International Review of Economics and Finance 75 (2021) 609–624

Contents lists available at ScienceDirect

International Review of Economics and Finance

journal homepage: www.elsevier.com/locate/iref

Monetary policy and corporate investment: A panel-data analysis of transmission mechanisms in contexts of high uncertainty

Luis P. de la Horra [b,*], Javier Perote [a], Gabriel de la Fuente [b]

[a] School of Economics & Business, Department of Economics and Economic History, University of Salamanca, Campus Miguel de Unamuno (Edif.. FES), 37007, Salamanca, Spain

[b] Business & Economics School, Department of Financial Economics and Accounting, University of Valladolid, Avda. Valle Esgueva, 6, 47011, Valladolid, Spain

ARTICLE INFO

JEL classification:
C23
D80
E22
E52
E58

Keywords:
Real options
Investment decisions
Interest rates
Central banks
Risk
Panel VAR

ABSTRACT

This paper investigates the impact of monetary policy on firm-level investment in contexts of economic turmoil. Using a panel of US public firms for the period 2000–2019, we show that policy-rate-based transmission mechanisms are undermined when uncertainty spikes. Furthermore, we find evidence of the existence of asymmetries at the firm level. In line with real options theory's predictions, firms with higher levels of investment irreversibility, operational inflexibility, and market power, as well as firms with lower cash flows and who operate in low-innovation sectors tend to be less responsive to changes in monetary policy. The effectiveness of monetary policy thus depends on the ability of monetary authorities to reduce uncertainty via expectations-based monetary tools, whilst targeting those sectors more likely to be affected by monetary-policy shifts.

1. Introduction

The severity of the 2008 financial crisis and subsequent recession forced US monetary authorities to rethink the traditional transmission mechanisms of monetary policy in order to re-establish pre-crisis levels of investment and employment. This reassessment of monetary policy went along two lines. First, the Federal Reserve resorted to large-scale asset purchases (otherwise known as quantitative easing or QE) to overcome the problems derived from the zero lower bound, emphasizing the importance of the credit channel of monetary policy (Bernanke & Gertler, 1995). Second, the sluggish recovery pushed monetary authorities to employ expectations-based mechanisms such as forward guidance in order to lower uncertainty and spur economic activity.

Existing evidence suggests that QE was effective inasmuch as it helped lower long-term interest rates, preventing a decline in output and fostering firm-level investment (Foley-Fisher, Ramcharan, & Yu, 2016; Krishnamurthy & Vissing-Jorgensen, 2011; Kuttner, 2018; Sterk & Cui, 2018). In contrast, results are less clear in relation to the impact of forward-guidance policies. Whereas Smith and Becker (2015) and Katagiri (2016) show that forward guidance is a powerful tool to stimulate the economy when the policy rate is constrained

* Corresponding author. Business & Economics School, Department of Financial Economics and Accounting, University of Valladolid, Avda. Valle Esgueva, 6, 47011, Valladolid, Spain.

E-mail addresses: luispablo.horra@uva.es, luispablo.horra@uva.es (L.P. de la Horra), perote@usal.es (J. Perote), gabriel.fuente@uva.es (G. de la Fuente).

https://doi.org/10.1016/j.iref.2021.04.035
Received 11 February 2020; Received in revised form 11 October 2020; Accepted 28 April 2021
Available online 6 May 2021

by the zero lower bound, Gavin, King, Richter and Throckmorton (2013) and Hagedorn, Luo, Manovskii, and Mitman (2019) find that the effects of expectations-based transmission mechanisms are small, especially during deep recessions.

The effectiveness of such expectations-based mechanisms is implicitly grounded upon the assumption that uncertainty plays a moderating role in the relationship between monetary policy and investment (i.e., firms' responsiveness to shifts in the policy rate may differ under different uncertainty levels). This paper aims to address to what extent uncertainty modulates the effect of monetary policy on corporate investments. Previous research shows that the relationship between monetary policy and investment can be asymmetric depending on firms' characteristics (e.g., Gertler & Gilchrist, 1994). Firm heterogeneity and its influence in the relationship between uncertainty and corporate investment may be the key to understanding the contradictory evidence to emerge on the effectiveness of expectations-based mechanisms.

As a result, we undertake a firm-level analysis to elucidate how expansionary monetary-policy shocks affect firms with different idiosyncrasies in the presence of high uncertainty.[1] Specifically, we focus on three distinctive characteristics: investment irreversibility, operating inflexibility, and opportunity costs. According to the real options theory, uncertainty increases a firm's option value to wait (and thus, the incentive to delay new investments) when: a) investment is irreversible (Gulen & Ion, 2016); b) firms lack operational flexibility (Grullon, Lyandres, & Zhdanov, 2012); and c) the opportunity costs of not undertaking new investments in terms of unrealized cash flows and loss of competitive advantages are low (Folta & Miller, 2002).

Two strands in the literature are relevant for our research. The first strand deals with the determinants and behavior of corporate investments under uncertainty. As early as 1936, Keynes pointed out that corporate investment fluctuations over the business cycle are related to uncertainty concerning the expected yield of capital assets (Keynes, 1973). In the spirit of Keynes, Bernanke (1983) analyzes the impact of investment irreversibility on corporate investments, concluding that high uncertainty provides firms with an incentive to delay new commitments. McDonald and Siegel (1986) and Pindyck (1988) liken investment decisions within a company to financial call options, noting that uncertainty increases the value of waiting for new information, which in turn increases the value of a firm's real option to invest in the future and reduces current corporate investment.

On the empirical front, Caggiano, Castelnuovo, and Groshenny (2014) conclude that uncertainty shocks have a negative impact on aggregate investment. Similarly, Hendrickson (2017) shows that a 1% increase in economic policy uncertainty leads to an equivalent reduction in investment. A number of studies employ microeconomic data to test the effects of uncertainty on corporate investments. The pioneering study is that of Leahy and Whited (1996), who find a negative relationship between stock volatility and investment. Similarly, Bloom, Bond, and Van Reenen (2007) find that the response of investment to demand shocks is lower when uncertainty is high. In contrast, Kang, Lee, and Ratti (2014) conclude that economic policy uncertainty has no impact on the investment decisions of large manufacturing firms. Finally, Guiso and Parigi (1999) and Bontempi, Golinelli, and Parigi (2009) show that market power and irreversibility have a moderating effect on the relationship between uncertainty and investment.

The second strand examines the transmission mechanisms of monetary policy.[2] Since the publication by Friedman and Schwartz (1971), the influence of monetary policy on the real economy has been the focus of a multitude of theoretical and empirical studies.[3] Particularly relevant for our research is the literature on the effects of monetary policy under uncertainty. In this sense, the recent work by Aastveit, Natvik, and Sola (2017) represents a landmark in the study of transmission mechanisms in the presence of uncertainty. In it, the authors show that the impact of monetary policy on aggregate investment is considerably lower when uncertainty is in its top decile. This would explain why monetary policy tends to prove less effective during recessions (Tenreyro & Thwaites, 2016). However, by focusing on aggregate magnitudes, Aastveit et al. (2017) neglect the firm-level effects of monetary policy. In fact, few studies have considered how the effectiveness of monetary policy may depend on the idiosyncrasy of firms, especially in times of economic turmoil.

We contribute to the literature in two ways. First, we shed light on the asymmetric effects of shifts in the policy rate on corporate investments in the presence of high uncertainty. These asymmetries stem from three firm-level characteristics: investment irreversibility, operational flexibility, and opportunity costs. Second, we bring together two important bodies of research which had thus far remained separate: one that focuses on the effects of monetary policy on real variables; and another that explores the asymmetric impact of uncertainty on firm-level investment. In particular, we investigate the moderating role of uncertainty in the relationship between monetary policy and corporate investments on a panel of U.S. firms over the period 2000–2019. In order to do so, the panel-VAR methodology introduced by Holtz-Eakin, Newey, and Rosen (1988) is employed.

Results show that uncertainty not only plays a moderating role in the relationship between monetary policy and investment, but that it also influences firm-level investment asymmetrically. We find that, in the presence of uncertainty, and in line with real options theory, firms with higher levels of investment irreversibility, operational inflexibility, and market power tend to be less responsive to changes in monetary policy. Similarly, firms with low cash flows and who operate in low-innovation sectors are less affected by expansionary monetary-policy shocks. This suggests that both the characteristics and composition of a country's business network play a moderating role in the relationship between investment under uncertainty and monetary policy.

The rest of the paper is structured as follows. Section 2 examines the theoretical relationship between monetary policy and investment under uncertainty. Section 3 develops an empirical model to study the impact of monetary policy on corporate investment in contexts of high and low uncertainty. Section 4 shows the results and robustness checks. Section 5 analyzes whether the influence of

[1] We follow Bernanke et al. (2005) and Boivin et al. (2010) and define monetary-policy shocks as shocks to the relevant monetary-policy rate that affect macroeconomic variables. In particular, we focus on expansionary shocks.

[2] For a comprehensive summary of monetary transmission mechanisms, see Boivin et al. (2010).

[3] Some significant contributions are those of Romer and Romer (1990), Bernanke and Blinder (1992), Bernanke and Gertler (1995), Bernanke, Gertler, and Gilchrist (1999), Bernanke, Reinhart, and Sack (2004), or Peek and Rosengren (2014), among others.

expansionary monetary-policy shocks on investment is asymmetric at the firm level. Finally, Section 6 concludes the paper.

2. Investment under uncertainty and monetary policy

According to the real options theory, an investment opportunity is similar to a financial call option: firms have the right (but not the obligation) to increase their capital stock at any moment in the future. The purchase of a capital asset is akin to exercising a call option insofar as it is irreversible: once an investment has been undertaken, the firm cannot fully recover the monetary value of the asset (Pindyck, 1991). The value of this option to invest is closely linked to uncertainty over the future cash flows the asset is expected to generate. Due to the irreversibility of most capital investments (Bertola, 1988; Pindyck, 1988), higher uncertainty over future economic conditions increases the value of waiting for new information, thereby providing an incentive for firms to delay their investment decisions. As a result, higher uncertainty discourages immediate capital investment, and increases the value of the option to invest in the future.

