

Financing Constraints, Short-term Uncertainty, and Tangible Investment: Evidence of Spatial Dependency in UK SMEs

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Abstract

This study investigates how financing constraints, cashflow uncertainty, and spatial spillovers influence SME investment in tangible assets using panel data from 2007 to 2021 in the UK. Evidence suggests that financing constraints increase the adverse effect of cashflow uncertainty on investment. Our findings show that financially constrained firms reduce their investment more sharply in response to uncertainty than unconstrained firms. In addition, we identify a significant effect of spatial dependency among SMEs regarding the investment in tangible assets. Our finding holds over a series of robustness tests.

Keywords: Short-term Uncertainty Financing Constraints Tangible Investment Small-medium enterprises

¹ **Author contributions**

Sundas Naeem: Conceptualisation, literature search, Methodology, writing original draft, data analysis, critical revisions, project administration.

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1. Introduction

Small and medium enterprises (SMEs) are the backbone of many economies, driving innovation and contributing approximately 90% of all businesses, 50% of job creation, and 40% of national income (GDP) (World Bank, 2023). According to International Finance Corporation (2023), estimated 65 million firms representing 40% of formal micro, small, and medium-sized enterprises (MSMEs) in developing countries collectively face an annual financing gap of \$5.2 trillion. Despite their critical role, SMEs face substantial financial challenges such as operating with limited financial buffers, constrained access to external capital, and a heavy reliance on stable cashflows for operational sustainability. Along with external shocks, such as delayed receivables, revenue volatility, and rising operational costs, (Berger and Udell, 1998; Guariglia, Tsoukalas and Tsoukas, 2012; Cowling, Liu and Zhang, 2018; Belghitar, Moro and Radić, 2022) undermine SMEs' capacity to engage in short-term investment and long-term strategic investment, often resulting in postponed or foregone capital commitments (Mulier, Schoors and Merlevede, 2016; Ponikvar, Zajc Kejžar and Peljhan, 2018; T Nicolas, 2022).

While a substantial body of research has examined how SMEs' financing constraints influence firm investment under long-term uncertainty, such as energy prices (Sauner-Leroy, 2004; Koetse, van der Vlist, et al., 2006), expected future sales (Bontempi, 2016), price volatility (Doshi, Kumar and Yerramilli, 2018), and economic policy uncertainty (Ma and Hao 2022). While some studies have examined short-term disruptions such as delayed payments and revenue volatility (Guariglia et al., 2012; Ponikvar et al., 2018), they tend to understate the persistent and geographically embedded nature of financial uncertainty and its consequences for SMEs' long-term investment strategies and adaptive capacity (Sokol, 2013). There remains a critical need for research into the spatial disparities of financial access across the UK, which continues to shape investment behaviour in tangible assets by amplifying short-term uncertainty (Lee and Drever, 2014; Bontempi, 2016; Guariglia et al., 2012).

Larger firms may hedge against such uncertainties using diversified revenue streams and extensive credit lines; however, SMEs often lack this financial flexibility (Danielson and Scott, 2007). Therefore, financing constraints may exacerbate the impact of short-term cashflow disruptions, intensifying SME's reluctance or inability to invest in critical-intensive assets, thereby compromising productivity, competitiveness, and survival. The effect of uncertainty on investment has gained significant attention following the recent global shocks,

such as the 2007-2009 financial crisis and the COVID-19 pandemic, which revealed how uncertainty discourages firms from making irreversible investment commitments. Financial shocks exert long-lasting adverse effects on both large and small firms. Trigeorgis (1993) and Stokey (2016) explored how uncertainty influences firms' investment decisions, suggesting that firms may delay or avoid investing in tangible assets due to associated risks. Furthermore, Etemad (2020) mentions that the global financial crisis and the recent COVID-19 pandemic have introduced an additional layer of complexity for SMEs, limiting their reliance on internal financial resources. Contemporary research by Alnahedh et al. (2019) and Beladi et al. (2021) highlights that cashflow uncertainty significantly delays valuable investments of large enterprises. SMEs face more short-term than long-term uncertainty due to their less diversified product lines, narrower customer bases, and greater unpredictability of future cashflows. Consequently, SMEs must develop strategies and financial solutions to navigate economic downturns (Eggers, 2020) effectively.

Prior studies presented theoretical and empirical evidence on the relevance of geography in shaping SMEs' access to finance. Cowling et al. (2019) find that while credit access is uniformly assessed across regions for similarly risky firms, peripheral SMEs face a price penalty, indicating spatial disparities in credit pricing. Zhao and Jones-Evans (2017) similarly highlight regional variation, showing that stronger local banking markets and shorter distances to branches improve finance availability. Degryse et al. (2018) further demonstrate that these spatial effects intensified during the financial crisis, with a "flight to headquarters" reducing credit in distant regions. Complementary research by Brown and co-authors reveals uneven equity and angel investment flows, heavily favouring London and core urban areas. Although the mechanisms differ, these studies collectively confirm the geographic unevenness of SME finance, with variations shaped by credit type, economic conditions, and institutional proximity.

While prior research has extensively explored how geography affects SME access to finance and how financing constraints influence investment behaviour, few studies have integrated cashflow uncertainty, financing constraints, and spatial spillovers into a unified empirical framework. Existing work treats spatial effects and firm-level financial frictions separately, overlooking how regional financial interdependence may moderate or amplify the impact of financial uncertainty on investment. This study addresses this gap by jointly modeling firm-specific financing constraints and spatial spillovers, offering new insights into the geographically uneven effects of financial frictions on investment decisions.

This study examines the determinants of firm tangible investment decisions, focusing on the role of financing constraints, cashflow uncertainty, and spatial spillovers. Using a panel dataset of 11,385 firm-year observations across 759 firms, we estimate both fixed effects, GMM, and spatial autoregressive (SAR) models. Results indicate that cashflow uncertainty significantly reduces investment, while spatial spillovers generate positive neighbourhood effects. The findings contribute to the literature on investment behaviour by incorporating both firm-specific financial factors and spatial interdependence. This study makes two key contributions to the literature on SME financing and regional economic development. First, the study explores the effect of short-term uncertainty on tangible assets with the moderating effect of financing constraints. Second, we incorporate firm-level spatial dependency to investigate the effects of financing constraint and short-term uncertainty on tangible investment.

The findings provide strong empirical support for the research hypotheses. Consistent with hypothesis 1a, cashflow uncertainty significantly reduces SME investment in tangible assets across all estimation methods, demonstrating that higher uncertainty discourages capital commitments. Financing constraints increase the adverse effect of cashflow uncertainty on investment, with financially constrained firms reducing investment more sharply in response to uncertainty than unconstrained firms, supporting hypotheses 2a and 2b. Furthermore, consistent with hypothesis 3a, the spatial spillover effects have existed and geographic proximity to other firms influence firm investment behaviour. Lastly, hypothesis 3b is confirmed by the strong negative interaction between cashflow uncertainty and financing constraints within a spatial context since we identify significant spatial spillovers that moderate financing constraints. These findings collectively bridge firm-level investment theory with spatial economic analysis, offering a more nuanced framework for understanding how micro-level financial decisions interact with regional financial networks.

The remainder of this paper is structured as follows. Section 2 reviews relevant literature and develops the hypotheses. Section 3 provides a detailed description of the dataset and empirical methodology. Section 4 reports and discusses the empirical findings. Section 5 concludes the paper.

