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TRADE POLICY UNCERTAINTY AND BUSINESS INVESTMENT IN THE US

Key points

- *Using the news-based index of trade policy uncertainty of Baker et al. (2016), we find evidence of a significant negative relationship in the US between domestic business investment and the level of uncertainty associated with future trade policy outcomes.*

- *In spite of the limited degree of trade openness of the US economy, the estimated impact of trade policy uncertainty on business investment is economically significant when compared to the effects of fiscal and monetary policy uncertainty, suggesting that trade tensions can be similarly damaging to private investment as domestic sources of policy uncertainty.*

- *Further highlighting the importance of a stable trade policy environment, our study finds that a given increase in trade policy uncertainty has a larger negative impact on business investment during periods of heightened trade policy uncertainty, as would be during the prevailing environment of escalated US-China trade tensions.*

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I. INTRODUCTION

> *Trade wars are good, and easy to win.*[1]
>
> *… (Business) contacts in some Districts indicated that plans for capital spending had been scaled back or postponed as a result of uncertainty over trade policy.*[2]

Uncertainty over trade policy escalated markedly in the US since early 2018 as the Trump administration increasingly pursued protectionist trade measures. While the conventional wisdom is that the US economy is likely to be little affected by trade tensions because of its limited degree of trade openness, anecdotal evidence suggests that domestic businesses responded to the escalation in trade policy uncertainty by cutting back investment.

Motivated by these observations, we investigate the empirical relationship between trade policy uncertainty and business investment in the US. In addition to assessing how the *level* of trade policy uncertainty would affect business investment, we go one step further to investigate whether the response of business investment to trade policy uncertainty is *state-dependent*, i.e. whether the uncertainty-investment relationship is the same during periods of tranquillity compared to those of heightened uncertainty. We find that, not only does an increase in trade policy uncertainty hurt business investment, but the drag on investment resulting from a given increase in trade policy uncertainty is larger when uncertainty is at a high level.

This memorandum proceeds as follows. The next section provides a brief review of the uncertainty-investment literature, and describes how our work contributes to this field of study. Section III discusses data, methodology and model specifications. Section IV presents the empirical results, and the last section concludes our findings and discusses their policy implications.

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1 From a Twitter post by Donald Trump, President of the United States, published on 2 March 2018.

2 From the minutes of the Federal Open Market Committee (FOMC) meeting in June 2018.

II. LITERATURE REVIEW AND CONTRIBUTIONS

The relationship between uncertainty and corporate investment has been extensively studied in the literature (see Carruth et al. (2000) for a survey). A general conclusion is that increased uncertainty tends to reduce investment rates, because investment projects are usually irreversible once begun and uncertainty raises the value of the firms' option to delay commitment to investment. In recent years, advancements in technology allowed economists to construct alternative, high-frequency measures of uncertainty that were previously unavailable, a prominent example being the Economic Policy Uncertainty (EPU) index (Baker et al. (2016)). The EPU index quantifies the level of aggregate economic policy uncertainty by counting the occurrences of selected keywords in major newspapers. Using the EPU index, Gulen et al. (2015) found a strong negative relationship between the level of economic policy uncertainty and firm-level capital investment. In a similar vein, Barkbu et al. (2015) used a variant of the EPU index for Europe and found empirical evidence of a negative relationship between economic policy uncertainty and private non-residential investment in the Euro Area.

To date, however, we are not aware of any existing literature that investigates the relationship between the *categorical* EPU indices and corporate investment. Indeed, the keyword-counting methodology advocated by Baker et al. (2016) can be readily adopted to construct uncertainty indices for specific policy categories, such as trade policy, fiscal policy and monetary policy, by modifying the lists of keywords to be counted.[3] These category-specific uncertainty indices allow one to capture different dimensions of economic policy uncertainty. We believe our work is among the first attempts to systematically compare the impacts of trade policy uncertainty (TPU) with two major domestic sources of policy uncertainty, namely, fiscal policy uncertainty (FPU) and monetary policy uncertainty (MPU), on business investment in the US.