When we incorporate the real options theory to the neoclassical theory of investment, we find that a firm will invest as long as the marginal product of capital is higher than its user cost of capital plus the value of the option to invest (Bloom et al., 2007). Let $mpk = \frac{\alpha AK^{\alpha}L^{\beta}}{K}$ be the marginal product of capital under a Cobb-Douglas production function, and $r_u = r + u$ the uncertainty-adjusted user cost of capital, where r is the user cost of capital as defined by the neoclassical theory of investment, and u the value of the option to invest in the future, which increases with uncertainty.[4] A new investment will be undertaken if and only if $\frac{\alpha AK^{\alpha}L^{\beta}}{K} > r_u$ where r_u is higher than r when uncertainty spikes. An increase in uncertainty thus leads to an increase in firms' uncertainty-adjusted user cost of capital, raising the threshold that makes investment profitable. Therefore, for a given r, investment demand will be lower when the level of uncertainty about expected profits increases.[5]

We can thus derive the following logical corollary with respect to the effectiveness of monetary policy when uncertainty is high. In a traditional IS-LM framework, changes in the short-term policy rate tend to impact firms' investment decisions (Boivin, Kiley, & Mishkin, 2010). For instance, a decrease in the short-term policy rate reduces firms' user cost of capital, encouraging them to undertake new investments.[6] Given that $r_u = r + u$, a decrease in r resulting from a monetary-policy shock in a context of high uncertainty will only reduce r_u if $\frac{\partial r_u}{\partial r} > \frac{\partial r_u}{\partial u}$. Since the value of u increases with uncertainty, central-bank policies aimed at stimulating investment through firm's user cost of capital would fail to achieve their purpose, if the above condition were not to hold.[7] Accordingly, we state our first hypothesis[8]:

H1. Expansionary monetary-policy shocks will be less effective in expanding firm-level investment in contexts of high uncertainty.

3. Data and methodology

In order to test the impact of monetary policy on corporate investment and the moderating effect of uncertainty in this relationship, we use evidence from two different datasets, each of which contains annual data covering the period 2000–2019. First, we draw upon an unbalanced panel of all US publicly traded firms with a market cap of at least $100 million from the Eikon database developed by Thomson Reuters. This database covers all US companies filing with the Securities and Exchange Commission. Following Pindado, Requejo, and de la Torre (2011), we exclude from our sample financial firms and regulated utilities (Eikon industry groups 4300–4395 and 8200–8280). Second, we use a dataset of US macroeconomic variables from the Federal Reserve Bank of St. Louis.[9]

The methodology used is a reduced-form VAR that includes a cross-sectional dimension that is typical of panel data models. Panel VARs have been used to address numerous research questions in the areas of macroeconomics and finance due to their many advantages (Canova & Ciccarelli, 2013). First, panel VARs show the dynamic and static interdependencies among variables. Second, they can be used to measure the impact of an exogenous shock in one of the variables on the other variables. Third, the use of a panel VAR allows unobservable heterogeneities to be factored in at the micro level. Finally, variables are treated as endogenous in a panel VAR, although identifying restrictions may be introduced to analyze the influence of exogenous shocks on the model (Abrigo & Love, 2016). As a result, exogeneity assumptions are not a priori necessary to estimate the model.

In order to overcome any problems arising from the potential endogeneity of regressors, we resort to an instrumental variable

[4] For a Cobb-Douglas production function of the form $Y = AK^{\alpha}L^{\beta}$, the mpk is calculated as $\frac{\partial y}{\partial K} = \alpha AK^{\alpha-1}L^{\beta} = \frac{\alpha AK^{\alpha}L^{\beta}}{K}$. The user cost of capital would be defined as $P_k + P_k\,(i+\delta)$, where P_k is the price of a unit of capital, i is the real interest rate, and δ the depreciation rate.

[5] The negative relationship between investment and uncertainty tends to be stronger under high levels of uncertainty (Sarkar, 2000).

[6] Since businesses tend to draw upon long-term financing to acquire new capital assets, the relevant interest rate for firms would not be the short-term policy rate, but longer-term interest rates (Boivin et al., 2010). However, if the expectations hypothesis of the term structure holds true, the short-term policy rate should affect investment through the influence of short-term rates on the long end of the yield curve, which in turn reduces corporate bond spreads.

[7] The incremental value of the option to invest in the presence of uncertainty may also weaken the bank-lending channel since the incentive to delay new investments and wait for new information may impact the demand for credit, undermining monetary authorities' efforts to increase the supply of credit via increases in bank reserves.

[8] Further hypotheses related to the effects of firm heterogeneity on the effectiveness of monetary policy under uncertainty are stated in Section 5.

[9] There are two exceptions: the shadow interest rate and the Economic Policy Uncertainty (EPU) index, which have been retrieved from the Federal Reserve Bank of Atlanta and www.policyuncertainty.com, respectively.

method. Specifically, a difference GMM estimator is used to remove fixed effects (Arellano & Bond, 1991). This estimator uses the lagged values of the endogenous variables to address potential endogeneity issues that may lead to biased estimates. Furthermore, a GMM estimator is preferred when working with dynamic models that include lags as explanatory variables (Pindado et al., 2011). Fixed effects are eliminated using first differences, whereas endogeneity issues are addressed using all variables in levels lagged from $t-2$ to $t-4$ as instruments. Missing values of instruments are replaced with zeros to make estimated coefficients more efficient (Holtz-Eakin et al., 1988).

In particular, we propose the following reduced-form panel VAR model:

$$I_{i,t} = \sum_{j=1}^{p} \beta_j I_{i,t-j} + \sum_{j=1}^{p} \gamma_j Q_{i,t-j} + \sum_{j=1}^{p} \delta_j CF_{i,t-j} + \sum_{j=1}^{p} \theta_j MPR_{t-j} + \omega_i + \nu_{i,t} \tag{1}$$

where i denotes the firm, t denotes the year, and p the VAR lag order[10]; I represents investment; Q is Tobin's marginal q; CF is a cash-flow measure; MPR is a monetary-policy rate; ω is a vector of firm-specific effects; ν is the serially-uncorrelated error term; and β, γ, δ and θ are matrices of coefficients capturing the marginal effects of every lagged variable on investment.

Investment $(I_{i,t})$ is measured as capital expenditures in the year of the observation over beginning-of-year gross fixed assets (Carpenter & Guariglia, 2008). The lagged dependent variable $(I_{i,t-p})$ captures the dynamics of investment as well as the accelerator effect (Aivazian, Ge, & Qiu, 2005). We use the ratio of enterprise value in the year of observation to gross fixed assets to proxy for Tobin's q $(Q_{i,t})$ (Pindado et al., 2011). The potential existence of financial constraints is captured by cash flows $(CF_{i,t})$ (Fazzari, Hubbard, & Petersen, 1988) calculated as after-tax profits plus depreciation normalized by gross fixed assets at the beginning of the year (Carpenter & Guariglia, 2008). The fed funds rate (MPR_t) indicates the Federal Reserve's stance on monetary policy (Bernanke & Blinder, 1992). In order to identify periods of high and low uncertainty, we use a monthly economic policy uncertainty (EPU_t) index developed by Baker, Bloom, and Davis (2016), which is based on newspaper coverage frequency of terms reflecting economic uncertainty. Since our model is based upon annual data, we construct a yearly variable by taking the simple average of EPU index's monthly observations.[11] Table 1 shows descriptive statistics for these variables.

4. Results

4.1. Base model

We estimate a reduced-form, first-order panel VAR based on eq. (1) using the whole sample.[12] All variables are cointegrated at a 1% level.[13] The Granger causality test shows that the fed funds rate Granger-causes investment.[14] In order to test the responsiveness of investment to expansionary unexpected shocks on the fed funds rate, we use the Cholesky decomposition and estimate orthogonalized impulse-response functions. A short-run restriction is imposed so that investment reacts with a lag to monetary-policy shocks.[15] Fig. 1 illustrates how investment reacts to an orthogonalized one-standard-deviation expansionary shock on the fed funds rate.[16] The shock results in corporate investment increasing to a maximum of 11.24% after two years. After that, investment starts to decline, reaching its pre-shock level in around five years.

We now split our sample into two subsamples using the EPU index in order to grasp a better understanding of the moderating role of uncertainty. In order to do so, we define a dummy variable that takes the value 1 when the uncertainty variable is in the top quartile and we perform two separate estimations.[17] Fig. 2 displays the impact of an expansionary policy-rate shock on investment in contexts of low uncertainty (left) and high uncertainty (right).[18] [19] In line with **H1**, monetary policy seems to be less effective when uncertainty is high. A one-standard-deviation shock increases investment to a maximum of 11.33% under low uncertainty as opposed to 4.87% in contexts of high uncertainty. This suggests that transmission mechanisms are undermined when uncertainty rises.[20]

[10] Without loss of generality, we consider the same lag length p for all variables.

[11] Based on Baker et al. (2016), Husted, Rogers, and Sun (2019) have recently developed a novel monetary policy uncertainty index to capture uncertainty generated by Federal Reserve policy actions. However, we prefer the EPU index since it represents a broader measure of economic uncertainty.

[12] Lag selection is based on the adjusted coefficient of determination, as estimated in Abrigo and Love (2016). Adjusted coefficients of determination for different lag orders can be found in the Appendix, Table A.

[13] Panel-data cointegration tests based on Kao (1999) can be found in the Appendix, Table B.

[14] Results can be found in the Appendix, Table C.

[15] In econometrics literature, this is called the *recursiveness assumption* (Sims, 1980).

[16] The Tables corresponding to Fig. 1 can be found in the Appendix, Tables E and F.

[17] The choice of this threshold is based on the dynamic panel threshold methodology developed by Seo, Kim, and Kim (2019) and Seo and Shin (2016). The threshold estimated by the model coincides almost exactly with the 75th percentile of the EPU index. Results can be found in the Appendix, Table D. Dynamic panel threshold models have previously been applied to firm-level data (e.g., Dang, Kim, & Shin, 2012).

[18] The Tables corresponding to Fig. 2 can be found in the Appendix, Tables E and F.

[19] We thank an anonymous referee for the suggestion to use a dynamic panel threshold model for choosing the uncertainty threshold.

[20] Aastveit et al. (2017) obtain similar results using aggregate data.

Table 1
Summary statistics.