2. Literature Review and Hypothesis

The real options theory, a widely applied framework, suggests that the sunk cost components of expenditures can adversely affect input and production decisions under conditions of uncertainty (Trigeorgis, 1993; Dixit and Pindyck, 1994). Furthermore, the asymmetric information between lenders and borrowers increases uncertainty. It can distort the flow of credit to specific categories of businesses, thereby influencing their input and production decisions and, by extension, affecting employment and investment opportunities (Stiglitz and Weiss, 1981; Myers, 1984). The literature further identifies various sources of uncertainty, including demand fluctuations (Peeters, 2001), price volatility (Pindyck, 2007), input costs volatility (Jovanovic and Yatsenko, 2012), cashflow instability (Folta, Johnson and O'Brien, 2006), uncertain project returns (Merton, 1980) (Merton, 1973), technological change (Guiso, 1998), and shifts in regulatory or economic policy (Bloom, 2007; Van Nguyen, Hoang and Doan, 2022) as determinants of firms' investment decisions.

Empirical evidence highlights that uncertainty plays a crucial role in shaping investment decisions for SMEs, primarily due to limited financial resources, heightened risk aversion, and exposure to highly competitive market investment. Ghosal and Loungani (2000) found that the negative impact of profit uncertainty on investment is more dominant in small firms compared to their larger counterparts (Sauner-Leroy, 2004; Koetse, Van Der Vlist and De Groot, 2006; Bontempi, 2016a). Similarly, Alti (2003) notes that younger firms face uncertainty regarding their growth prospects, which gradually diminishes as this uncertainty is resolved over time as cashflow realizations provide updated information. The effects of uncertainty are particularly acute for smaller businesses due to their distinct market dynamics and structural vulnerabilities (Ghosal and Ye, 2019).

Studies have further found that sales and environmental uncertainty exert differentiated effects across various types of investment (Lensink, Steen and Sterken, 2005). Such uncertainty influences SMEs' competitive strategies, often promoting a preference for cost-based approaches. It also shapes strategic choices in local markets and within the broader economic landscape, particularly for non-listed SMEs (Parnell, Long and Lester, 2015). In contrast, listed SMEs are more exposed to exchange rate uncertainty, particularly following China's 2005 policy shift, which significantly impacted firm-level investment behaviour. Empirical evidence indicates that rising uncertainty dampens investment responses among Chinese exporters

facing demand shocks, with the effect being especially pronounced for firms characterized by higher capital irreversibility (Zeng, Zhao and Liu, 2022).

Delays in investment decisions necessitate a closer examination of capital budgeting practices. Findings show that firms, despite relying on simple techniques, adjust payback periods and discount rates in response to uncertainty and investment irreversibility (Chittenden and Derregia, 2015). Cho and Lee (2021) further suggest a concave relationship between uncertainty and investment, where increasing uncertainty leads to diminishing levels of SME investment. Such delays can negatively impact firms' creditworthiness, exposing them to balance sheet shocks that reduce their attractiveness to lenders and ultimately contract the overall supply of credit (Kim, Lee and Lim, 2023). The COVID-19 pandemic has intensified these challenges by prompting severe economic disruptions that deeply affected entrepreneurial finance and SMEs' capital availability (Etemad 2020; Brown et al. 2020). These crises also affected economic policy uncertainty, further influencing corporate behaviour, financial decision-making, and overall economic outcomes (Ma and Hao, 2022).

Despite limited empirical evidence on the link between cashflow uncertainty and tangible investment in SMEs, studies on larger firms show that financially constrained firms tend to reduce investment in response to volatility and negative cashflow growth (O'Connor Keefe and Tate, 2013). Firms facing higher cashflow uncertainty also adopt more cautious R&D and capital expenditure strategies, whereas lower cashflow volatility is associated with increased investment activity, consistent with the suggestion of real options theory (Alnahedh, Bhagat and Obreja, 2019; Beladi, Deng and Hu, 2021). Given SMEs' crucial role in economic development and heightened sensitivity to internal financing constraints, examining this relationship in the SME context is essential.

Building on this background, this study applies financial flexibility theory to investigate how short-term cashflow uncertainty affects tangible investment decisions in SMEs. According to the theory, firms with higher financial flexibility, those that can access capital easily, maintain liquidity, and avoid excessive debt, are better positioned to withstand cashflow uncertainty and continue investing in tangible assets (Marchica and Mura, 2010). In contrast, firms with lower financial flexibility, such as those dependent on external financing or carrying high debt, are more likely to delay or reduce investments during periods of financial volatility (Gamba and Triantis, 2008). This underscores the critical role of internal financial management in mitigating uncertainty and sustaining investment in tangible assets (Gupta and Mohammad,

2025). Accordingly, the following hypotheses are formulated and grounded in the financial flexibility literature.

H1a: The higher level of cashflow uncertainty in SMEs significantly restricts investment in tangible assets.

H1b: Variations in cashflow uncertainty have a differential impact on investment in tangible assets.

The literature acknowledges that financing constraints can amplify or dampen the relationship between uncertainty and investment, depending on the availability of external funding and the strategic use of internal funds. When a firm faces limited access to credit or external financing, the adverse effect of uncertainty on investment becomes more pronounced (Carreira and Silva, 2010). During periods of high uncertainty, firms often prefer to postpone investment decisions (Dixit and Pindyck, 1994), aligning with real options theory, which treats investments as options to be exercised under favourable conditions. As external financing becomes constrained, firms may experience cash shortfalls, exacerbating the adverse effects of cashflow volatility on investments (Bonini, 1977; Bloom, 2007).

Empirical evidence on the real options theory suggests different associations between cashflow uncertainty and investment, depending on firms' financing constraints. For financially constrained firms, some evidence points to a positive relationship between cashflow uncertainty and investment (Han and Qiu, 2007; Carreira and Silva, 2010; Beladi, Deng and Hu, 2021). These firms may perceive uncertainty as an opportunity to invest in profitable projects despite limited financial resources. This occurs because, under greater uncertainty, firms may increase current investment to hedge against potential future financing constraints (Boyle and Guthrie 2003; Baum et al. 2006). In contrast, financially unconstrained firms show a negative relationship between cashflows uncertainty and investment (Chan, Lu and Zhang, 2013; Deng *et al.*, 2023), as heightened uncertainty makes them more cautious, promoting them to restrict corporate investment decisions (Kaplan and Zingales, 1997; Campello, Graham and Harvey, 2010).

The other stream of financial flexibility literature argues that financially constrained firms curtail investments in the face of cashflow uncertainty. These firms often prioritize cash preservation, which weakens their internal financing capacity (Kaplan and Zingales 1997, 2000; Liu et al. 2021) and leads to a negative relationship between cashflow uncertainty and investment (Almeida et al. 2004; O'Connor Keefe and Tate 2013; Liu et al. 2021). This strategy

eventually undermines firm's value (Yang *et al.*, 2022) and increase investment cashflow sensitivity (Fazzari, Hubbard and Petersen, 1987). Compared to SMEs, large firms have superior access to financial instruments and risk management strategies, making them better equipped to handle such uncertainty (Koetse, Van Der Vlist and De Groot, 2006).

SMEs are particularly vulnerable to external financing constraints due to pervasive asymmetric information, limited credit histories, and a frequent lack of collateralizable assets. These structural limitations intensify their dependence on internal finance, making them especially sensitive to fluctuations in cashflow and uncertainty. As a result, even profitable investment opportunities may be forgone under financial stress (Perotti and Vesnaver 2004; Whited and Wu 2006; Liu 2013; Vermoesen *et al.* 2013; O'Toole *et al.* 2016; Melander *et al.* 2017; Gul and Tastan 2020). Unlike larger firms with diversified access to capital markets, SMEs often face constrained financial flexibility. Prior studies commonly differentiate between highly and less financially constrained firms to capture this dependency using tools such as the KZ index and WW index (Kaplan and Zingales, 2000; Whited and Wu, 2006). While methodological specifics are discussed later, this distinction is essential for identifying how cashflow uncertainty differentially impacts SME investment behaviour under varying levels of financing constraints (Christodoulou *et al.*, 2022; de Guevara *et al.*, 2021; Doshi *et al.*, 2018; Khataybeh, 2021; Mulier *et al.*, 2016; Nicolas, 2022).