Another contribution of our work is the application of Markov switching models to classify categorical EPU indices into *high-uncertainty* and *low-uncertainty* states. In many of the existing studies that make use of EPU indices, their model specifications assume that the macroeconomic variables of interest (e.g. real GDP, investment, etc.) vary linearly with (the logarithm) of policy uncertainty indices. This implies that a 1% rise in policy uncertainty,

[3] See the appendix of Baker et al. (2016) for the lists of keywords they counted for the construction of various category-specific EPUs.

regardless of its prevailing level, will have the same marginal effect on the macro economy. However, this assumption seems questionable. Intuition suggests that, while changes in perception of uncertainty in future economic policy outcomes may not matter a lot to businesses when the economic environment is overall stable, it may exert a much larger dampening effect on confidence and sentiment when the policy environment is highly uncertain. To test this conjecture, we need to identify periods of high and low economic policy uncertainty, which we achieve using Markov switching models. To the best of our knowledge, this state-contingent view of uncertainty is new in the empirical literature.[4] Based on the classification results of Markov switching models, we construct dummy variables of high-uncertainty states to interact with the categorical EPU indices in our regression models, as a means of assessing whether business investment responds differently to a rise in policy uncertainty in high-uncertainty and low-uncertainty states.

III. EMPIRICAL MODELS

3.1 Data and baseline model

The data used in our empirical analysis extend from Q1 1990 to Q3 2018 (see Appendix 1 for their definitions and data sources). The sample period is chosen to match the availability of cash-flow data of S&P 500 companies, which are taken as a proxy of cash flows available to US businesses. An encompassing model for assessing the relationship between policy uncertainty and business investment, which borrows heavily from Gulen et al. (2015) and Barkbu et al. (2015), is shown below:

$$\frac{Inv_{tD}}{K_{t-1D}} = D + D_1 \log(PU_{t-1}) + D_2 TQ_{t-1D} + D_3 real10yUST_{t-1D} + D_4 \frac{ebt_{t-1D}}{Equity_{t-1D}}$$

$$+ D_{5D} \frac{CF_{t-1D}}{Sales_{t-1D}} + \sum_{i=1D}^{4} \gamma_i \frac{\Delta Y_{t-i}}{K_{t-1D}} + \varepsilon_t \qquad (1)$$

[4] Bloom et al. (2007) developed a theoretical model on corporate investment, which predicts that the response of a firm's investment to demand shocks would be smaller at higher levels of uncertainty, due to the "cautionary effect" of uncertainty. This idea is consistent with our conjecture that the impact of uncertainty on investment should be state-contingent.

Here, t indexes quarters, α is the intercept term and ε denotes the error term. Business investment (Inv_t) is measured by real private investment in non-residential fixed assets in quarter t, normalised by the previous quarter's estimated net stock of non-residential fixed assets (K_{t-1}). The policy uncertainty variable (PU_{t-1}) is the arithmetic average of the (monthly) policy uncertainty index in the three months of quarter $t-1$ and, as mentioned before, three types of policy uncertainty (namely, TPU, FPU and MPU) are considered in our study. Panel A of Table 1 reports the pairwise correlation coefficients among the three categorical EPU indices.

A number of control variables are included to account for economic factors that may also affect business investment. First, economic theory suggests that business investment should be negatively related to user cost of capital (Hall et al., 1697) and positively related to Tobin's q (Tobin, 1969), which leads us to incorporate the lagged average Tobin's q ratio of US non-financial corporate businesses (TQ_{t-1}) and real 10-year US Treasury yield ($real10yUST_{t-1}$, as a proxy of inflation-adjusted user cost of capital) in our specification. Second, the lagged debt-to-equity ratio of US non-financial corporate businesses $(\frac{Debt_{t-1}}{Equity_{t-1}})$ is included to control for the negative effects of firms' leverage on business investment (e.g. Myers (1977)). Third, economic theory suggests that, in the presence of capital market imperfections, firms with higher cash flows are likely to invest more (e.g. Gilchrist et al. (1995)), and we control for this effect by including the lagged free-cash-flow-to-sales ratio of S&P 500 corporations $(\frac{CF_{t-1}}{Sales_{t-1}})$ in our model. Finally, lagged changes in real quarterly GDP normalised by net capital stock $(\sum_{i=1}^{N} \gamma_i \frac{\Delta Y_{t-i}}{K_{t-1}})$ is incorporated to capture the positive impact of real output growth on firms' investment.[5] Panel B of Table 1 shows the summary statistics of the variables included in our study.