Variable	Mean	Median	St. dev.	Maximum	Minimum	Observations
$I_{i,t}$	.158	.0976	.2047	2.1278	.0014	29,867
$Q_{i,t}$	12.49	3.74	31.11	391.051	.2365	29,786
$CF_{i,t}$	-.749	0.1639	5.5435	4.96	−79.8	29,857
EPU_t	125.73	133.3	32.29	188.7	67.13	20
MPR_t	.0178	.0124	.0186	.0624	.0089	20

This table provides summary statistics for investment ($I_{i,t}$), Tobin's Q ($Q_{i,t}$), cash flows ($CF_{i,t}$), the EPU index (EPU_t), and the fed funds rate (MPR_t). For the first three variables, observations below the 1st percentile and above the 99th percentile have been removed. The sample comprises 3,856 U.S. publicly traded firms with a market cap of at least $100 million. Financials and utilities are excluded from the sample. The period covered goes from 2000 to 2019.

4.2. Robustness checks

In order to test the robustness of our results, we examine a number of alternative specifications.[21] We first use an alternative measure of monetary policy: the shadow policy rate (Wu & Xia, 2016). This variable reflects the overall stance of monetary policy at the zero lower bound (ZLB). When the fed funds rate is above 0.25%, the shadow policy rate broadly coincides with the fed funds rate. Below this threshold, the shadow policy rate can become negative. Fig. 3 compares the fed funds rate with the shadow policy rate over the period 2000 and 2019. In 2009, the shadow policy rate starts diverging from the fed funds rate, coinciding with the period where monetary authorities hit the ZLB. Orthogonalized impulse-response functions are displayed in Fig. 4.[22] Results barely differ from those in our baseline model: investment is more sensitive to monetary-policy shocks in contexts of low uncertainty when using the shadow policy rate.

We also analyze the use alternative measures of uncertainty by replacing the EPU index in the initial model. First, we follow Bekaert, Hoerova, and Lo Duca (2013) and Caggiano, Castelnuovo, and Pellegrino (2017) and use the VIX index.[23] Second, we use bond spreads as uncertainty proxies (Bachmann, Elstner, & Sims, 2013; Caldara, Fuentes-Albero, Gilchrist, & Zakrajšek, 2016; Gilchrist & Zakrajšek, 2012; Stock & Watson, 2012). In particular, two different bond spreads are employed: the corporate spread and the TED spread.[24] Based on these three uncertainty proxies, the sample is again divided into two subsamples using a dummy that takes the value 1 when the variable is in the top quartile (periods of high uncertainty) and 0 (periods of low uncertainty) otherwise. Impulse-response functions in Fig. 5 (where uncertainty is measured through the VIX index) and Fig. 6 (uncertainty is proxied using two spreads) are consistent with our initial estimates: a monetary-policy shock is less effective when uncertainty is high.[25] As shown in both figures, the difference in the impact of monetary policy on investment in contexts of high uncertainty is more pronounced when using the VIX index and spreads to measure uncertainty.

Table 2
Summary statistics.

Variable	Mean	Median	St. dev.	Maximum	Minimum
SR_t	.0124	.0108	.0234	.0628	-.0274
VIX_t	.1949	.1764	.06	.3179	. 1105
CS_t	.0262	.0275	.0062	.0404	.01689
TS_t	.00428	.0034	.0032	.0154	.0019

This table provides summary statistics for the shadow rate (SR_t), the VIX index (VIX_t), and the corporate (CS_t) and TED (TS_t) spreads. The period covered goes from 2000 to 2019. Data come from the Federal Reserve Bank of St. Louis except the shadow rate, which has been retrieved from the Federal Reserve Bank of Atlanta.

[21] Table 2 shows descriptive statistics for the variables used in the robustness checks.
[22] The Tables corresponding to Fig. 4 can be found in the Appendix, Tables G and H.
[23] Chicago Board Options Exchange Market Volatility Index. We build the yearly variable by averaging monthly data.
[24] The corporate spread variable is built using the spread of Moody's Baa corporate bond yield over the 10-Year Treasury bond yield. The TED spread is calculated as the difference between the 3-Month LIBOR based on US dollars and the 3-Month Treasury Bill. Both variables are built using monthly data and then taking the yearly average.
[25] The Tables corresponding to Figs. 5 and 6 can be found in the Appendix, Tables G and H.

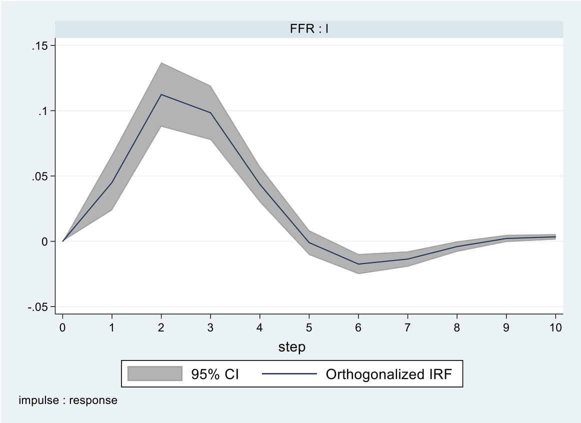

Fig. 1. Orthogonalized impulse-response function (*IRF*). Response of investment (*I*) to a one-standard-deviation expansionary shock on the fed funds rate (*FFR*) over ten periods. The shaded area represents a 95% confidence interval.

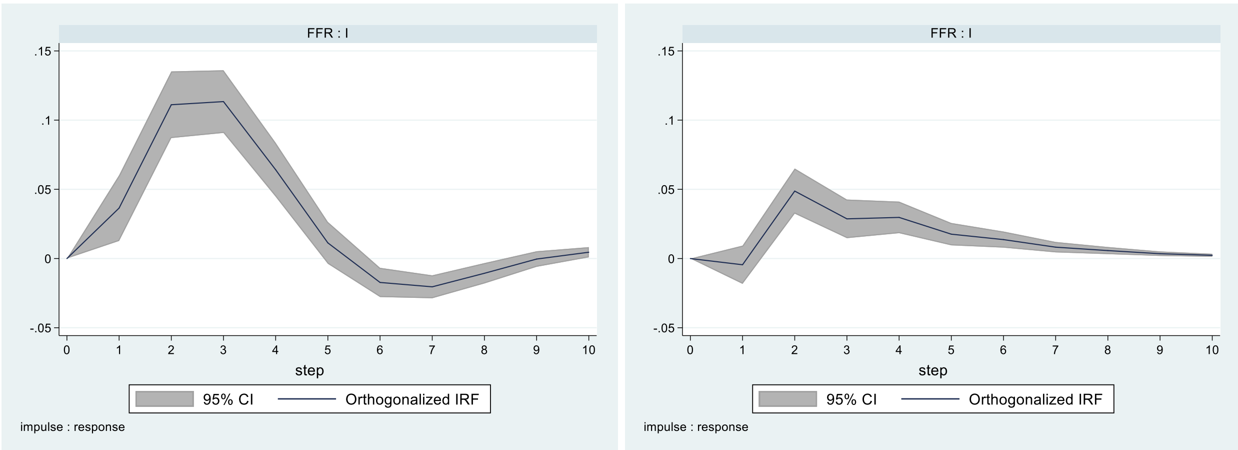

Fig. 2. Response of investment to a one-standard-deviation expansionary shock on the fed funds rate in periods of low (left) and high (right) uncertainty.

5. The influence of firm heterogeneity on the effectiveness of monetary policy under uncertainty

The impact of monetary-policy shifts on corporate investment may vary depending on a number of factors related to the idiosyncrasy of each firm. For instance, Gertler and Gilchrist (1994) show that the decline in investment of small firms after a monetary-policy shock is higher than that of large firms. Similarly, Givens and Reed (2018) find that the response of firms to anticipated monetary-policy variations is asymmetric depending on the industry to which these belong. In the presence of high uncertainty, asymmetries in the impact of monetary policy on corporate investment may emerge based on other subtler characteristics, which in turn affect the value of the option to invest.

Given that the condition for undertaking a new investment $\left(\frac{\alpha AK^{\alpha}L^{\beta}}{K} > r+u\right)$ depends on the value of the option to postpone the commitment (u), a decrease in the policy rate might not be expansionary enough to lower the threshold that makes investment profitable when u is high. As a result, a policy-rate cut is expected to have a lower impact on those firms with more valuable options to wait. According to the real options theory, the value of the option to wait depends on the trade-off between costs and benefits from immediate commitment (Estrada, De La Fuente, & Martín-Cruz, 2010; Folta & O'Brien, 2004; Kogut, 1991). The costs from immediate commitment increase in investment irreversibility (Bloom et al., 2007; Gulen & Ion, 2016), and decrease in operational flexibility (Grullon et al., 2012). Benefits from immediate commitment emerge in the form of cash flows and competitive advantages from preemption, which represent the opportunity cost of waiting (Folta & Miller, 2002; Smit & Ankum, 1993; Trigeorgis, 1991). Moreover, the higher the uncertainty, the higher the costs and the lower the benefits from immediate commitment. As a consequence, irreversibility, operational flexibility and opportunity costs may interact with uncertainty and thus make corporate investments less sensitive to monetary-policy shocks.

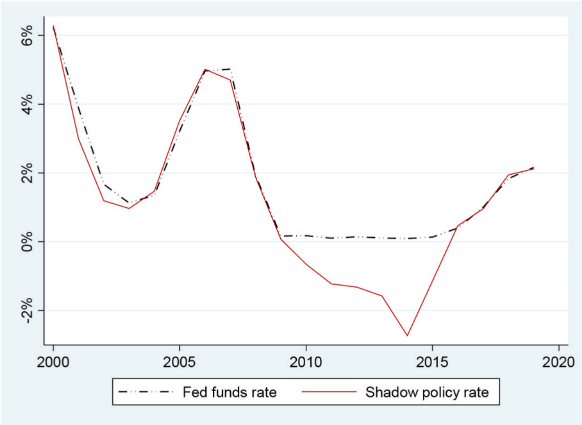

Fig. 3. Fed funds rate vs. Shadow policy rate (2000–2019).