This study employed Pecking Order Theory (POT) to examine the moderating role of external financing constraints in shaping SMEs' investment behaviour under short-term cashflow uncertainty. According to POT (Myers, 1984), firms prioritize their financing sources hierarchically- starting with internal funds, then debt, and finally equity, if external financing is necessary. Due to information asymmetry, external financing is generally more costly and risk-laden, particularly for SMEs. Therefore, when SMEs encounter financing constraints, they are more likely to rely on internal funds and adjust their investment decisions accordingly. POT, therefore, provides a relevant framework for explaining how financing constraints moderate the effect of uncertainty on SME investment behaviour. Based on the above discussion, the following hypotheses are proposed:

H2a: External financing constraints strengthen the effect of cashflow uncertainty on investment in tangible assets.

H2b: The varying level of external financing constraints has a differential effect on the relationship between cashflow uncertainty and investment in tangible assets.

While the relationship between financing constraints, uncertainty, and SME investment behaviour is documented, the conventional SME finance literature often does not adequately explore the geographic context. However, spatial differentiation significantly influences uncertainty, and financing constraints are particularly relevant within a geographically uneven financial landscape like the United Kingdom (Cowling & Brown, 2025).

Recent studies highlight that geographic segmentation in credit markets contributes to significant regional disparities in access to finance, particularly during periods of economic uncertainty. SMEs in peripheral or underbanked regions often face greater financing frictions under such conditions (Zhao and Jones-Evans, 2016; Zhao, Luintel and Matthews, 2021). Spatial dynamics also influence equity financing, particularly angel investment, which tends to concentrate in financial institutions. For instance, Brown et al. (2019) found that geographic proximity to London in the UK significantly increases access to international equity, especially for later-stage ventures, reinforcing the "money-distance nexus." Similarly, Cowling & Brown (2025) showed that few UK regions are net recipients of angel capital, while most remain net losers in deal flow and investment volume. This may undermine local entrepreneurial ecosystems and raise concerns about the efficacy of regional finance policies.

These regional disparities are further exposed during macroeconomic shocks such as Brexit, which disproportionately impact SMEs in both urban and peripheral areas (Brown, Liñares-Zegarra and Wilson, 2019) and shape investment behaviour (Amidi and Fagheh Majidi, 2020; Brown *et al.*, 2025). It also introduces apparent asymmetries in how SMEs experience financing constraints and uncertainty. Recognizing this dimension is essential for understanding SME investment behaviour. To address this, the study formulated the following hypothesis:

H3a: Spatial differences significantly influence the impact of cashflow uncertainty on SMEs' tangible investment decisions.

H3b: The moderating effect of financing constraints on the relationship between cashflow uncertainty and tangible investment decisions differs across geographic regions.

Figure 1 illustrates the Conceptual Framework of this study.

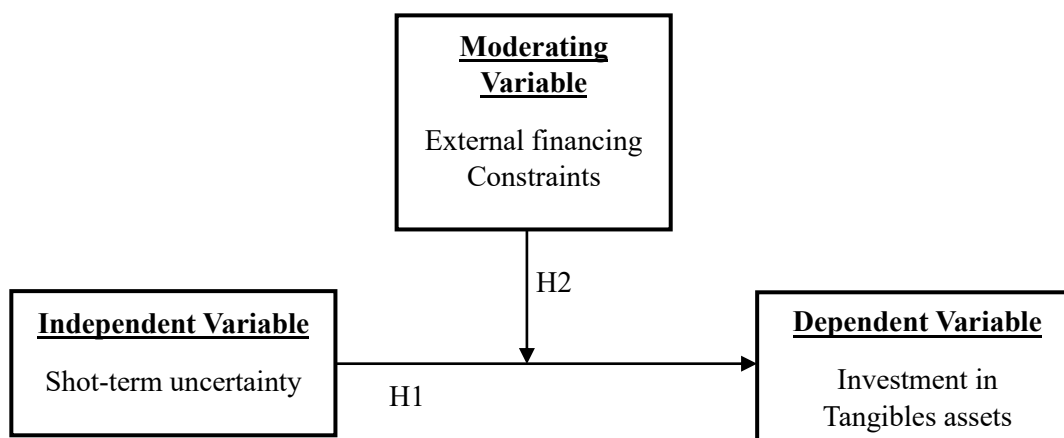


Figure 1: Conceptual Framework

3. Methodology

3.1. Data and Sample

The study collects data from the Financial Analysis Made Easy (FAME) database, which provides financial information for public and private UK firms; the selected timeframe spans from 2007 to 2021. The sample of UK SMEs was composed based on the definition offered by European Commission (2023). Small firms have 10 to 49 employees and an annual turnover of up to £8.6 million. In comparison, medium-sized firms have 50 to 249 employees and an annual turnover ranging from £10.2 million to £43 million over the last ten years. SMEs younger than two years were excluded from the sample, as this is the minimum period required to estimate financial ratios. Furthermore, we applied a standardised data filtering procedure to ensure robustness and consistency of data. (1) Extreme values winsorized at the 1st and 99th percentiles to lessen the impact of outliers. (2) Firms with incomplete data for any variable were excluded, and all financial variables, except firm age, were deflated using gross domestic production (GDP) as the deflator. After dropping firms under 2 years of age, left with 24,000 observations in the final sample of UK SME firm-year data.

3.2. Variable Setting

3.2.1. Dependent Variable

This study employs a holistic approach to measure investment in tangible assets beyond the traditional way. The study extends the existing literature to construct an investment

measure for tangible assets. The investment in tangible assets ($Inew_tang_{i,t}$), is constructed by taking away the sum of depreciation and amortization as maintenance investment expenditure for non-current assets ($Imain_tang_{i,t}$) from total investment ($Inv_tang_{i,t}$), the sum of capital expenditure made for tangible assets ($CAPEX_tang_{i,t}$) and acquisitions and research, and development expenses (Richardson 2006; Guariglia and Yang 2016).

$$Inv_tang_{i,t} = CAPEX_tang_{i,t} + Acquisitions + R\&D \quad (1)$$

$$Inew_tang_{i,t} = Inv_tang_{i,t} - Imain_tang_{i,t} \quad (2)$$

3.2.2. Measurement of Cashflow Uncertainty ($\sigma_{i,t}^{CF}$)

The cashflow uncertainty, the main independent variable, is constructed using a time-varying cashflow distribution generated by assets in place. While previous studies have measured cashflow uncertainty based on a firm's equity returns, this approach often faces an endogeneity issue (O'Connor Keefe and Tate, 2013; Beladi, Deng and Hu, 2021). The key challenge is to develop a return-based measure of cashflow uncertainty not influenced by the firm's investment opportunities. To address this, we adopt a method that captures how cashflows from a firm's existing assets fluctuate over time, ensuring a more accurate representation of uncertainty.

The measurement of cashflow uncertainty is primarily firm-specific and time-varying, extracted from accounting data using econometric techniques widely applied in asset pricing literature (O'Connor Keefe and Tate, 2013; Beladi, Deng and Hu, 2021). This approach addresses the challenges of imprecise firm-specific and time-evolving market beta estimations. This technique involves grouping firms into quartiles in each period based on a ranking variable that ensures firms with similar characteristics are classified together. Instead of estimating the variable of interest (e.g., market beta) at the individual firm level, it is computed at the quartile level for each period. Firms are then assigned the corresponding quartile estimate based on their position within the ranking variable. This technique allows for a firm-specific measure that evolves over time, reducing biases and improving robustness.