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[5] The accelerator model of investment suggests that investment and real output are related in the following manner (see Oliner et al. (1995) for derivation):

$$\frac{I_t}{K_{t-1}} = \frac{D}{K_{t-1}} + \sum_{i=1}^{N} \gamma_i \frac{\Delta Y_{t-i}}{K_{t-1}} + \delta$$

Here, I is investment, K is capital stock, ΔY is the change in real GDP, and δ is an (indirect) estimate of depreciation rate. To achieve a parsimonious model, N is taken to be 4.

Table 1. Summary statistics

Panel A: Correlation matrix of selected categorical EPUs

	TPU	FPU	MPU
TPU	1.000		
FPU	0.054	1.000	
MPU	0.078	0.556	1.000

Panel B: Summary statistics of variables used in analysis

	N	Mean	SD	Min	Max
Inv / K	115	0.094	0.016	0.063	0.122
TPU	115	97.738	103.061	7.706	672.541
FPU	115	101.606	58.378	32.038	337.480
MPU	115	87.611	45.300	24.892	252.101
Tobin's *q*	115	0.984	0.218	0.485	1.690
User cost of capital	115	4.154	2.268	-0.076	7.888
Debt / Equity	115	0.453	0.136	0.276	0.969
CF / Sales	115	0.069	0.028	0.017	0.123
$\Delta Y_{t-1} / K_{t-1}$	115	0.005	0.005	-0.018	0.015

Note: In Table 1, data extend from Q1 1990 to Q3 2018. Panel A presents correlation coefficients among the trade, fiscal and monetary policy uncertainty indices constructed according to Baker et al.'s (2016) methodology, which have been converted into quarterly frequency by simple average of monthly observations. Panel B presents summary statistics of the key variables used in our study. The summary statistics of $\Delta Y_{t-2} / K_{t-1}$, $\Delta Y_{t-3} / K_{t-1}$ and $\Delta Y_{t-4} / K_{t-1}$ are omitted as they are essentially the same as those of $\Delta Y_{t-1} / K_{t-1}$.

However, it is found that this specification suffers from multicollinearity, as revealed by the very high values of variance inflation factors (VIFs) of the coefficients associated with Tobin's *q* and debt-to-equity ratio (Table 2).[6] Moreover, in the presence of either the Tobin's *q* or the debt-to-equity ratio, the *MPU* variable would become statistically insignificant, again due to the problem of a high degree of collinearity.[7] We therefore drop these two problematic variables altogether, resulting in the following specification that will form the baseline model for subsequent analysis:

$$\frac{Inv_{tD}}{K_{t-1D}} = D + D_1 \log(PU_{t-1}) + D_2 real10yUST_{t-1D} + D_{3D} \frac{CF_{t-1D}}{Sales_{t-1D}} + \sum_{i=1D}^{4} \gamma_i \frac{\Delta Y_{t-i}}{K_{t-1D}} + \varepsilon_t \qquad (1')$$

[6] This is not entirely unexpected, because both variables involve the market value of equity.

[7] Inclusion of alternative measures of firm leverage, such as the debt-to-asset ratio, would also render the coefficient of *MPU* statistically insignificant. Estimation results are available upon request.