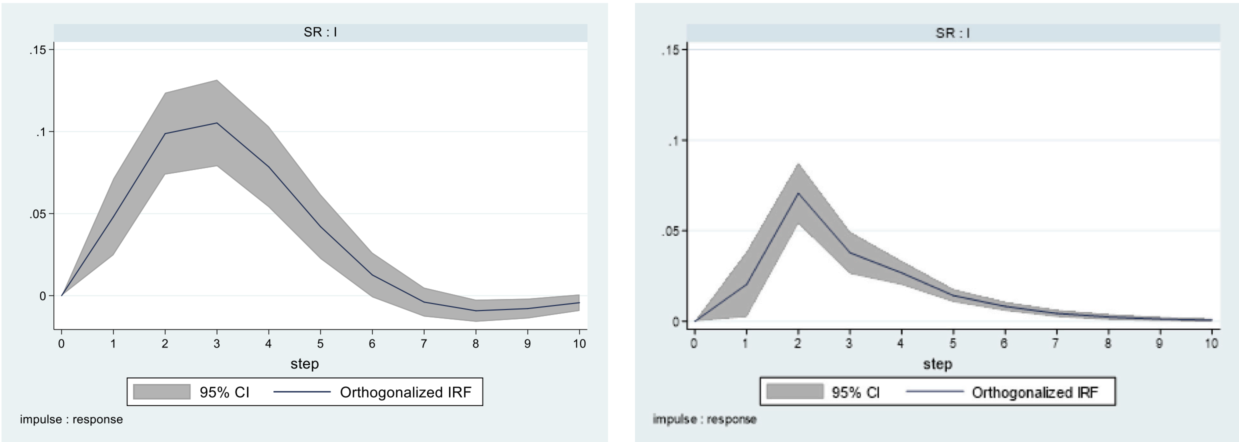

Fig. 4. Response of investment to a one-standard deviation expansionary shock on the shadow policy rate (*SPR*) in periods of low (left) and high uncertainty (right).

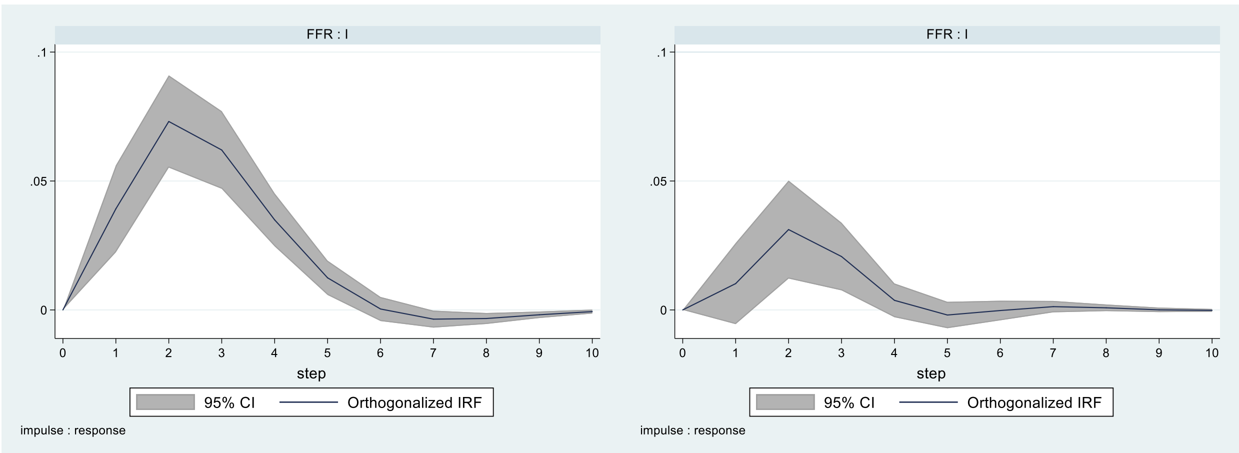

Fig. 5. Response of investment to a one-standard-deviation expansionary shock on the fed funds rate in periods of low (left) and high (right) uncertainty. The VIX index is used to measure uncertainty.

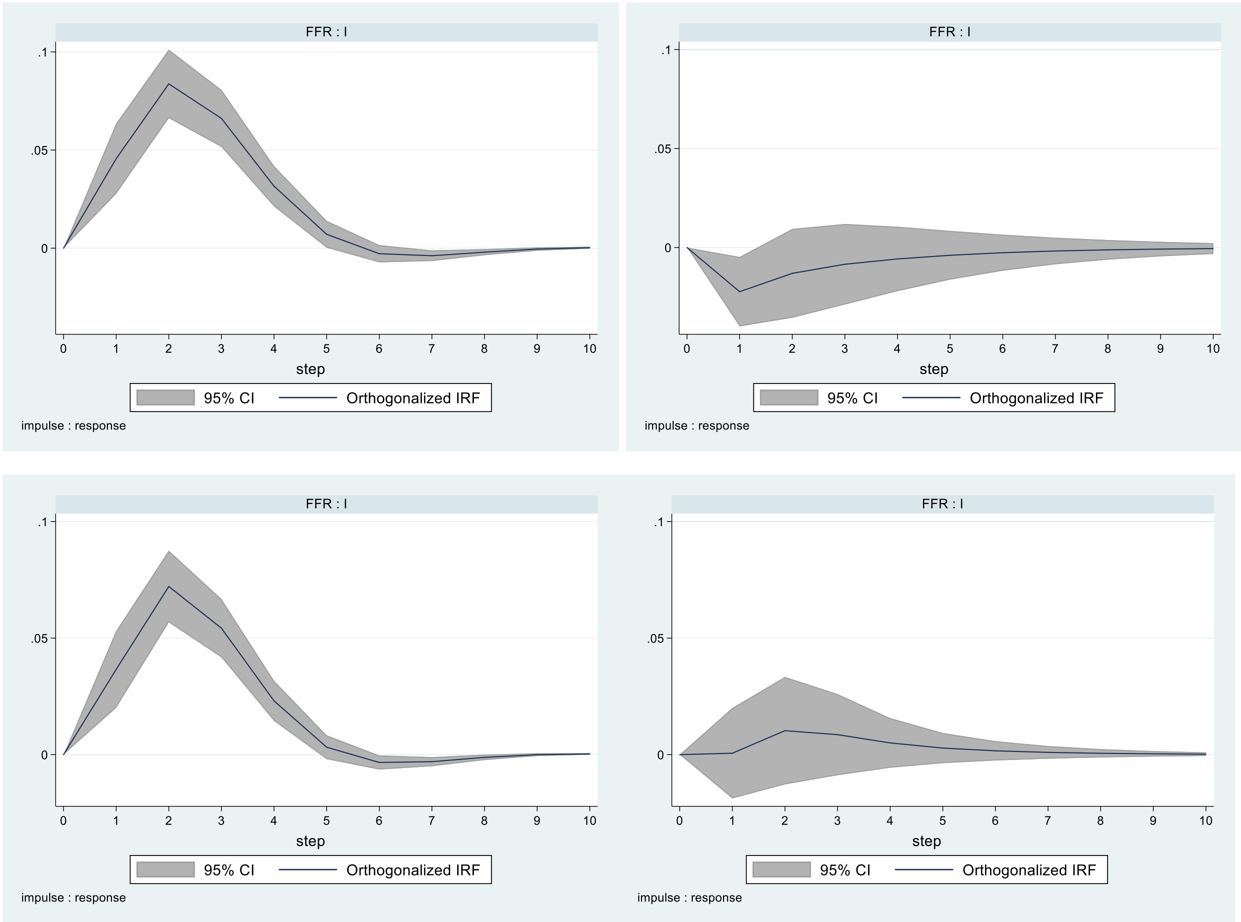

Fig. 6. Response of investment to a one-standard deviation expansionary shock on the fed funds rate in periods of low (left) and high (right) uncertainty. A corporate spread (first row) and the TED spread (second row) are used to measure uncertainty.

First, we consider the irreversible nature of most capital-good investments. An investment is economically irreversible when a firm lacks the opportunity to recoup the capital invested without incurring high costs (Bernanke, 1983). These recovering costs can arise from asset specificity, information imperfections, or market narrowness (Cooper, 2006). Irreversibility entails comparing the value of immediate commitment to the value of investing in the future (McDonald & Siegel, 1986). When uncertainty increases, capital-intensive firms are more likely to delay new projects, since irreversibility increases potential costs of unrecoverable immediate commitment above the present value of its uncertain benefits (Bloom et al., 2007; Gulen & Ion, 2016). As a result, the value of the option to wait will be higher for these firms, making them less sensitive to expansionary monetary-policy shocks. Accordingly, we state the following hypothesis:

H2. In contexts of high uncertainty, expansionary monetary-policy shocks will be less effective in stimulating investment of firms with high investment irreversibility.

Yet the potential costs from prompt investments do not only depend on irreversibility. Operational flexibility also plays an important role in a firm's ability to adapt to future adverse events. Operationally-inflexible firms tend to be more cautious when it comes to undertaking new investments (i.e., the value of the option to wait is higher), leading to a decline in investment demand in contexts of high uncertainty (Bontempi et al., 2009). As a consequence, investments undertaken by firms that have higher operational flexibility will be less sensitive to expansionary monetary-policy shocks aimed at fostering firm-level investment. This leads us to posit the following hypothesis:

H3. In contexts of high uncertainty, expansionary monetary-policy shocks will be less effective in stimulating investment of operationally inflexible firms.

Postponing investments may involve opportunity costs in the form of foregone cash flows, which can be defined as cash flows that the firm will not capture unless an investment is undertaken. In the same way as an American call option on a non-dividend-paying stock is optimally exercised at maturity, low-cash flow firms will postpone the exercise of their option to invest as long as possible in contexts of high uncertainty due to the low monetary opportunity cost of doing so. This will increase the value of the option to wait, making low-cash-flow firms less sensitive to monetary-policy shocks. Accordingly, we state the following hypothesis:

H4. In contexts of high uncertainty, expansionary monetary-policy shocks will be less effective in stimulating investment of firms with low foregone cash flows.

A second source of opportunity costs are diminished competitive advantages. Diminished competitive advantages may be the result of either preemption by rivals or the loss of the opportunity to preempt rivals (Folta & Miller, 2002). As long as investment opportunities are not proprietary, the result of exercising them may be influenced by rivals' anticipation. In fact, such a threat may accelerate the early exercise investment opportunities by firms trying to preserve their competitive advantages. And vice versa; when preemption risk is low, firms will be more prone to delaying new investments. Such competitive risks depend on both a firm's relative competitive position and its business innovation speed rate. Under high uncertainty, firms with high market power tend to be less vulnerable to preemptive actions by rivals (Bontempi et al., 2009; Caballero, 1991). Similarly, the probability of deferring the option to invest is closely linked to the innovation speed rate. Innovative firms usually operate in highly competitive sectors where the opportunity cost of deferring investments tends to be high. In contrast, the opportunity cost for low-innovation firms may be lower, leading them to invest less under high uncertainty. Consequently, we conjecture that the following hypotheses should hold:

H5. In contexts of high uncertainty, expansionary monetary-policy shocks will be less effective in stimulating investment of firms with high market power.

