	Non-Class
BBDO	-0.1882*	0.5994***	-0.0731***	-0.1090***	-0.0811***	-1.3294***
	(-1.73)	(11.84)	(-6.60)	(-4.01)	(-5.83)	(-5.87)
Size	0.1653**	0.2560***	0.0109	-0.0353	0.0560***	-0.0256
	(2.50)	(11.82)	(1.17)	(-0.01)	(4.69)	(-0.38)
Cash	-0.0121	-0.0747	0.0247	0.3122**	0.0356	0.3330
	(-0.07)	(-0.72)	(0.87)	(2.48)	(1.50)	(1.63)
Leverage	0.0295*	0.0353***	-0.0555*	0.0368	-0.0365	-0.0397**
	(1.84)	(2.91)	(-1.71)	(1.43)	(-0.59)	(-2.12)
Sale Growth	0.0376**	0.0184**	0.0300***	0.1254***	0.0372***	0.0587***
	(2.14)	(3.45)	(2.08)	(8.75)	(5.00)	(3.71)
GDP Growth	-4.8894	-2.2510**	1.6833***	0.8460	0.8432**	13.8900***
	(-1.03)	(-2.04)	(5.04)	(0.88)	(2.16)	(5.32)
VXO	0.0520	-0.0995***	0.0184***	0.0233**	0.0228***	-0.0139***
	(1.22)	(-7.36)	(5.91)	(2.58)	(4.91)	(-3.87)
Constant	0.1671	-2.9630***	0.3011***	0.5475**	0.1142	5.9920***
	(0.30)	(-11.45)	(4.38)	(2.49)	(1.28)	(6.06)
Firm Controls	YES	YES	YES	YES	YES	YES
Firm F.E	YES	YES	YES	YES	YES	YES
Robust Std Errors	YES	YES	YES	YES	YES	YES
N	2830	16224	200670	51860	79019	5160
R^2	0.0674	0.231	0.0326	0.00143	0.0706	0.178

NOTE: t-statistics in parentheses: * p:0.10, ** p:0.05, *** p:0.01

TABLE 10: Accounting for the Effects of Demand Shocks on Productivity

This table reports panel regression estimates with TFP as the dependent variable and policy uncertainty measures plus a set of firm controls as the independent variables. All regressions include firm F.E and standard errors are clustered at the firm level. Robust t-stats are reported in the brackets. The policy uncertainty measures used are based on Baker, Bloom and Davis (2016). Sales growth proxy for demand shocks (Bloom 2007).

	(1)	(2)	(3)
	TFP	**TFP**	**Cash**
BBDO	-0.0437***	-0.0435***	- 0.0045**
	(-4.72)	(-4.64)	(2.42)
Sale GrowthxBBDO	0.0299***	0.0303***	-0.0018
	(5.01)	(5.08)	(-0.81)
Leverage		-0.0065**	
		(-2.16)	
LeverageXBBDO		0.0012**	
		(2.12)	
GDP Growth	1.2941***	0.5313*	0.3405***
	(5.14)	(1.83)	(6.13)
VXO	0.0010***	0.0009***	-0.0003***
	(3.88)	(3.51)	(-5.32)
Constant	0.0851	0.3230***	0.1808***
	(1.50)	(8.10)	(16.52)
Firm Controls	YES	YES	YES
Firm F.E	YES	YES	YES
Clustered Std. Errors	YES	YES	YES
N	394214	394199	394214
R^2	0.0454	0.0377	0.0116

NOTE: t-statistics in parentheses * p:0.10, ** p:0.05, *** p:0.01

TABLE 11: Accounting for Financial Flexibility

This table reports panel regresion estimates with TFP as the dependent variable and policy uncertainty measure plus a set of firm controls as the independent variables. All regressions include firm F.E and standard errors are clustered at the firm level. Robust t-stats are reported in the brackets. The policy uncertainty measures used are based on Baker, Bloom and Davis (2016). Financial flexibility (FL) is estimated as the ratio between current period total assets scaled by the difference between current period total assets and total debt. Financial flexibility serves as a proxy for the ability of a firm to take on more debt

	(1)	(2)	(3)
	TFP	TFP	Cash
BBDO	-0.0452***	-0.0610***	0.0112***
	(-4.84)	(-6.31)	(6.16)
BBDOXFL	0.00394**	0.00370**	-0.0136***
	(2.29)	(1.99)	(-38.25)
Leverage		-0.000230***	
		(-3.07)	
LeveragexBBDO		0.0000627***	
		(3.44)	
GDP Growth	1.290***	1.377***	0.397***
	(5.13)	(5.38)	(7.35)
VXO	0.000943***	0.000957***	-0.000234***
	(3.78)	(3.81)	(-4.16)
Constant	0.0843	0.200***	0.168***
	(1.49)	(3.44)	(15.92)
Firm Controls	YES	YES	YES
Firm F.E	YES	YES	YES
Clustered Std Errors	YES	YES	YES
N	394214	379697	394310
R^2	0.0601	0.0607	0.171