Table 2. Variance inflation factors, Equation (1)

	Specification		
Dep. variable	(1)	(2)	(3)
log(TPU)	1.46		
log(FPU)		1.64	
log(MPU)			1.55
Tobin's *q*	4.73	4.75	4.87
User cost of capital	2.80	2.82	2.99
Debt / Equity	6.84	6.25	6.32
CF / Sales	2.21	2.46	2.44
$\Delta Y_{t-1} / K_{t-1}$	1.50	1.58	1.69
$\Delta Y_{t-2} / K_{t-1}$	1.51	1.55	1.56
$\Delta Y_{t-3} / K_{t-1}$	1.42	1.39	1.40
$\Delta Y_{t-4} / K_{t-1}$	1.36	1.35	1.36

Note: In Table 2, the variance inflation factors (VIFs) associated with each coefficient in the three specifications of Equation (1) are reported. VIFs are a measure of the degree of collinearity among explanatory variables in a linear regression, and a general rule of thumb is that VIFs exceeding 4 indicate potential problems that warrant further investigation.

3.2 Extension: Markov switching model of categorical EPU indices

As a next step of investigation, we are interested in assessing the presence of nonlinearities, if any, in terms of responses of business investment to policy uncertainty. One way to do so is to identify periods of high and low policy uncertainty using Markov switching models. While switching models are commonly applied to economic variables that tend to have distinct regimes (e.g. real GDP during economic expansions and recessions as in Hamilton (1989)), we are not aware of any attempts in the literature to identify regimes of high and low policy uncertainty using switching models.

In Appendix 2, we outline the specification, estimation strategy and classification results of our Markov switching models for distinguishing between periods of high and low policy uncertainty. For each quarter *t*, Markov switching models provide estimates of the (filtered) probability that the US economy belongs to the *high-uncertainty state* or the *low-uncertainty state*, based on the observed values of $PU_0, PU_1, \ldots, PU_T$. Given the estimated probabilities, we follow the standard practice in the literature and treat quarter *t* as in a high-uncertainty state when the estimated probability of being in a high-uncertainty state, $\Pr(s_t =$ "high uncertainty"$)$, is greater than or equal to 0.5, and we define the following *high-uncertainty-state* dummy variables for each of $PU = \{TPU, FPU, MPU\}$:

$$PU_{high,t} = \begin{cases} 1, if \Pr(S_t = \text{"}high\ uncertainty\text{"}) \geq 0.5 \\ 0, otherwise \end{cases}$$

Now that we have constructed dummy variables for periods of high policy uncertainty, we consider an extension of Equation (1) by introducing interaction terms between the dummy variables and the policy uncertainty indices ($PU_{high,t-1} * \log(PU_{t-1})$). This specification allows us to investigate separately the mean responses of business investment to changes in PU = *{TPU, FPU, MPU}* during high-uncertainty state (with coefficient $(\beta_1 + \beta_1^{high})$) and low-uncertainty state (with coefficient β_1):[8]

$$\frac{Inv_t}{K_{t-1}} = \alpha + \beta_1 \log(PU_{t-1}) + \beta_1^{high} * PU_{high,t-1} * \log(PU_{t-1})$$
$$+ \beta_2 real10yUST_{t-1} + \beta_3 \frac{CF_{t-1}}{Sales_{t-1}} + \sum_{i=1}^{4} \gamma_i \frac{\Delta Y_{t-i}}{K_{t-1}} + \varepsilon_t \quad (2)$$

IV. ESTIMATION RESULTS

<u>4.1 Baseline model</u>

We begin our empirical analysis by estimating three separate specifications of Equation (1'), one for each PU = *{TPU, FPU, MPU}*, to compare the impact of the three types of policy uncertainty on business investment. As a robustness check, we also estimate a regression that includes all three *PU*s at the same time. To facilitate comparison of the coefficients associated with different explanatory variables (within the same model as well as across models involving different policy uncertainty indices), all variables are normalised by their respective sample standard deviations, such that each regression coefficient can be interpreted as the change in dependent variable (as a proportion of its standard deviation) associated with a one-standard-deviation increase in the explanatory variable. An exception is β_1, the coefficient associated with PU_{t-1}. Since we have taken logarithm of the normalised PU_{t-1} variable, its normalising constant is absorbed by α and, hence,

[8] As a robustness check, one may also wish to assess whether the responses of investment to changes in other explanatory variables are state-dependent as well. However, this cannot be done easily in our existing framework, as the inclusion of interaction terms between the high-uncertainty dummy and each of the independent variables in the regressions would render almost all of the coefficients statistically insignificant. More appropriate methods of checking robustness of our results will be a direction of future research.