H6. In contexts of high uncertainty, expansionary monetary-policy shocks will be less effective in stimulating investment of firms operating in low-innovation sectors.

In order to test the moderating role of investment irreversibility, operational inflexibility, foregone cash flows, market power and innovation speed in the relationship between monetary policy and investment, we successively split the sample using proxies for each of the above variables.[26] Based on equation (1), and using the EPU index to measure uncertainty, orthogonalized impulse-response functions are estimated.

Following Gulen and Ion (2016), we use the capital intensity ratio of firms, measured as property, plant and equipment over total assets (*PPE*) to measure investment irreversibility. The rationale behind this choice is closely linked to two typical characteristics of capital-intensive firms: the high cost of new capital investments and the difficulties involved in disposing of or reusing the machinery in a different line of business should the investment project not go as planned. Operational flexibility is measured using fixed costs over sales (*FC*).[27] A firm that cannot adjust its workforce when needed without incurring significant costs can be said to lack *operational flexibility* (Grullon et al., 2012). Unrealized cash flows (i.e., cash flows from unrealized investments) are measured as operating cash flow over total assets (*OPCF*). We use the price-cost margin of firms (*PCM*) to quantify market power as it tends to be higher for firms with more monopoly power (Bontempi et al., 2009; Domowitz, Hubbard, & Petersen, 1986).[28] Finally, the innovation rate of firms is measured using R&D spending normalized by beginning-of-the-year total assets (*RD*). Table 3 displays descriptive statistics for the above variables.

Table 3
Summary statistics.

Variable	Mean	Median	St. dev.	Maximum	Minimum	Observations
$PPE_{i,t}$	.231	.1659	.1997	.7998	.01038	31,875
$FC_{i,t}$	.3404	.239	.3443	2.67	.0393	30,239
$OPCF_{i,t}$	.0592	.0821	.1218	.2439	-.4814	31,826
$PCM_{i,t}$	.4899	.4398	.2449	1	.1094	29,236
$RD_{i,t}$	.0854	.0328	.1202	.5918	0	19,308

This table provides summary statistics for property, plant, and equipment ($PPE_{i,t}$), fixed costs ($FC_{i,t}$), operating cash flows ($OPCF_{i,t}$), price-cost margin ($PCM_{i,t}$), and R&D spending ($RD_{i,t}$). Observations below the 5th percentile and above the 95th percentile have been removed. The sample comprises 3,856 U.S. publicly traded firms with a market cap of at least $100 million. Financials and utilities are excluded from the sample. The period covered goes from 2000 to 2019. Data come from Eikon Reuters.

[26] The dummies used to split the samples take the value 1 when the variable is above the sample median and 0 otherwise. In the case of market power, the dummy takes the value 1 when the variable is above the industry median.

[27] Fixed costs are proxied using the accounting entry "Selling, Administrative and General Expenses."

[28] The price-cost margin is calculated as $\frac{Sales + \Delta\ Inventory - Cost\ of\ goods\ sold}{Sales}$.

5.1. Results

Figs. 7–11 display the effect of a one-standard-deviation expansionary monetary-policy shock on firm-level investment.[29] In all figures, left (right) panels show the effect on the subsample where the value of the option to wait is assumed to be lower (higher) and, therefore, the impact of monetary policy should be higher (lower). Consistent with the stated hypotheses, only the effects under higher uncertainty are analyzed.

Fig. 7 shows the effect of monetary policy on investments for firms with low (left) and high (right) irreversibility. Monetary policy seems to be less effective when irreversibility is high. This result appears to provide support for **H2**: the irreversibility effect increases the value of the option to invest, pushing capital intensive firms to postpone their investments in contexts of high uncertainty. In Fig. 8, the impact of an expansionary monetary-policy shock on investment is shown for firms with low (left) and high (right) operational flexibility. Operational inflexibility makes firms less responsive to monetary-policy shocks as the value of the option to invest increases under uncertainty, encouraging businesses to postpone their investment decisions. Yet the difference is barely noticeable, providing limited support for **H3**.

Fig. 9 presents the effects of monetary policy on investment for firms with high and low cash flows (respectively, in the left and right

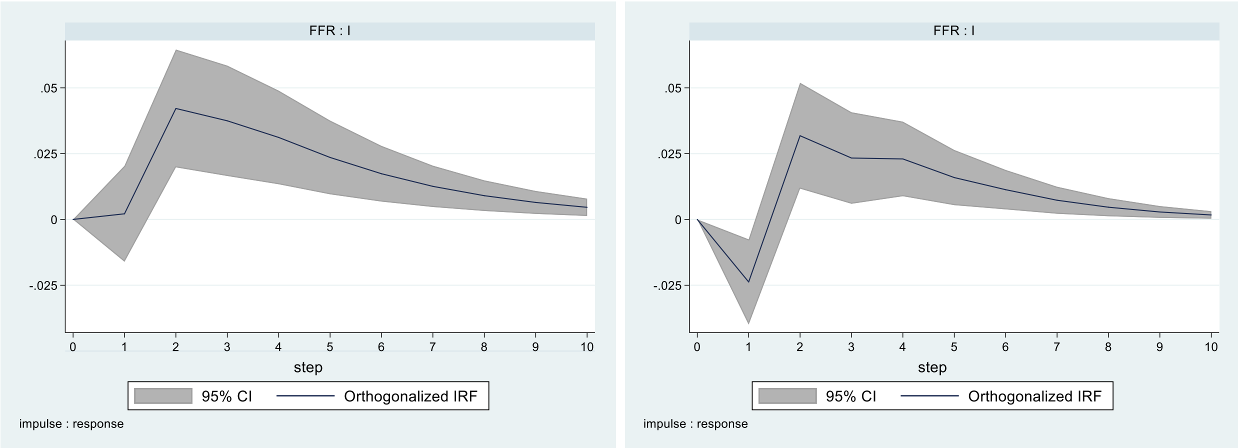

Fig. 7. Response of investment to a one-standard deviation expansionary shock on the fed funds rate in periods of high uncertainty for firms with low (left) and high (right) investment irreversibility.

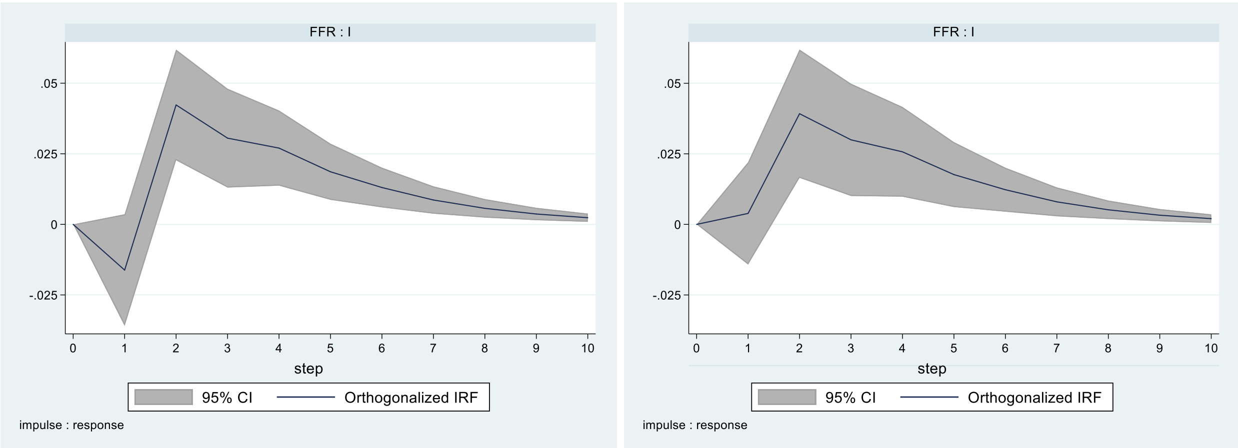

Fig. 8. Response of investment to a one-standard deviation expansionary shock on the fed funds rate in periods of high uncertainty for firms with low (left) and high (right) operational flexibility.

[29] The Tables corresponding to Figs. 7–11 can be found in the Appendix, Tables I and J.

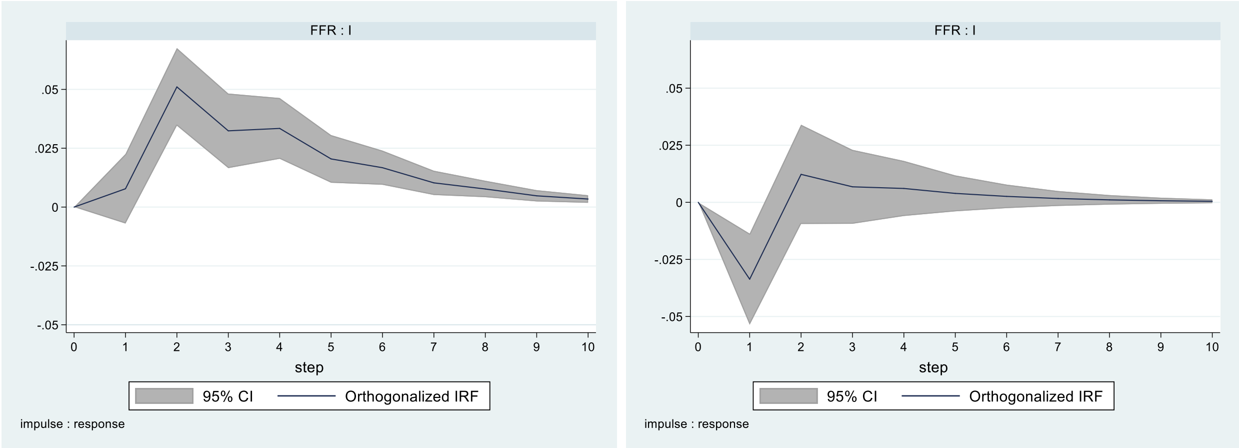

Fig. 9. Response of investment to a one-standard deviation expansionary shock on the fed funds rate in periods of high uncertainty for firms with high (left) and low (right) cash flows.