The study employs this methodology to construct a cashflow uncertainty measure, using a modified version of the gross profit margin to categorize and group firms into quartiles

within each industry. The modified gross profit margin is one minus the ratio of the combined cost of goods sold (COGS) and selling, administrative, and general costs to total sales. Based on this measure, firms within the same industry are then ranked into quartiles, ensuring an industry-specific and time-varying allocation. By grouping firms into quartiles, we ensure that those within the same quartile share similar levels of certainty, allowing us to estimate the variable of interest at the quartile level rather than at the individual firm level. This approach improves measurement robustness and reduces firm-specific noise. Given our focus on assessing the cashflow uncertainty associated with a firm's existing assets, the first step is to verify that firms within the same industry quartile operate similar types of assets, ensuring the validity of our grouping methodology.

Furthermore, to ensure that the estimates at the industry-quartile level are representative, the second criterion requires that firms within the same industry quartile exhibit similar gross profit margin (ranking variable). This ensures that firms within the same quartile share comparable performance levels. The study prefers gross profit margins over operating profits for two key reasons. First, the gross profit margins are less influenced by variations in financing, investment decisions, and tax optimization strategies, such as depreciation, amortization, corporate tax, and the choice between expensing or capitalizing R&D expenses. Second, the gross profit margin ratio is notably easier to interpret, with less ambiguity regarding its computation than operating profits.

The construction of an industry quartile changes over time, with some firms entering and exiting while migrating across quartiles within the same industry. For example, a firm may be in the top quartile at time t but shift to the bottom quartile at time $t+3$. The study runs a panel regression while fixing the industry quartile to construct the cashflow uncertainty measure at the quartile level for a specific industry over time. This regression used data from firms that have been part of a given quartile within the last three years ($t-3$ to t). By incorporating firms that have moved between quartiles during this period, the approach provides a more dynamic and representative estimate of cashflow uncertainty for an industry quartile by examining the

firms that have occupied that quartile position over the past three years. $\log(sales)_{is} =$

$$\beta_t^{J,q} \log(sales)_{i,s-1} + \gamma_t^{J,q} \log(K)_{is} + \delta_{js}^{J,q} + \epsilon_{is},$$

$$\text{for } t - 3 \leq s \leq t \quad (3)$$

Where “ i ” is the firm in industry quartile “ $J:q$ ”, $sales_{is}$ and K_{is} are firm i 's sales and capital stock at times, and $\delta_{js}^{J,q}$ are industry-year fixed effects. Let $\hat{\sigma}_t^{J,q}$ denote the root mean square

error (RMSE) of the regression estimated on quartile q in industry J at time t . The study defines the cashflow uncertainty for firm i at time t , $\sigma_{i,t}^{CF}$, as the RMSE estimate of the residuals of the quartile q in industry J contains firm i at time t . Specifically,

$$\sigma_{i,t}^{CF} = \hat{\sigma}_t^{J,q}, \text{ for all } i \in \text{industry } J, \text{ quartile } q \quad (4)$$

SMEs often face business uncertainty or market distress during different business cycle phases, leading to intensified cashflow shocks. Therefore, the relationship between the distribution of a firm's cashflows and new investment becomes stronger. This study assumes that the uncertainty measure effectively captures such shocks, particularly when idiosyncratic cashflow uncertainty is estimated using sales, lagged sales, capital, and industry-year fixed effects to account for cross-sectional unobservable factors.

3.2.3. Financing constraint measure

To measure financing constraints at the firm level, I use a version of the Altman Z-Score model (Altman *et al.*, 2017), which is specifically designed for private and non-manufacturing firms across a wide range of countries. This model combines four key financial ratios that reflect a firm's liquidity, profitability, and leverage: working capital to total assets (WCTA), retained earnings to total assets (RETA), EBITDA to total assets (EBITTA), and equity to total liabilities (EQTL). Each of these ratios is weighted, and the Z-score is calculated as the sum of the following presented in equation 5:

$$6.56 \times WCTA + 3.26 \times RETA + 6.72 \times EBITTA + 1.05 \times EQTL \quad (5)$$

Firms with a total Z-score below 2.6 are classified as financially constrained. This approach offers a more comprehensive measure than single indicators, capturing multiple dimensions of a firm's financial health. It is especially useful for identifying firms that may face difficulties accessing external finance, a critical issue in understanding how financing constraints vary across regions and influence investment decisions.

3.2.4. Other variables

The control variables include investment opportunities, such as ($MQ_{i,t}$), which focuses on profitability relative to the cost of capital. The data is available, making it a more practical measure for understanding investment decisions in smaller firms. The cash ratio ($Cash_{i,t}$) is computed as the cash and cash equivalents ratio to total assets. Firm size ($Size_{i,t}$) is measured as the natural logarithm of total assets. Age represents the number of years since the firm's

commencement. Profitability is captured using return on equity ($ROE_{i,t}$), computed as net profit divided by total equity. The leverage ratio ($LEV_{i,t}$), included as a control variable, is calculated as the ratio of short-term and long-term debt to total assets. To mitigate endogeneity concerns, all explanatory variables are lagged by one period.

4. Results and Discussions

4.1. Descriptive and Summary Statistics

Table 1 presents descriptive statistics for the main variables, including the mean, median (p50), 25th and 75th percentiles (p25, p75), minimum, maximum, and standard deviation (SD). On average, firms show a near-zero net change in tangible investment (mean = -0.001), with moderate variation (SD = 0.049). Cashflow uncertainty has a mean of 0.053, indicating modest variability across firms. The marginal Q has low average values (mean = 0.075), suggesting a limited market premium for many firms. Cash holdings are also low (mean = 0.007), while firm size (mean = 8.415) varies considerably, indicating diversity in scale. The negative average leverage (mean = -0.127) suggests some firms rely more on internal financing. Return on equity shows a mean of 0.128 and high dispersion (SD = 0.419), indicating heterogeneous profitability. Firm age spans from -2 to 112 years (mean = 27.19), capturing both startups and mature firms. Z-score values display extreme variability (SD = 7.49), reflecting substantial differences in financial health among UK SMEs.

[Insert Table 1 Here]

Table 2 compares the dependent and independent variables between financially unconstrained and constrained firms, classified using Z-score values. Unconstrained firms exhibit slightly lower tangible investment (mean = -0.004) than constrained firms (-0.001). They also show marginally higher cashflow uncertainty (mean = 0.057 vs. 0.052) and lower investment opportunities (mean = 0.084 vs. 0.367). Unconstrained firms tend to be slightly larger (mean size = 8.47) but have lower leverage (mean = -0.067) and higher profitability (ROE mean = 0.273) than constrained firms.

Conversely, constrained firms, while smaller on average (mean size = 8.396), carry higher leverage (mean = -0.147) and exhibit lower profitability (ROE mean = 0.08). Firm age is comparable across groups, with constrained firms marginally older (mean = 27.83 years vs. 25.23 years). The t-tests confirm that differences between the two groups are statistically

significant across all reported variables at the 1% level, underscoring the financial and operational distinctions tied to financing constraints.

[Insert Table 2 Here]

4.2. Empirical specification

This section presents the empirical analysis of the impact of cashflow uncertainty on investment in tangible assets. Furthermore, it examines the moderating role of external financing constraints in shaping this relationship. Various alternative estimation models are used for the main equation and robustness: (i) Fixed effects (ii) the system Generalised Method of Moments (system-GMM), (iii) spatial regression model (SAR), and (iv) instrumental variables. These specifications are further tested with and without industry and region fixed effects.

$$Y_{i,t} = \alpha_0 + \alpha_1 \sigma_{i,t-1}^{CF} + \alpha_2 X_{i,t-1} + \mu_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$Y_{i,t} = \alpha_0 + \alpha_1 \sigma_{i,t-1}^{CF} + X_{i,t-1} + FC_{i,t-1} + \sigma_{i,t-1}^{CF} * FC_{i,t-1} + \mu_{i,t-1} + \varepsilon_{i,t} \quad (6)$$

Where ‘ i ’ and ‘ t ’ represent firms and time, respectively; $Y_{i,t}$ denotes investment in tangible assets ($Inew_{i,t}$); $\sigma_{i,t}^{CF}$ measures cashflow uncertainty; $FC_{i,t}$ captures financing constraints using $ASCL_{index_{i,t}}$; $X_{i,t}$ represents the vector of control variables, including $GGAV_{i,t}$, cash ratio, size, leverage, age, ROA, and tangibility; $\mu_{i,t}$ is year fixed effects. Alternative specifications include industry (δ_j) and region (δ_r) fixed effects. $\varepsilon_{i,t}$ is the error term.