β_1 can be interpreted as the number of standard deviations by which the dependent variable changes when the policy uncertainty index increases by 100% (i.e. doubles).

The estimation results are shown in columns (a) to (d) of Table 3. Column (a) shows that when trade policy uncertainty increases by 100% (i.e. doubles), the investment-to-capital stock ratio declines by 0.20 standard deviations in the next quarter. Since the standard deviation of the (Inv / K) ratio is 0.016 (please refer to Panel B of Table 1), this is equivalent to a 32-basis-point decrease, or 3.4% of the average investment ratio in the sample (0.094). Similar calculations reveal that a doubling of fiscal policy uncertainty and monetary policy uncertainty would decrease investment by 7.7% and 3.7% relative to the sample mean.[9]

How can we interpret these findings? In the existing literature, it is well established that fiscal and monetary policy shocks are *the* major sources of US business cycle fluctuations, with the work by Rossi et al. (2011) establishing a stylised fact that these two types of shocks play a bigger role in explaining medium-cycle fluctuations and business-cycle fluctuations respectively. As such, our estimated result that fiscal and monetary policy uncertainties have relatively large impacts on business investment is to be expected.[10] What is more surprising, however, is that the estimated impact of a doubling of trade policy uncertainty on business investment (-3.4%) are also sizeable when compared with those associated with fiscal (-7.7%) and monetary (-3.7%) policy uncertainty, in spite of the very low degree of trade openness of the US economy (especially when compared with other major advanced economies such as Japan and the Euro Area). Our results therefore suggest the following *main finding #1: trade tensions can be similarly damaging as domestic sources of policy uncertainty in terms of dampening business investment*.

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[9] Column (d) of Table 3 shows the result of our robustness check. In a "horse race" among the three categorical EPUs, fiscal policy uncertainty wins out as it remains a statistically significant drag on investment, and its presence renders the other two categorical EPUs statistically insignificant. Even so, the coefficient associated with *TPU* remains negative (albeit only with a p-value of 0.16), while that of *MPU* becomes statistically indistinguishable from zero at any conventional significance levels.

[10] While policy uncertainty and policy shocks are different concepts, both notions pertain to the "unexpectedness" of policy outcomes.

Table 3. Policy uncertainty and business investment – Baseline model

	(a)	(b)	(c)	(d)
β_1 (TPU)	-0.20**			-0.12
	(-2.61)			(-1.40)
β_1 (FPU)		-0.45***		-0.40***
		(-4.97)		(-3.15)
β_1 (MPU)			-0.22*	0.03
			(-1.95)	(0.21)
β_2	-0.59***	-0.59***	-0.63***	-0.56***
	(-6.77)	(-7.74)	(-6.68)	(-6.75)
β_3	0.23***	0.32***	0.23***	0.31***
	(3.32)	(5.04)	(3.06)	(4.88)
γ_1	0.12*	0.05	0.09	0.06
	(1.87)	(0.82)	(1.27)	(0.90)
γ_2	0.12*	0.06	0.10	0.06
	(1.78)	(0.83)	(1.39)	(0.96)
γ_3	0.11*	0.07	0.09	0.09
	(1.75)	(1.22)	(1.40)	(1.45)
γ_4	0.11*	0.08	0.09	0.09
	(1.72)	(1.35)	(1.46)	(1.51)
N	114	114	114	114
Adj. R^2	0.63	0.66	0.62	0.67

Notes: In Table 3, we regress economy-wide private investment ratio (Inv / K) on three different measures of policy uncertainty (β_1), real user cost of capital (β_2), S&P 500 corporates' cash-flow-to-sales ratio (β_3) and lagged changes of real GDP normalised by net capital stock (γ_1 to γ_4). Heteroscedasticity and autocorrelation robust (HAC) t-statistics are reported in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

4.2 Extended model (with high-uncertainty-state dummy)

Next, we report the regression estimation results of Equation (2), for each of *PU* = {*TPU, FPU, MPU}*, in columns (a) to (c) of Table 4. Due to the fact that the high-uncertainty-state dummy variables are "generated" regressors originating from another model, the commonly-used HAC t-statistics may not be valid for Equation (2). As such, we report the bootstrapped t-statistics in Table 4.