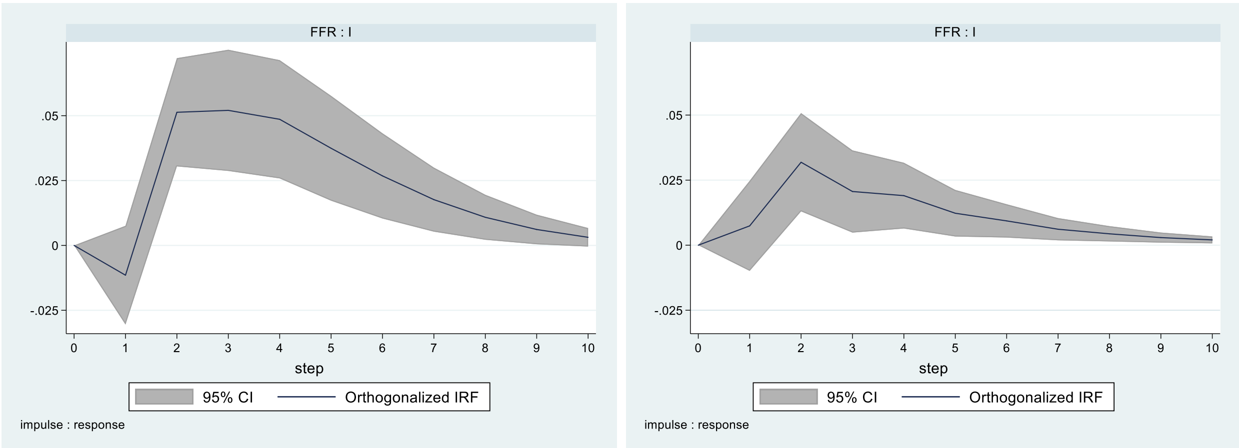

Fig. 10. Response of investment to a one-standard deviation expansionary shock on the fed funds rate in periods of high uncertainty for firms with low (left) and high (right) market power.

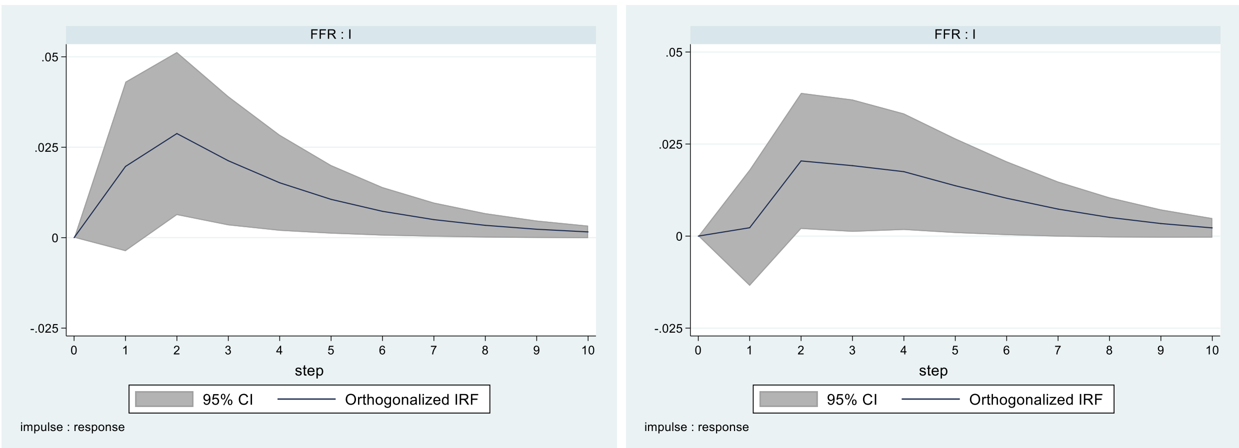

Fig. 11. Response of investment to a one-standard deviation expansionary shock on the fed funds rate in periods of high uncertainty for firms with high (left) and low (right) innovation rates.

graphs). Consistent with H4, the investment of firms with low cash flows is more responsive to expansionary monetary-policy shocks. This indicates that, when uncertainty is high, the value of the option to invest increases more for firms with low cash-flow-related opportunity costs, weakening the link between monetary policy and investment for these firms. Fig. 10 displays the impact of an expansionary monetary-policy shock on investment in firms with low (right) and high (left) market power. In line with H5, the transmission mechanisms of monetary policy are undermined for firms with substantial market power when uncertainty is high. Finally, as shown in Fig. 11, the investment of low-innovation firms (right graph) is affected less by shifts in monetary policy than high-innovation firms (left graph), thus confirming **H6.**

6. Conclusions

In this paper, we explore the effectiveness of monetary policy on corporate investment in the presence of high uncertainty. By means of a panel of US firms, we find that the transmission mechanisms affecting investment are weakened when uncertainty increases. Results are robust to using different measures of uncertainty and monetary-policy rates. At the firm level, and consistent with the real options theory, our results suggest that firms with high levels of investment irreversibility, operational inflexibility, and market power tend to be less responsive to monetary-policy shocks. Similarly, firms with low innovation rates and low foregone cash flows are less affected by monetary-policy shocks.

Several policy implications can be drawn from our findings. First, given the importance of uncertainty to economic activity, political authorities should commit themselves to maintaining political stability and undertaking predictable economic policies in order to prevent uncertainty from rising, particularly in moments of economic turmoil. Second, central banks should focus their efforts on reducing uncertainty, as the transmission mechanisms of monetary policy become less effective in high uncertainty contexts. In this sense, expectation-based mechanisms, such as forward guidance, can be useful tools in anchoring economic agents' expectations, thereby reducing uncertainty and helping the economy to recover after a crisis. Finally, the asymmetric effects of monetary policy when uncertainty is high should lead monetary authorities to factor in the firm-level impact of monetary policy in order to enhance its effectiveness in times of economic distress. For instance, central banks could limit their corporate bond purchasing programs to those sectors and subsectors that are more likely to be affected by changes in monetary policy.

Author statement

The three authors have contributed equally to this paper.

Declaration of competing interest

None.

Acknowledgements

This work is supported by the Spanish Ministry of Economy and Competitiveness and the Regional Government of Castilla y Leon under research projects ECO 2017-84864-P and SA049G19, respectively. Luis P. de la Horra has benefited from a Ph.D. fellowship funded by the European Social Fund and the Regional Government of Castilla y Leon. We are also grateful to Prof. Eliza Wu, associate editor at IREF, to the anonymous referees, and to Profs. Carlos Borondo and George Karras for their helpful comments.

Appendix

Table A
Lag selection

Lags	Adjusted coefficient of determination
1	.9882
2	.9630
3	.9353

Adjusted coefficients of determination for models with 1, 2, and 3 lags.

Table B
Panel-data cointegration tests

Modified Dickey-Fuller *t*	Dickey-Fuller *t*	Augmented Dickey-Fuller *t*	Unadjusted modified Dickey-Fuller *t*	Unadjusted Dickey-Fuller *t*
−30.78***	−33.037***	−14.875***	−39.162***	−36.462***

Cointegration tests based on Kao (1999). *** indicates statistical significance at a 1% level. Results of the five tests suggest that variables are cointegrated.

Table C
Granger Causality Test

	$Q_{i,t}$	$CF_{i,t}$	MPR_t	All
χ^2 *test*	340.556***	0.791	17.958***	343.679***
Degrees of freedom	1	1	1	3

Investment ($I_{i,t}$) serves as the dependent variable. *** indicates statistical significance at a 1% level, respectively.

Table D
Dynamic Panel Threshold Model

	Lower regime		**Upper regime**
$I_{i,t-1}$	-.2578***		.0226***
	(.0038)		(.0077)
$Q_{i,t-1}$	.3480***		-.0043
	(.0085)		(.0145)
$CF_{i,t-1}$	.0858***		.0504***
	(.0048)		(.0093)
MPR_{t-1}	.0379***		-.1108***
	(.0023)		(.0105)
Threshold (EPU index)		**149.271*****	
		(1.2639)	
Linearity (p-value)		0.00	

Investment ($I_{i,t}$) serves as the dependent variable. *** indicate statistical significance at a 1% level. Estimations are performed using a first-difference GMM estimator. All variables in levels lagged from t-2 to t-4 are used as instruments except the fourth lag of the dependent variable. The estimated threshold coincides almost exactly with the 75th percentile of the EPU index.

Table E
Panel VAR Estimations

	Fig. 1	Fig. 2	Fig. 3
	All the sample	Low uncertainty	High uncertainty
$I_{i,t-1}$	.2291***	0.2266***	.2511***
	(.0247)	(.0284)	(.0423)
$Q_{i,t-1}$	.8407***	.6543***	1.021***
	(.0456)	(.0438)	(.0895)
$CF_{i,t-1}$	.015	.0009	.0554**
	(.0168)	(.0203)	(.0282)
MPR_{t-1}	-.0255***	-.0188***	.0107
	(.006)	(.0061)	(.0169)

Investment ($I_{i,t}$) serves as the dependent variable. All variables enter the model in logarithmic form except for the monetary-policy variable. The three models meet the stability condition. *, **, and *** indicate statistical significance at 10, 5, and 1%, respectively. Standard errors are in parentheses.

Table F
Impulse-response functions

	Fig. 1	Fig. 2	Fig. 2
Periods	All sample	Low uncertainty	High uncertainty
0	0	0	0
1	.045	.0364	-.0045
2	.1124	.1111	.0487
3	.0984	.1133	.0287
4	.0436	.0641	.0297
5	-.001	.011	.0176
6	-.0174	-.0173	.0137
7	-.0136	-.0204	.0082
8	-.004	-.0107	.0056

(*continued on next page*)

Table F (*continued*)

Periods	Fig. 1 All sample	Fig. 2 Low uncertainty	Fig. 2 High uncertainty
9	.0022	0	.0035
10	.0034	.0045	.0023

Response of investment to a one-standard-deviation shock on the fed funds rate for all the sample (Fig. 1) and in contexts of low (Fig. 2, left) and high (Fig. 2, right) uncertainty.