Moreover, to examine how geographic proximity influences SME investment behaviour under conditions of uncertainty, we employ a spatial econometric framework that explicitly accounts for interdependence among neighbouring regions. We generate spatial weighting matrices, which define pairwise weights based on inverted distances as $w_{ij} = (1/D_{ij})$. D_{ij} is the distance in road kilometres averaged over pairs of major towns in each region. The empirical analysis proceeds through several carefully designed stages. First, we calculate the pairwise road distances between all regional economic centres using geospatial network analysis tools, ensuring accurate measurement of transportation linkages. These raw distances are then transformed into spatial weights through the inverse distance function, with diagonal elements set to zero to exclude self-influence. The resulting matrix is row-standardized to facilitate the interpretation of the spatial lag coefficients. We implement Spatial Autoregressive (SAR) with the specification,

$$y = \rho Wy + X\beta + \epsilon,$$

This allows us to test whether investment levels in neighbouring regions (Wy) directly influence local SME investment decisions, while controlling for firm-specific characteristics (X).

Table 3 shows the baseline estimation results examining how cashflow uncertainty affects investment in tangible assets across three estimation methods: Fixed Effects (FE), System Generalized Method of Moments (System-GMM), and Spatial Autoregressive (SAR) models. Across all specifications, cashflow uncertainty ($\sigma_{i,t}^{CF}$) shows a statistically significant negative impact on tangible asset investment, with coefficients of -0.028 (FE), -0.085 (System-GMM), and -0.022 (SAR) at the 5% and 10% levels. These findings support hypotheses H1a, which posits that higher levels of cashflow uncertainty deter investment in tangible assets. The results are aligned with real options theory, where firms treat investment as an option and defer it under uncertainty.

The control variables, such as investment opportunities (MQ), exhibit a positive and significant relationship with tangible investment in all models, reinforcing the role of growth prospects in driving capital expenditures. Similarly, cash holdings consistently display a significant adverse effect on tangible investment, which may reflect firms' preference to preserve liquidity over committing funds to long-term tangible assets under uncertain conditions. The diagnostic tests support the validity of the system-GMM specification, with no second-order autocorrelation (AR (2) $p = 0.351$) and a Hansen J-test p -value of 0.108, suggesting instrument validity. The Wald test in the SAR model confirms the significance of the overall model. Overall, the results indicate the dampening effect of cashflow uncertainty on tangible investment for UK SMEs, reflecting financial stability's importance in investment decisions within regional economic contexts.

[Insert Table 3 Here]

Table 4 shows the results from moderation models studying how cashflow uncertainty affects tangible investment, depending on financing constraints. It also aims to capture regional spillover effects using the Spatial Autoregressive (SAR) model. Estimates are provided for fixed effects (Column 1), System-GMM (Column 2), and the SAR model (Column 3). The interaction between cashflow uncertainty and financing constraints consistently has a negative and statistically significant impact on investment across all models. This indicates that firms

facing tighter financing constraints reduce tangible investment more sharply in response to uncertainty, suggesting that constrained firms are less capable of absorbing risk or reallocating capital flexibly. In contrast, unconstrained firms appear more resilient or adaptable, potentially due to better credit access or internal buffers.

The finding of the SAR model incorporating spatial dependencies yields a negative and highly significant interaction effect ($-0.089, p < 0.01$), confirming that regional dynamics shape the investment behavior of financially constrained SMEs. This suggests that firm-level responses to uncertainty are not isolated but conditioned by their geographic context, likely influenced by local financial ecosystems, spatial clustering, or institutional support. The significance of the spatial term ($\text{Sigma}^2 = 0.02$) further highlights that geographic proximity to other firms or financial centers shapes firm-level investment decisions under uncertainty. These findings align with recent economic geography literature highlighting the embeddedness of firm behavior within regional financial environments (Brown, Liñares-Zegarra and Wilson, 2019; Amidi and Fagheh Majidi, 2020; Brown *et al.*, 2025). The results show that policymakers need to focus on enhancing SME financing and should consider local institutional capacity and spatial credit gaps, not only firm-level traits.

[Insert Table 4 Here]

Using fixed-effects estimations, Table 5 examines the impact of cashflow uncertainty on tangible investment among financially constrained and unconstrained SMEs (classified with a Z-score above 2.6 indicating financing constraint). The regression results reveal that financially constrained SMEs exhibit a negative and statistically significant association between cashflow uncertainty and tangible investment (coefficient = $-0.048, p < 0.05$) and support for Hypothesis H2a. This indicates that uncertainty in internal cashflows causes constrained firms to reduce investment, likely because they depend more on internal funds and find it harder to secure external capital during volatile times.

In contrast, financially unconstrained SMEs show a negative but statistically insignificant relationship (coefficient = -0.018), indicating that cashflow uncertainty has a negligible effect on their tangible investment decisions and support Hypothesis H2b. This may reflect their access to more stable financing sources, better risk management practices, or the ability to delay or smooth investments in response to changing financial conditions.

The results align with the pecking order theory, indicating that SMEs with limited external financing tend to act more cautiously in uncertain situations. Instead of pursuing opportunistic investments, constrained firms might focus on maintaining liquidity and avoiding risk. In contrast, unconstrained firms can tolerate short-term uncertainty and stick to investment plans, highlighting the strategic benefit of financial flexibility.

[Insert Table 5 Here]

4.3. Further tests

4.3.1. Alternatives Measures of Cashflow Uncertainty

The study employed various measures to confirm the robustness of the findings. Table 6 reports the long-term impact of cashflow uncertainty ($\sigma_{i,t}^{CF}$) on tangible asset investment using fixed-effects models. The alternative proxies of cashflow uncertainty are employed to ensure the robustness of the relationship between cashflow uncertainty and investment in tangible assets. The primary proxy involves calculating the rolling standard deviation of firm-level cashflow from operation (where $T \geq 3$), as presented in Equation 7, following Bates et al., (2009) and O'Connor Keefe and Tate, (2013).

$$CFUID_{it} = \sqrt{\frac{1}{T-1} \sum_{t=1}^T \left(rCF_{i,t} - \frac{1}{T} \sum_{t=1}^T rCF_{i,t} \right)^2} \quad (7)$$

The second proxy, denoted as $CFUind_{it}$, captures industry-adjusted cashflow uncertainty and is computed as the standard deviation of a firm's deviation from the industry average cashflow over time (where $T \geq 3$), as presented in Equation (8) and (9).

$$C_{it} = rCashflow_{i,t} - \frac{1}{Ni} \sum_{i=1}^{Ni} rCashflow_{i,t} \quad (8)$$

$$CFUind_{it} = \sqrt{\frac{1}{T-1} \sum_{t=1}^T \left(C_{i,t} - \frac{1}{T} \sum_{t=1}^T C_{i,t} \right)^2} \quad (9)$$

The use of lags allows for the assessment of delayed investment responses to evolving financial uncertainty, while the inclusion of industry-level uncertainty accounts for spatial spillovers and

sectoral volatility. The results in columns (1) and (4) show a negative and statistically significant impact of one-period lagged firm-level and industry-level cashflow uncertainty on tangible investment (coefficients = -0.049 , $p < 0.10$; -0.051 , $p < 0.05$, respectively). This suggests that firms reduce their investment activity in response to prior uncertainty, possibly reflecting heightened risk aversion, reduced internal liquidity buffers, or postponed capital allocation decisions.