NOTE: t-statistics in parentheses * p:0.10, ** p:0.05, *** p:0.01

A Appendix

A.1 Measuring Total Factor Productivity (TFP)

A.1.1 A Parsimonious Model of Firm-Level Productivity

In this section, we outline a parsimonious model for estimating firm-level quarterly total factor productivity (TFP). We closely follow the methods of Olley and Pakes (1996) and Tuzel and Imrohoroglu (2014) and estimate production function based on labor and physical capital as the sole inputs. In particular, Olley and Pakes (1996) assume that productivity is a state variable in firm's input decision problem. The firm production function can be characterised by a Cobb-Douglas production function of the form y_{it} = F(l_{it},k_{it}, w_{it}) where y_{it} is the natural logarithm of firm input for each period t. l_{it} is the natural logarithm of labor (Compustat, EMP), k_{it} is fixed capital input at time t whose value is conditional on the distribution of productivity, and w_{it} is the estimate of productivity. A reduced form of the production function can be written as in equation (A.1) below where η is the error term. Marschak and Andrews (1944) noted that the fact that productivity is known to the firm's decision makers but unknown to the econometrician creates a simultaneity problem. Firstly, future productivity shocks are correlated with productivity levels. Secondly, low productivity firms are likely to exit resulting in selection bias. As a result, OLS estimates of the Cobb-Douglas function will yield biased estimates [5].

$$y_{it} = \beta_0 + \beta_1 l_{it} + \beta_2 k_{it} + w_{it} + \eta_{it} \tag{A.1}$$

The simultaneity problem can be solved by using investment as a proxy for unobserved time-varying productivity shocks and the self-selection exits can be addessed by using survival probabilities (Olley and Pakes, 1996). A firm exits the market if its productivity is below a certain threshold and it stays in the market if its productivity level is above the given threshold. At a minimum a firm's expected discounted returns should at least be greater than its sell-off or salvage value. The firm optimization problem (Bellman equation) can

[5] Yasar and Raciborski 2008.

then be characterised as:

$$V_{it}(k_{it}, l_{it}, w_{it}) = Max[\phi, \{\Pi_{it}(k_{it}, l_{it}, w_{it}) - C_{it} + \rho E_t V_{i,t+1}(k_{it+1}, l_{it+1}, w_{it+1}|j_{it})\}] \quad (A.2)$$

Such that π is the profitable function and C_{it} is the cost of current period profit investment. ρ is the discount rate and $\{E_{it}|j_{it}\}$ is the firm's expectations conditional on information j_{it} at time t. ϕ is the sell-off or salvage value of firm/plant. Since there exists a productivity threshold $\overline{w_{it}}$, the solution to the Bellman programming problem in Equation (A.2) above results in a Markov equilibrium that characterises the firm exit strategy and an investment decision rule. The decision rules can be written as follows:

$$\Gamma_{it} = \begin{cases} 1 & \text{if} \quad w_{it} \geq \overline{w_{it}} \\ 0 & \text{if} \quad otherwise \end{cases} \quad (A.3)$$

$$I_{it} = i_t(w_{it}, k_{it}) \quad (A.4)$$

Future productivity is dependent on current productivity shocks, such that a firm that experiences a positive productivity shock at time t will increase its investment in period t. The inverse function of Equation (A.4) can be written as:

$$w_{it} = i^{-1}(w_{it}, k_{it}) = h_t(i_t, k_t) \quad (A.5)$$

To control for the simultaneity problem, substitute Equation (A.5) into Equation (A.1) which yields Equation (A.6) below in which inputs are no longer correlated with the error term.

$$y_{it} = \beta_0 + \beta_1 l_{it} + \beta_2 k_{it} + h_t(I_{it}, k_{it}) + \eta_{it} \quad (A.6)$$

In order to control for selection bias, use Equation (A.3) (probit of survival indicator) to estimate survival probabilities $\mathbb{P}_{survival,t}$. Equation (A.6) can be re-written as:

$$y_{it} - \beta_1 l_{it} = \beta_0 + \beta_2 k_{it} + h_t(I_{it}, K_{it}) \quad (A.7)$$

$$E_t(y_{i,t+1} - \beta_1 l_{i,t+1}) = \beta_0 + \beta_k k_{i,t+1} + E_t(w_{i,t+1}|w_{it}, survival) = \beta_o + \beta_k k_{i,t+1} + g(w_{it}, \mathbb{P}_{survival,t}) \tag{A.8}$$

where g(.) is a function of firm specific state variables. Fitting a nonlinear least squares into Equation (A.8) and assuming that w_{it} (Equation A.5) follows an AR(1) process[6]:

$$w_{it} = \rho w_{it-1} + \zeta_{it} \tag{A.9}$$

where ζ_{it} is innovation to the process yields the productivity equation:

$$Productivity_{it} = e^{(y_{it} - \hat{\beta}_0 - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it})} \tag{A.10}$$

Empirically, y_{it} is the natural logarithm of value added, l_{it} is the natural logarithm of total labor and k_{it} is the natural logarithm of capital stock.

[6]Note that using AR(2) process yields similar outcome.