Table G
Panel VAR estimations

	Fig. 4: **Shadow rate**		Fig. 5: **VIX index**		Fig. 6: **Corporate spread**		Fig. 6: **TED spread**	
	Low uncertainty	High uncertainty	Low uncertainty	High uncertainty	Low uncertainty	High uncertainty	Low uncertainty	High uncertainty
$I_{i,t-1}$	.2659***	.1811***	.2529***	.2259***	.2517***	.295***	.2591***	.2089***
	(.0305)	(.0406)	(.0284)	(.0547)	(.0268)	(.0485)	(.0271)	(.0498)
$Q_{i,t-1}$	.6118***	.8873***	.7337***	.8438***	.747***	.4492***	.6805***	.07114***
	(.0518)	(.0955)	(.0579)	(.0805)	(.0521)	(.1274)	(0.545)	(.0674)
$CF_{i,t-1}$	.0069	.1415***	.0361**	.0288	.034*	.0439	.0154	.0751*
	(.0238)	(.0263)	(.0171)	(.0583)	(.0174)	(.0348)	(.0176)	(.0422)
MPR_{t-1}	-.0255*** (.0064)	-.0293 (.0123)	-.0281*** (.00641)	-.0151 (.0116)	-.0308*** (.006)	.0471** (.0187)	.0345*** (.0079)	-.0004 (.0077)

Investment ($I_{i,t}$) serves as the dependent variable. All variables enter the model in logarithmic form except for the monetary-policy variable. All models meet the stability condition. *, **, and *** indicate statistical significance at 10, 5, and 1%, respectively. Standard errors are in parentheses.

Table H
Impulse-response functions

Periods	Fig. 4: Shadow rate		Fig. 5: VIX index		Fig. 6: Corporate spread		Fig. 6: TED spread	
	Low uncertainty	High uncertainty	Low uncertainty	High uncertainty	Low uncertainty	High uncertainty	Low uncertainty	High uncertainty
0	0	0	0	0	0	0	0	0
1	.0481	.0204	.0392	.0102	.0456	-.0223	.0366	.0006
2	.0988	.0707	.0731	.0312	.0837	-.013	.0722	.0103
3	.1053	.0378	.062	.0207	.0661	-.0084	.0543	.0086
4	.785	.0267	.0349	.0037	.0316	-.0058	.0231	.005
5	.0421	.0142	.0125	-.002	.0071	-.0039	.0032	.0028
6	.0126	.0082	.0004	-.0002	-.0028	-.0026	-.0034	.0016
7	-.0039	.0043	-.0036	.0013	-.0038	-.0018	-.003	.001
8	-.0092	.0024	-.0036	.0008	-.002	-.0012	-.0012	.0005
9	-.0079	.0012	-.0019	0	-.0004	-.0008	0	.0004
10	-.0042	.0007	-.0007	-.0002	-.0002	-.0005	.0003	.0002

Response of investment to a one-standard-deviation shock on the shadow rate (Fig. 4) and the fed funds rate (Figs. 5-6) using different proxies for uncertainty.

Table I
Panel VAR estimations

	Fig. 7		Fig. 8		Fig. 9		Fig. 10		Fig. 11	
	Low irreversibility	High irreversibility	Low flexibility	High flexibility	High cash flows	Low cash lows	Low market power	High market power	High innovation	Low innovation
$I_{i,t-1}$	.0863***	.3674***	.2664***	.1843***	.2051***	.2857***	.408***	.1934***	.0983	.3582***
	(.0613)	(.0547)	(.0541)	(-.0626)	(.0504)	(.0714)	(.0604)	(.0575)	(.0821)	(.0665)
$Q_{i,t-1}$	.07534***	1.2031***	1.2366***	.7719***	1.055***	1.011***	1.1318***	.7845***	.6963***	.9158***
	(.1292)	(.1118)	(0.1176)	(.1371)	(.098)	(.1517)	(.1489)	(.1038)	(.1673)	(.1244)
$CF_{i,t-1}$	-.0119	-.03	.051	.0211	.122***	-.0191	.0728*	.0949**	.0165	.0516
	(.0394)	(.038)	(.0367)	(.0457)	(.0396)	(.0372)	(.0402)	(.0387)	(.0469)	(.0471)
MPR_{t-1}	-.0057	-.0571**	.0415*	.0099	-.0209	.0947***	.0296	-.0194	-.0534*	.0071
	(.0242)	(.0225)	(.0247)	(.0236)	(.0197)	(.0306)	(.0259)	(.0228)	(.0317)	(.0071)

Investment ($I_{i,t}$) serves as the dependent variable. All variables enter the model in logarithmic form except for the monetary-policy variable. All models meet the stability condition. *, **, and *** indicate statistical significance at 10, 5, and 1%, respectively. Standard errors are in parentheses. All estimations are performed in contexts of high uncertainty.

Table J
Impulse-response functions

	Fig. 7		Fig. 8		Fig. 9		Fig. 10		Fig. 11	
Period	Low irreversibility	High irreversibility	Low flexibility	High flexibility	High cash flows	Low cash lows	Low market power	High market power	High innovation	Low innovation
0	0	0	0	0	0	0	0	0	0	0
1	.0021	-.0238	-.0162	.0039	.0079	-.0337	-.0115	.0074	.0197	.0023
2	.0422	.0318	.0423	.0392	.0511	.0122	.0513	.0319	.0288	.0204
3	.0375	.0233	.0305	.03	.0324	.0068	.0521	.0206	.0213	.0191
4	.0312	.023	.0270	.0257	.0334	.0061	.0486	.019	.0152	.0175
5	.0236	.0159	.0186	.0176	.0205	.0039	.0374	.0123	.0106	.0137
6	.0174	.0113	.013	.0123	.0167	.0026	.0268	.0093	.0073	.0103
7	.0126	.0073	.0086	.008	.0103	.0017	.0176	.0061	.005	.0073
8	.009	.0046	.0057	.0052	.0077	.0011	.0108	.0043	.0034	.0051
9	.0065	.0028	.0037	.0033	.0049	.0007	.0061	.0029	.0023	.0034
10	.0046	.0017	.0024	.002	.0034	.0004	.0031	.002	.0016	.0022

Response of investment to a one-standard-deviation shock on the fed funds rate for firms with low and high investment irreversibility (Fig. 3), operational flexibility (Fig. 4), cash flows (Fig. 5), market power (Fig. 6), and innovation (Fig. 7). All estimations are performed in contexts of high uncertainty.

References

Aastveit, K. A., Natvik, G. J., & Sola, S. (2017). Economic uncertainty and the influence of monetary policy. *Journal of International Money and Finance, 76*, 50–67. https://doi.org/10.1016/j.jimonfin.2017.05.003.

Abrigo, M. R. M., & Love, I. (2016). Estimation of panel vector autoregression in Stata. *Stata Journal, 16*(3), 778–804. https://doi.org/10.1177/1536867x1601600314.

Aivazian, V. A., Ge, Y., & Qiu, J. (2005). Debt maturity structure and firm investment. *Financial Management, 34*(4), 107–119. https://doi.org/10.1111/j.1755-053X.2005.tb00120.x.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies, 58*(2), 277–297. https://doi.org/10.2307/2297968.

Bachmann, R., Elstner, S., & Sims, E. R. (2013). Uncertainty and economic activity: Evidence from business survey data. *American Economic Journal: Macroeconomics, 5*(2), 217–249. https://doi.org/10.1257/mac.5.2.217.

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *Quarterly Journal of Economics, 131*(4), 1593–1636. https://doi.org/10.1093/qje/qjw024.

Bekaert, G., Hoerova, M., & Lo Duca, M. (2013). Risk, uncertainty and monetary policy. *Journal of Monetary Economics, 60*(7), 771–788. https://doi.org/10.1016/J.JMONECO.2013.06.003.

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *Quarterly Journal of Economics, 98*(1), 85–106. https://doi.org/10.2307/1885568.

Bernanke, B. S., & Blinder, A. S. (1992). The federal funds rate and the channels of monetary transmission. *The American Economic Review, 82*(4), 901–921. Retrieved from file:, ///C:/Users/su/Desktop/2117350.pdf.

Bernanke, B. S., & Gertler, M. (1995). Inside the black Box : The credit channel of monetary policy transmission. *The Journal of Economic Perspectives, 9*(4), 27–48.

Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of Macroeconomics, 1*, 1341–1393. https://doi.org/10.1016/S1574-0048(99)10034-X.

Bernanke, B. S., Reinhart, V. R., & Sack, B. P. (2004). Monetary policy alternatives at the zero bound: An empirical assessment. *Brookings Papers on Economic Activity, 2*, 1–100. Retrieved from https://www.brookings.edu/wp-content/uploads/2004/06/2004b_bpea_bernanke.pdf.

Bertola, G. (1988). *Adjustment costs and dynamic factor demands: Investment and employment under uncertainty*. Massachusetts Institute of Technology. Retrieved from https://www.worldcat.org/title/adjustment-costs-and-dynamic-factor-demands-investment-and-employment-under-uncertainty/oclc/45764051.

Bloom, N., Bond, S., & Van Reenen, J. (2007). Uncertainty and investment dynamics. *The Review of Economic Studies, 74*(2), 391–415. https://doi.org/10.1111/j.1467-937X.2007.00426.x.

Boivin, J., Kiley, M. T., & Mishkin, F. S. (2010). How has the monetary transmission mechanism evolved over time? *Handbook of Monetary Economics, 3*, 369–422. https://doi.org/10.1016/B978-0-444-53238-1.00008-9.

Bontempi, M. E., Golinelli, R., & Parigi, G. (2009). Why demand uncertainty curbs investment: Evidence from a panel of Italian manufacturing firms q. *Journal of Macroeconomics, 32*, 218–238. https://doi.org/10.1016/j.jmacro.2009.03.004.

Caballero, R. J. (1991). On the sign of the investment-uncertainty relationship. *The American Economic Review, 81*(1), 279–288. Retrieved from https://www.jstor.org/stable/pdf/2006800.pdf?refreqid=excelsior%3Ab1c3b1b51359c9614188b211bbaad19a.

Caggiano, G., Castelnuovo, E., & Groshenny, N. (2014). Uncertainty shocks and unemployment dynamics in U.S. recessions. *Journal of Monetary Economics, 67*, 78–92. https://doi.org/10.1016/J.JMONECO.2014.07.006.

Caggiano, G., Castelnuovo, E., & Pellegrino, G. (2017). Estimating the real effects of uncertainty shocks at the Zero Lower Bound. *European Economic Review, 100*(Nov. 2017), 257–272. https://doi.org/10.1016/j.euroecorev.2017.08.008.