In contrast, the second and third lags of firm-level uncertainty (columns 2 and 3) show no significant or even marginally positive coefficients (e.g., $L3. \sigma_{i,t}^{CF} = 0.025$), implying that the impact of uncertainty disperses over time, likely due to firms adjusting their investment plans once uncertainty becomes resolved or more predictable. Particularly, the third lag of industry-level uncertainty (column 6) is positive and marginally significant (0.042 , $p < 0.10$), indicating that firms may eventually resume investment in response to past external volatility, possibly after competitive pressure or pent-up demand is comprehended.

[Insert Table 6 Here]

Table 7 presents robustness checks using an alternative measure of cashflow uncertainty that adjusts for industry-level variation. In Column (1), the coefficient on industry-adjusted cashflow uncertainty is negative and statistically significant at the 1% level, indicating that greater firm-specific deviation from industry cashflow volatility is associated with higher investment in tangible assets. This suggests that firms experiencing higher relative uncertainty within their industry may increase investment, possibly capitalizing on strategic opportunities.

Column (2) introduces the financing constraint variable (Fincon) and its interaction with cashflow uncertainty. The interaction term between cashflow uncertainty and financing constraints is negative and statistically significant ($p < 0.01$). This indicates that financing constraints weaken the negative impact of cashflow uncertainty on investment. In other words, financially constrained firms are less able or willing to increase investment under uncertain cashflow conditions than unconstrained firms.

These findings support Hypothesis 2a and 2b, which propose that external financing constraints moderate the relationship between cashflow uncertainty and tangible investment. Specifically, the results confirm that financing constraints dampen firms' investment responsiveness to cashflow uncertainty, consistent with pecking order theory and financial frictions limiting firms' investment capacity under uncertainty. The use of industry-adjusted measures also

accounts for spatial and sectoral dependency, reinforcing the robustness of these relationships in a geographic economic context.

[Insert Table 7 Here]

4.3.2. Alternative Constructs of Financing Constraint

The study further tests the financing constraint hypotheses (H2a, H2b) with alternative measures of financing constraints. Specifically, two established indices are used: the WW index, introduced by Whited and Wu (2006), and the Hadlock and Pierce (HP) index (Hadlock & Pierce, 2010), which are particularly appropriate for capturing SME-specific constraints.

The WW index, introduced by Whited and Wu (2006), is the second measure of financing constraints employed. This index is a linear function as presented in Equation 10:

$$WW = -0.091 \times CF_t/BA_{t-1} - 0.062 \times DIVPOS_t + 0.021 \times TLTD_t/CA_{t-1} - 0.044 \times LNTA_t - 0.035 \times SGR_t + 0.102 \times ISG_t \quad (10)$$

Where CF_t/BA_{t-1} denotes cashflow (i.e., net income plus depreciation), divided by opening book assets; $DIVPOS_t$ represents the dividend with positive values; $TLTD_t/CA_{t-1}$ stands for long-term debt relative to total current assets; $LNTA_t$ presents firm size, defined as the natural logarithm of the book value of assets; SGR_t indicates firm real sales growth; and ISG_t denotes industry sales growth. A higher value of the WW index suggests a higher degree of financing constraint.

The HP index is another measure of financing constraint employed, using firm size and age. For under-investing SMEs, the study calculates the HP index using the estimated coefficients from Hadlock and Pierce (2010) presented in Equation 11. A higher HP index value indicates a greater level of financing constraint.

$$HP = -0.737 \times \log(TA) + 0.043 \times (\log(TA))^2 - 0.04 \times age \quad (11)$$

Table 8 examines the robustness of the relationship between cashflow uncertainty and tangible investment using alternative financing constraints measures: the Hadlock and Pierce (HP) index and the Whited and Wu (WW) index. The interaction-term between cashflow uncertainty and financing constraints ($\sigma_{it}^{CF} \times FC$) is negative and statistically significant in both models (–0.036 in the HP model and –0.045 in the WW model), confirming that the negative investment response to uncertainty is significantly weaker for financially constrained firms. While the direct effect of financing constraints (FC) alone is insignificant, the interaction effect implies that constraints limit the ability of firms to invest under uncertainty, aligning with Hypothesis 2a. This supports the view that constrained firms are more sensitive to internal financial conditions and less capable of managing uncertainty through investment.

These findings also support Hypothesis 2b, as the results demonstrate that the relationship between cashflow uncertainty and investment differs depending on financing constraints. Specifically, constrained firms invest less in response to rising uncertainty than their unconstrained counterparts, consistent with the prediction that external financing conditions shape the firm's investment sensitivity to risk.

[Insert Table 8 Here]

4.3.3. Instrumental Variables

Further robustness checks using instrumental variables (IV) are presented in Table 9 to examine the moderating role of financing constraints in the relationship between cashflow uncertainty and investment in tangible assets. In Column (4), financing constraints (Fincon) are negatively associated with investment (–0.000, **), indicating that constrained firms generally invest less. The interaction term between cashflow uncertainty and financing constraints ($\sigma_{it}^{CF} \times \text{Fincon}$) is negative and statistically significant (–2.809, $p < 0.10$), confirming that the effect of uncertainty on investment is more adverse for financially constrained firms.

These findings provide strong empirical support for Hypothesis H2a, reinforcing the view that financing constraints exacerbate the negative investment response to uncertainty. The consistency of these results across different model specifications and identification strategies confirms the robustness of the moderating effect.

[Insert Table 9 Here]

5. Conclusion

This study contributes to the financial management literature by investigating firm tangible investment decisions, focusing on financing constraints, cashflow uncertainty, and spatial spillovers. Using a panel dataset of 11,385 firm-year observations across 759 firms, we estimate both fixed effects, GMM, and spatial autoregressive (SAR) models. A novel measure of quantile-specific cashflow uncertainty was employed to measure the short-term uncertainty, which differs from the traditional measures of uncertainty that rely on stock returns, which may contribute to theoretical and practical implications (Alnahedh et al., 2019).

The findings provide strong empirical support for the research Hypothesis 1a, cashflow uncertainty significantly reduces SME investment in tangible assets across all estimation methods, demonstrating that higher uncertainty discourages capital commitments. This aligns with real options theory, confirming that firms delay investments under uncertain conditions. Financing constraints increase the adverse effect of cashflow uncertainty on investment, with financially constrained firms reducing investment more sharply in response to uncertainty than unconstrained firms, supporting hypotheses 2a and 2b. Furthermore, consistent with hypothesis 3a, the spatial spillover effects identified through the Spatial Autoregressive model highlight that regional financial ecosystems and geographic proximity to other firms influence firm investment behaviour. Lastly, hypothesis 3b is confirmed by the strong negative interaction between cashflow uncertainty and financing constraints within a spatial context, showing that regional dynamics further condition the adverse effect of uncertainty on investment. These results emphasize the complex interplay of uncertainty, financing constraints, and spatial factors in SME investment decisions.

These research findings provide substantial theoretical and practical implications. The theoretical implication of this study is to considerably enhance the real options theory by incorporating the financing constraints as moderators with POT in explaining the complexities of SME behaviour. This valuable insight contributes to the academic discussion about uncertainty amid financing constraints and holds practical implications for SMEs in effectively managing uncertainties. Prospective researchers may delve deeper into these findings to observe the underlying reasons for the adverse impact of cashflow uncertainty and financing constraints on investment in tangible investment. It helps to formulate initiatives that address challenges associated with securing external financing for SMEs.