Column (a) shows that, in low-uncertainty states, a doubling of trade policy uncertainty would result in a reduction of the investment-to-capital-stock ratio by 0.03 standard deviations in the next quarter, and such reduction is not statistically different from zero. During high-uncertainty stage, however, a doubling of trade policy uncertainty would result in an ***additional*** 0.46 standard-deviation decrease in the investment-to-capital-stock ratio in the next quarter. Similarly, column (b) shows that a rise in fiscal policy uncertainty does not have any statistically significant impact on investment during low-uncertainty state, but can induce a much greater drag on investment when the economy is in a high-fiscal-policy-uncertainty state.[11] Our results therefore suggest the following *main finding #2: trade tensions can be more damaging to business investment when the economy is faced with a high level of trade policy uncertainty*.

[11] Nonetheless, column (c) shows that monetary policy uncertainty may help to *boost* investment when it is at elevated levels, as reflected by the *positive*, albeit not highly significant, coefficient associated with $_{1D}^{highD}$(MPU). A plausible explanation of the positive coefficient is that a period of heightened monetary policy uncertainty could indicate a turning point for subsequent easing of monetary policy. Since monetary policy uncertainty is not the focus of our work, we do not plan to expand our model to account for such possible endogeneity.

Table 4. Policy uncertainty and business investment – Extended model

Dependent variable: Inv_t / K_{t-1}

	(a)	(b)	(c)
β_1 (TPU)	-0.03		
	(-0.33)		
${}_{1}^{high}$(TPU)	-0.46**		
	(-2.88)		
β_1 (FPU)		-0.11	
		(-0.70)	
${}_{1}^{high}$(FPU)		-0.42***	
		(-2.68)	
β_1 (MPU)			-0.41***
			(-2.60)
${}_{1}^{high}$(MPU)			0.32*
			(1.86)
β_2	-0.64***	-0.62***	-0.63***
	(-6.96)	(-6.88)	(-7.81)
β_3	0.22***	0.29***	0.25***
	(3.29)	(4.06)	(3.28)
γ_1	0.15**	0.05	0.13*
	(2.28)	(0.83)	(1.66)
γ_2	0.13**	0.04	0.11*
	(1.98)	(0.64)	(1.72)
γ_3	0.09	0.10	0.07
	(1.60)	(1.60)	(0.92)
γ_4	0.10	0.09*	0.10
	(1.42)	(1.68)	(1.51)
N	114	114	114
Adj. R^2	0.65	0.68	0.63

Notes: In Table 4, we regress the (Inv / K) ratio on three different measures of policy uncertainty (β_1), interaction between high-uncertainty dummy and the three measures of policy uncertainty (${}_{1D}^{highD}$), real user cost of capital (β_2), S&P 500 corporates' cash-flow-to-sales ratio (β_3) and lagged changes of real GDP normalised by net capital stock (γ_1 to γ_4). Bootstrapped t-statistics are reported in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

V. CONCLUSION

In this study, we have investigated the empirical relationship between trade, fiscal and monetary policy uncertainty on one hand, and US business investment on the other. Contrary to common belief that the US economy should be little affected by trade tensions due to its limited degree of trade openness, our findings suggest that trade policy uncertainty can be similarly damaging to private investment as domestic sources of policy uncertainty. Moreover, we find that business investments tend to fall more sharply in response to a rise in trade policy uncertainty when the economy is at a high-uncertainty state, highlighting the importance of a stable trade policy environment.