Caldara, D., Fuentes-Albero, C., Gilchrist, S., & Zakrajšek, E. (2016). The macroeconomic impact of financial and uncertainty shocks. *European Economic Review, 88*, 185–207. https://doi.org/10.1016/j.euroecorev.2016.02.020.

Canova, F., & Ciccarelli, M. (2013). *Panel vector autoregressive models: A survey* (ECB working paper series, 1507).

Carpenter, R. E., & Guariglia, A. (2008). Cash flow, investment, and investment opportunities: New tests using UK panel data. *Journal of Banking & Finance, 32*(9), 1894–1906. https://doi.org/10.1016/j.jbankfin.2007.12.014.

Cooper, I. (2006). Asset pricing implications of nonconvex adjustment costs and irreversibility of investment. *The Journal of Finance, 61*(1), 139–170. https://doi.org/10.1111/j.1540-6261.2006.00832.x.

Dang, V. A., Kim, M., & Shin, Y. (2012). Asymmetric capital structure adjustments: New evidence from dynamic panel threshold models. *Journal of Empirical Finance, 19*(4), 465–482. https://doi.org/10.1016/j.jempfin.2012.04.004.

Domowitz, I., Hubbard, R. G., & Petersen, B. C. (1986). Business cycles and the relationship between concentration and price-cost margins. *The RAND Journal of Economics, 17*(1), 1–17. https://doi.org/10.2307/2555624.

Estrada, I., De La Fuente, G., & Martín-Cruz, N. (2010). Technological joint venture formation under the real options approach. *Research Policy, 39*(9), 1185–1197. https://doi.org/10.1016/j.respol.2010.05.015.
Fazzari, S. M., Hubbard, R. G., & Petersen, B. C. (1988). Financing constraints and corporate investment. *Brookings Papers on Economic Activity, 1*, 141–195. https://doi.org/10.2307/2534426.
Foley-Fisher, N., Ramcharan, R., & Yu, E. (2016). The impact of unconventional monetary policy on firm financing constraints: Evidence from the maturity extension program. *Journal of Financial Economics, 122*(2), 409–429. https://doi.org/10.1016/j.jfineco.2016.07.002.
Folta, T. B., & Miller, K. D. (2002). Real options in equity partnerships. *Strategic Management Journal, 23*(1), 77–88. https://doi.org/10.1002/smj.209.
Folta, T. B., & O'Brien, J. P. (2004). Entry in the presence of dueling options. *Strategic Management Journal, 25*(2), 121–138. https://doi.org/10.1002/smj.368.
Friedman, M., & Schwartz, A. J. (1971). *A Monetary history of the United States, 1867-1960*. Princeton University Press. Retrieved from https://press.princeton.edu/titles/746.html.
Gavin, W. T., Keen, B. D., Richter, A. W., & Throckmorton, N. A. (2013). *The limitations of forward guidance*. St. Louis Working Paper Series: Federal Reserve Bank of.
Gertler, M., & Gilchrist, S. (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *Quarterly Journal of Economics, 109*(2), 309–340. Retrieved from http://www.uh.edu/~bsorense/Gertler&Gilchrist.MP business cycles and behavior of small manufactoring firms.pdf.
Gilchrist, S., & Zakrajšek, E. (2012). Credit spreads and business cycle fluctuations. *The American Economic Review, 102*(4), 1692–1720. https://doi.org/10.1257/aer.102.4.1692.
Givens, G. E., & Reed, R. R. (2018). Monetary policy and investment dynamics: Evidence from disaggregate data. *Journal of Money, Credit, and Banking, 50*(8), 1851–1878. https://doi.org/10.1111/jmcb.12519.
Grullon, G., Lyandres, E., & Zhdanov, A. (2012). Real options, volatility, and stock returns. *The Journal of Finance, 67*(4), 1499–1537. https://doi.org/10.1111/j.1540-6261.2012.01754.x.
Guiso, L., & Parigi, G. (1999). Investment and demand uncertainty. *Quarterly Journal of Economics, 114*(1), 185–227. https://doi.org/10.1162/003355399555981.
Gulen, H., & Ion, M. (2016). Policy uncertainty and corporate investment. *Review of Financial Studies, 29*(3), 523–564. https://doi.org/10.1093/rfs/hhv050.
Hagedorn, M., Luo, J., Manovskii, I., & Mitman, K. (2019). Forward guidance. *Journal of Monetary Economics, 102*, 1–23. https://doi.org/10.1016/j.jmoneco.2019.01.014.
Hendrickson, J. R. (2017). *Interest rates, policy uncertainty, and investment (AIER sound money project No. 2017–13)*. SSRN Electronic Journaln. https://doi.org/10.2139/ssrn.2620408.
Holtz-Eakin, D., Newey, W., & Rosen, H. S. (1988). Estimating vector autoregressions with panel data. *Econometrica, 56*(6), 1371–1395. https://doi.org/10.2307/1913103.
Husted, L., Rogers, J., & Sun, B. (2019). Monetary policy uncertainty. *Journal of Monetary Economics*. https://doi.org/10.1016/j.jmoneco.2019.07.009.
Kang, W., Lee, K., & Ratti, R. A. (2014). Economic policy uncertainty and firm-level investment. *Journal of Macroeconomics, 39*(PA), 42–53. https://doi.org/10.1016/j.jmacro.2013.10.006.
Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of Econometrics, 90*(1), 1–44. https://doi.org/10.1016/S0304-4076(98)00023-2.
Katagiri, M. (2016). *Forward Guidance as a monetary policy rule (No. 16- E-6)*. Bank of Japan Working Paper Series.
Keynes, J. M. (1973). *The collected writings of John Maynard Keynes. Volume VII, the general theory of employment, interest and money*. London: Macmillan. Keynes, J. M. (1973).
Kogut, B. (1991). Joint ventures and the option to expand and acquire. *Management Science, 37*, 19–33. https://doi.org/10.1287/mnsc.37.1.19.
Krishnamurthy, A., & Vissing-Jorgensen, A. (2011). The Effects of quantitative easing on interest Rates: Channels and implications for policy. *Brookings Papers on Economic Activity*, 215–287. https://doi.org/10.1353/eca.2011.0019. Fall.
Kuttner, K. N. (2018). Outside the box: Unconventional monetary policy in the great recession and beyond. *The Journal of Economic Perspectives, 32*(4), 121–146. https://doi.org/10.1257/jep.32.4.121.
Leahy, J. V., & Whited, T. M. (1996). The effect of uncertainty on investment: Some stylized facts. *Journal of Money, Credit, and Banking, 28*(1), 64–83. Retrieved from https://www.jstor.org/stable/pdf/2077967.pdf?refreqid=excelsior%3Aedf68fe2eca46efd9366d206b6490c45.
McDonald, R., & Siegel, D. (1986). The value of waiting to. *Invest. The Quarterly Journal of Economics, 101*(4), 707–728. https://doi.org/10.2307/1884175.
Peek, J., & Rosengren, E. S. (2014). In A. N. Berger, P. Molyneux, & J. O. S. Wilson (Eds.), *The role of banks in the transmission of monetary policy*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199688500.013.0019.
Pindado, J., Requejo, I., & de la Torre, C. (2011). Family control and investment–cash flow sensitivity: Empirical evidence from the Euro zone. *Journal of Corporate Finance, 17*(5), 1389–1409. https://doi.org/10.1016/J.JCORPFIN.2011.07.003.
Pindyck, R. S. (1988). Irreversible investment, capacity choice, and the value of the firm. *The American Economic Review, 78*(5), 969–985. Retrieved from https://about.jstor.org/terms.
Pindyck, R. S. (1991). Irreversibility, uncertainty, and investment. *Journal of Economic Literature, XXIX*, 1110–1148. Retrieved from https://about.jstor.org/terms.
Romer, C. D., & Romer, D. H. (1990). New evidence on the monetary transmission mechanism. *Friedman Source: Brookings Papers on Economic Activity*, (1), 149–213. https://doi.org/10.2307/2534527.
Sarkar, S. (2000). On the investment-uncertainty relationship in a real options model. *Journal of Economic Dynamics and Control*, (24), 219–225. https://doi.org/10.1016/s0165-1889(99)00005-6.
Seo, M. H., Kim, S., & Kim, Y.-J. (2019). Estimation of dynamic panel threshold model using Stata. *STATA Journal: Promoting Communications on Statistics and Stata, 19*(3), 685–697. https://doi.org/10.1177/1536867X19874243.
Seo, M. H., & Shin, Y. (2016). Dynamic panels with threshold effect and endogeneity. *Journal of Econometrics, 195*(2), 169–186. https://doi.org/10.1016/j.jeconom.2016.03.005.
Sims, C. A. (1980). Macroeconomics and reality. *Econometrica, 48*(1), 1–48. https://doi.org/10.2307/1912017.
Smit, H. T. J., & Ankum, L. A. (1993). A real options and game-theoretic approach to corporate investment strategy under competition. *Financial Management, 22*(3), 241–250.
Smith, A., & Becker, T. (2015). Has forward guidance been effective? *Economic Review*, 57–78. Jul-Sep.
Sterk, V., & Cui, W. (2018). *Quantitative easing: Monetary economics and fluctuations*. Centre for Economic Policy Research. Discussion paper series No. DP13322).
Stock, J., & Watson, M. W. (2012). Disentangling the channels of the 2007-2009 recession. *Brooking papers econ. Activity, 44*(1), 81–156. Retrieved from https://www.brookings.edu/bpea-articles/disentangling-the-channels-of-the-2007-2009-recession/.
Tenreyro, S., & Thwaites, G. (2016). Pushing on a string: US monetary policy is less powerful in recessions. *American Economic Journal: Macroeconomics, 8*(4), 43–74. https://doi.org/10.1257/mac.20150016.
Trigeorgis, L. (1991). Anticipated competitive entry and early preemptive investment in deferrable projects. *Journal of the Economics of Business, 43*(2), 143–156. https://doi.org/10.1016/0148-6195(91)90014-N.
Wu, J. C., & Xia, F. D. (2016). Measuring the macroeconomic impact of monetary policy at the zero lower bound. *Journal of Money, Credit, and Banking, 48*(2–3), 253–291. https://doi.org/10.1111/jmcb.12300.