The study offers significant practical implications for SMEs, as they prioritize investment in tangible assets even amidst high cashflow uncertainty. This means they adopt a more proactive approach to capital allocation, seizing favourable investment opportunities. This highlights the importance of relaxing lending companies' financing conditions, making financing more accessible and streamlined. Simplified and transparent lending procedures can provide equal opportunities for SMEs across all regions, ensuring that businesses in underserved areas have the same access to financial resources. Future research could explore the role of government interventions, digital transformation, and corporate governance in alleviating the adverse effects of cashflow uncertainty on SME investment decisions. By addressing both external and internal sources of uncertainty, stakeholders can promote a more resilient and growth-oriented SME sector.

Appendices

Appendix A: Definitions of Variables

Variables	Acronym	Definitions	Proxies	Predicted sign	Source	References
Dependent variable						
Tangible Investment	$I_{new_{i,t}}$	Investment expenditure on new NPV projects	$I_{new_{i,t}} = Inv_{i,t} - I_{main_{i,t}}$		Financial Statement FAME	(Richardson 2006 ; Guariglia 2016)
Explanatory Variables						
Short-term uncertainty	$\sigma_{i,t}^{CF}$	Root mean squared error from a 3-year rolling panel regression of firm output on lagged output and capital, capturing time-varying cashflow volatility by profitability quartile.	$\sigma_{i,t}^{CF} = \hat{\sigma}_t^{J,q}, \text{ for all } i \in \text{industry } J, \text{ quartile } q$	-	Financial Statement FAME	(Alnahedh et al. 2019)

Financing constraints	Z_score	Z-score is computed as a linear combination of financial ratios to predict the likelihood of financial distress.	$Z = 6.56 \times WCTA + 3.26 \times RETA + 6.72 \times EBITTA + 1.05 \times EQTL$	-	Financial Statement FAME	(Altman <i>et al.</i> , 2017)
Marginal Q	MQ	The ratio of profit per unit of capital to the cost of capital	$\frac{\text{Profit per unit of capital}}{\text{cost of capital}}$	+	Financial Statement FAME Refinitive	(Honda and Suzuki 2000; D'Espallier and Guariglia 2015)
Cash	Cash	a ratio of cash and cash equivalents to total assets	Cash and cash equivalents/ total assets	+	Financial Statement FAME Refinitive	(Fazzari and Petersen 1993)
Size	Size	natural logarithm of its total asset	Log (TA)	-	Financial Statement FAME Refinitive	(Fazzari and Petersen 1993)
Leverage	LEV	The ratio of its short-term investment and long-term investment to total asset	Total debt/ total assets	-	Financial Statement FAME Refinitive	(Fazzari and Peterse, 1993)
Age	Age	Represent the number of years firms have operated	number of years	-	Financial Statement FAME Refinitive	(Fazzari and Petersen 1993)
Return on equity	ROE	Represent the profitability of the firm.	Net profit/ total equity	+	Financial Statement FAME Refinitive	(Fazzari and Petersen 1993)

Table 1: Descriptive Statistics

Variables	Mean	p50	p25	p75	Min	Max	SD
$Inew_{tang_{i,t}}$	-.001	0.000	-.01	0	-.215	.277	.049
$\sigma_{i,t}^{CF}$	.053	0.052	0	.101	0	.156	.05
$MQ_{i,t}$	.075	0.000	0	0	-.881	4.587	.425
$Cash_{i,t}$	.007	0.000	0	.013	-.347	.339	.073
$SIZE_{i,t}$	8.415	8.910	8.183	9.414	0	10.38	1.894
$Lev_{i,t}$	-.127	0.000	-.19	0	-1.463	0	.224
$ROE_{i,t}$	.128	0.083	0	.208	-1.823	2.318	.419
Age	27.185	22.000	12	37	-2	112	22.014
Z_score	.057	0.996	-.614	2.587	-410.934	63.118	7.49

Notes: Table 1 presents descriptive statistics for key variables, including the mean, median (p50), 25th percentile (p25), 75th percentile (p75), minimum, maximum, and standard deviation (SD). The variables include tangible investment ($Inew_{tang_{i,t}}$), cashflow uncertainty ($\sigma_{i,t}^{CF}$), investment opportunities ($MQ_{i,t}$), cash ratio (Cash), firm size (Size), measured as the natural logarithm of total assets), leverage ratio (Lev), return on equity ($ROE_{i,t}$), firm age (Age), and the financing constraint (Z-score).

Table 2 Summary Statistics by Financing Constraints

Variables	Unconstrained firms		Constrained firms		t-test
	Mean	Std. Dev.	Mean	Std. Dev.	
$Inew_{tang_{i,t}}$	-.004	.045	-.001	.05	0.00***
$\sigma_{i,t}^{CF}$	.057	.049	.052	.051	0.00***
$MQ_{i,t}$	.084	.503	.367	.532	0.00***
$Cash_{i,t}$	.015	.092	.004	.066	0.00***
$SIZE_{i,t}$	8.47	1.251	8.396	2.063	0.00***
$Lev_{i,t}$	-.067	.167	-.147	.237	0.00***
$ROE_{i,t}$	.273	.414	.08	.41	0.00***
Age	25.233	18.419	27.83	23.043	0.00***

Notes: Table 2 presents the summary statistics for key variables, comparing unconstrained and constrained firms based on Z-score values. For each group, the mean and standard deviation of tangible investment ($Inew_{tang_{i,t}}$), cashflow uncertainty ($\sigma_{i,t}^{CF}$), investment opportunities ($MQ_{i,t}$), cash ratio (Cash), firm size (Size), leverage (Lev), return on equity ($ROE_{i,t}$) and firm age (Age) are reported. The t-test results show statistically significant differences between unconstrained and constrained firms across all variables, with all differences being significant at the 1% level (denoted by ***).

Table 3 Baseline Estimation, Cashflow Uncertainty and Investment in Tangible Assets

VARIABLES	(1)	(2)	(3)
Dep Variable: $Inew_{tang_{i,t}}$	FE	System-GMM	SAR model
$\sigma_{i,t}^{CF}$	-0.028* (0.017)	-0.085* (0.047)	-0.022* (0.012)
$MQ_{i,t}$	0.003* (0.002)	0.004* (0.002)	0.003** (0.001)
$Cash_{i,t}$	-0.104*** (0.007)	-0.155*** (0.018)	-0.094*** (0.006)
$Size_{i,t}$	-0.000 (0.003)	0.000 (0.008)	-0.000 (0.003)
$Lev_{i,t}$	0.001 (0.001)	0.001 (0.003)	0.001 (0.001)
$ROE_{i,t}$	-0.000 (0.001)	-0.000 (0.001)	0.000 (0.001)
Age	0.002 (0.007)	0.004 (0.009)	-0.003 (0.005)
F (p-value)	0.000	0.00	0.000
AR (2) P-value		0.351	
Hansen J test (p-value)		0.108	
Wald Test (Chi 2)			0.190
Sigma ²			
Observations	11,385	11,385	11,385

Notes: The estimation was performed with fixed effects in the first columns, through the system GMM estimator in the second columns, and with the SAR model in the third column. The dependent variable is expected new tangible investment ($Inew_{tang_{i,t}}$). All variables' test statistics and standard errors (shown in parentheses) in the regressions are asymptotically robust to heteroscedasticity. The estimation independent variable as cashflow uncertainty ($\sigma_{i,t}^{CF}$), and control variables such as investment opportunities ($MQ_{i,t}$), cash ratio (Cash), firm size (Size), leverage (Lev), return on equity ($ROE_{i,t}$) and firm age (Age). For the system GMM regression, the Hansen J test evaluates the validity of instrument restrictions and follows a Chi-square distribution under the null hypotheses. Additionally, the first differences of the same variables lagged twice, and are employed as supplementary instruments in the level equations. Significance levels are denoted by ** (for the 5% level) and *** (for the 1% level).