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Appendix 1: Data definitions and sources

Variable	Definition and data source
Investment	Definition: Aggregate US corporate investment is measured by quarterly data on private non-residential fixed asset investment (comprising investment on structures, equipment and intellectual property products), at seasonally adjusted annual rates in chained (2012) dollars. Source: Bureau of Economic Analysis (BEA)
Capital stock (1)	Definition: Annual series on estimated net stock of private non-residential fixed asset in chained (2012) dollars, linearly interpolated into quarterly frequency so that the stock of capital in the last quarter would match the corresponding annual figure. Source: BEA
Uncertainty indices (2)	Definition: Time series data on US trade, fiscal and monetary policy uncertainty indices constructed according to Baker et al.'s (2016) keyword-counting methodology. Source: http://www.policyuncertainty.com/us_monthly.html
Tobin's q	Definition: Ratio of market value of equities to replacement costs (i.e. net worth) of US non-financial corporate businesses. Source: Financial Accounts of the United States (Z.1), Federal Reserve
Real cost of capital	Definition: Real cost of capital faced by firms is approximated by the difference between quarterly average yield of 10-year constant-maturity US Treasury and the year-on-year change in investment deflator (price index of private non-residential fixed asset investment in GDP account). Sources: BEA and St. Louis Fed

Variable	Definition and data source
Cash flow-to-sales	Definition: Ratio of quarter-end free cash flow per share to quarter-end trailing 12-month sales per share of S&P500 corporations. Source: Bloomberg
Real GDP	Definition: Real quarterly GDP, at seasonally adjusted annual rates in chained (2012) dollars Source: BEA
Debt-to-equity ratio	Definition: Ratio of market values of debt securities and loans to market value of equities of US non-financial corporate businesses. Source: Financial Accounts of the United States (Z.1), Federal Reserve

Notes:

(1) The capital stock levels in Q1 and Q2 2018, which are not available at the time of this study, are approximated by linear extrapolation of 2017 data.

(2) These variables are converted into quarterly frequency by simple average of monthly observations.

Appendix 2: Description of our two-state Markov switching model[12]

We assume that, for each of PU_t = $\{TPU_t, FPU_t, MPU_t\}$, its time-series dynamics can be described by the following model:

$$PU_t = \begin{cases} c_0 + \varepsilon_t, when\ s_t = 0 \\ c_1 + \varepsilon_t, when\ s_t = 1 \end{cases}$$

Here, c_0 and c_1 are constants (without loss of generality, we may assume $c_1 \geq c_0$), $\varepsilon_t \sim N(0, \sigma^2)$ and $s_t = \{0, 1\}$ is a realisation of a two-state Markov chain:

$$\Pr(s_t = j \mid s_{t-1} = i, s_{t-2} = k, \ldots, PU_{t-1}, PU_{t-2}, \ldots) = \Pr(s_t = j \mid s_{t-1} = i) = p_{ij} \in (0,1)$$

Given these notions, we can denote $s_t = 0$ as *low-uncertainty state* and $s_t = 1$ as *high-uncertainty state*, as we assign $c_1 \geq c_0$. Obviously, we cannot directly observe s_t for t = {1, 2, … T}, but the value of s_t can be inferred from the observed values of PU_t. In particular, if we denote $\theta = (\sigma, c_0, c_1, p_{ij})'$ as the vector of population parameters, $\Omega_t = \{PU_t, PU_{t-1}, \ldots PU_1, PU_0\}$ as the set of observed policy uncertainty indices as of quarter *t*, and $\zeta_{i,t} = \Pr(s_t = i \mid \Omega_t; \theta)$ as the probability that $s_t = i \in \{0,1\}$ in quarter *t*, we can obtain estimates of θ and $\zeta_{i,t}$ by maximising the following conditional log likelihood of the observed data:[13]

$$\log f(PU_1, PU_2, \ldots, PU_T | PU_0; \theta) = \sum_{t=1}^{T} \log f\,(PU_t | \Omega_{t-1}; \theta)$$

Table A1 summarises the estimation results of Markov switching models applied to each of *PU* = {*TPU, FPU, MPU*}, and Charts A1 – A3 show their corresponding filtered probability $\Pr(s_t = 1)$ (i.e. the probability that PU_t belongs to the high-uncertainty state in quarter *t*). The three charts show that the estimated probabilities are largely reasonable, with periods of elevated readings of PU_t usually being associated with a high probability of $s_t = 1$.

[12] Our notations here follow closely to Hamilton (2010), which provides a gentle introduction to Markov switching models and their estimation.

[13] Note that $\log f\,(PU_t | \Omega_{t-1}; \theta)$ is a function of $\zeta_{i,t}$.

With these estimated probabilities in hand, we follow the standard practice in the literature and set a threshold of $\Pr(s_t = 1) \geq 0.5$ for classifying quarter t into the high-uncertainty state, and define the following *high-uncertainty-state* dummy variables for each of $PU = \{TPU, FPU, MPU\}$:

$$PU_{high,t} = \begin{cases} 1, if \ \Pr(s_t = 1) \geq 0.5 \\ 0, otherwise \end{cases}$$

Table A1. Markov switching models

	Dependent variable		
Parameters	TPU	FPU	MPU
c_1	70.88***	76.43***	72.95***
	(13.33)	(17.36)	(20.40)
c_2	319.3***	171.3***	164.8***
	(19.73)	(18.66)	(21.21)
log(σ)	4.06***	3.62***	3.41***
	(66.20)	(48.59)	(42.63)
p_{00}	-4.14***	-2.30***	-1.97***
	(-5.74)	(-5.80)	(-5.59)
p_{10}	2.29*	1.29*	0.15
	(2.43)	(2.52)	(0.32)
N	135	135	135

Note: In Table A1, data extend from Q1 1985 to Q3 2018, and monthly observations of policy uncertainty indices are converted in quarterly frequency by simple average. Standard errors derived from asymptotic theory are estimated; t-statistics are reported in parentheses. The transition probabilities p_{00} and p_{10} refer to those of PU_t staying in low-uncertainty state in quarter *t+1* and transitioning into a high-uncertainty state in quarter *t+1*, respectively. *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

Chart A1. TPU and filtered probability of $s_t = 1$

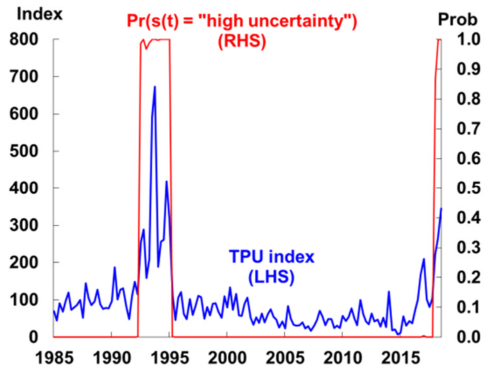


Chart A2. FPU and filtered probability of $s_t = 1$

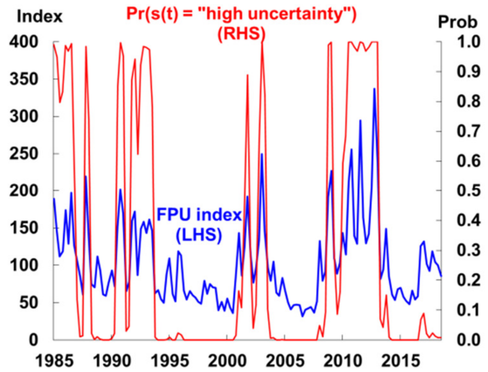
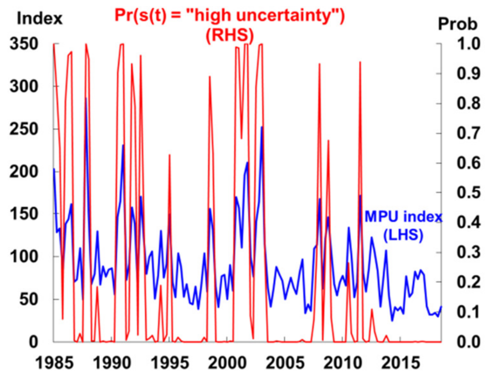


Chart A3. MPU and filtered probability of $s_t = 1$



Sources: Economic Policy Uncertainty and author's estimation.