Table 4: Moderation Estimation, Cashflow Uncertainty, Financing Constraints, and Investment in Tangible Assets

VARIABLES	(1)	(2)	(3)
Dep Variable:	FE	System_GMM	SAR Model
$Inew_{tang_{i,t}}$			
$\sigma_{i,t}^{CF}$	0.054* (0.030)	0.668* (0.368)	0.045** (0.022)
Fincon	0.013*** (0.003)	0.058** (0.027)	0.009*** (0.002)
$\sigma_{i,t}^{CF} * Fincon$	-0.104*** (0.037)	-0.906* (0.483)	-0.089*** (0.024)
$MQ_{i,t}$	0.003** (0.001)	0.002 (0.002)	0.003** (0.001)
$Cash_{i,t}$	-0.101*** (0.011)	-0.094*** (0.012)	-0.092*** (0.006)
$Size_{i,t}$	-0.000 (0.001)	0.000 (0.001)	0.000 (0.003)
$Lev_{i,t}$	0.000 (0.005)	-0.001 (0.005)	0.001 (0.001)
$ROE_{i,t}$	0.001 (0.002)	0.001 (0.002)	0.000 (0.001)
Age	0.004 (0.005)	0.008 (0.007)	-0.000 (0.005)
F (p-value)	0.00	0.00	0.00
AR (2) P-value		0.215	
Hansen J test (p-value)		0.113	
Wald Test (Chi 2)			0.02
Sigma ²			
Observations	11,385	11,385	11,385

Notes: Table 4 presents result from three estimation models such as Fixed Effects (FE), System Generalised Method of Moments (System-GMM), and the Spatial Autoregressive (SAR) model, examining the moderating effect of financing constraints on the relationship between cashflow uncertainty and tangible investment. The dependent variable is new tangible investment (**$Inew_{tang_{i,t}}$**). The estimation independent variable as cashflow uncertainty (**$\sigma_{i,t}^{CF}$**), and control variables such as investment opportunities (**$MQ_{i,t}$**), cash ratio (Cash), firm size (Size), leverage (Lev), return on equity (**$ROE_{i,t}$**) and firm age (Age). The key variable of interest is the interaction term (**$\sigma_{i,t}^{CF} * Fincon$**), which captures how the effect of cashflow uncertainty on investment varies with the degree of financing constraints. Significance levels are denoted by ** (for the 5% level) and *** (for the 1% level).

Table 5 Cashflow Uncertainty and Tangible Investment by Financing constraint Status

VARIABLES	(1)	(2)
Dep Variable:	Financially cons	Financially uncons
$Inew_{tang_{i,t}}$		
$\sigma_{i,t}^{CF}$	-0.048** (0.020)	-0.018 (0.038)
MQ	0.003 (0.002)	0.004 (0.002)
Cash	-0.134*** (0.010)	-0.045*** (0.011)
Lev	-0.001 (0.001)	0.005* (0.003)
ROE	0.001 (0.004)	0.008 (0.010)
Size	0.001 (0.002)	0.001 (0.003)
age_dummy	0.006 (0.008)	-0.032 (0.044)
Constant	0.001 (0.003)	-0.011 (0.046)
R-squared	0.029	0.012
Observations	8,557	2,828

Table 5 examines the relationship between cashflow uncertainty and investment in tangible assets, with financing and constraint, and the uncontrolled group. The analysis is conducted using the fixed effect model. Financially Constrained firms are identified in columns (1), while Financially Unconstrained firms are analyzed in columns (2). The dependent variable is expected new tangible investment ($Inew_{tang_{i,t}}$). The regression model includes variables cashflow uncertainty ($\sigma_{i,t}^{CF}$), growth opportunities ($MQ_{i,t}$), cash holdings (Cash), firm size (Size), leverage (Lev), return on equity ($ROE_{i,t}$), and age of the firm (Age). Significance levels are indicated by *, **, and *** representing the 10%, 5%, and 1% levels, respectively.

Table 6 Long run relationship of Cashflow Uncertainty, Financing constraint and Tangible investment

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Dep Variable:	Lag_1 ID	Lag_2 ID	Lag_3 ID	Lag_1 Industry	Lag2_Industry	Lag3_Industry
<i>Inew_{tang_{i,t}}</i>						
L. $\sigma_{i,t}^{CF}$	-0.049* (0.026)			-0.051** (0.025)		
L2. $\sigma_{i,t}^{CF}$		-0.016 (0.025)			-0.017 (0.022)	
L3. $\sigma_{i,t}^{CF}$			0.025 (0.025)			0.042* (0.024)
MQ	0.004 (0.003)	0.004 (0.002)	0.003 (0.003)	0.003 (0.003)	0.004 (0.002)	0.004 (0.003)
Cash	-0.155*** (0.011)	-0.131*** (0.011)	-0.144*** (0.011)	-0.155*** (0.011)	-0.131*** (0.011)	-0.144*** (0.011)
Lev	0.001 (0.005)	0.004 (0.005)	0.009 (0.006)	0.001 (0.005)	0.004 (0.005)	0.010* (0.006)
ROE	0.001 (0.002)	0.000 (0.002)	0.002 (0.002)	0.001 (0.002)	0.000 (0.002)	0.002 (0.002)
Size	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.002)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.002)
age_dummy	0.005 (0.012)	0.007 (0.013)	0.004 (0.014)	0.007 (0.012)	0.008 (0.013)	0.002 (0.014)
Constant	0.000 (0.005)	0.002 (0.006)	-0.000 (0.007)	0.007 (0.006)	0.004 (0.007)	-0.004 (0.008)
Observations	6,919	6,431	5,972	6,919	6,431	5,972
R-squared	0.033	0.028	0.034	0.034	0.028	0.034
Number of id	1,086	1,074	1,046	1,086	1,074	1,046
Notes: Table 6 presents the long-run relationship between cashflow uncertainty ($\sigma_{i,t}^{CF}$), financing constraints, and tangible investment, using fixed-effects estimations with lagged explanatory variables at both the firm and industry levels. Columns (1)–(3) introduce lagged cashflow uncertainty at the firm level (L. $\sigma_{i,t}^{CF}$, L2. $\sigma_{i,t}^{CF}$, L3. $\sigma_{i,t}^{CF}$), while columns (4)–(6) incorporate industry-level cashflow uncertainty to account for spatial and sectoral heterogeneity. The dependent variable is the tangible investment rate. Using lags captures the dynamic adjustment of investment behaviour in response to past uncertainty. Firm-level controls include Marginal Q (MQ), cash holdings (Cash), leverage (Lev), return on equity (ROE), firm size (Size), and firm Age. Standard errors are robust to heteroscedasticity and clustered at the firm level. R-squared values indicate model fit across specifications.						

Table 7 Alternative Measures of Cashflow Uncertainty, Financing Constraints, and Tangible Investment

VARIABLES	(1) CFU-industry_1	(2) CFU-industry_2
Dep Variable: $\mathbf{Inew}_{tang_{i,t}}$		
$\sigma_{i,t}^{CF}$	-0.026*** (0.009)	0.089*** (0.018)
Fincon		0.018*** (0.004)
$\sigma_{i,t}^{CF} * \text{Fincon}$		-0.077*** (0.019)
MQ	0.001 (0.003)	0.001 (0.003)
Cash	-0.131*** (0.009)	-0.129*** (0.009)
Lev	-0.011 (0.007)	-0.010 (0.007)
ROE	0.001 (0.003)	0.002 (0.003)
Size	-0.003 (0.004)	-0.003 (0.003)
Constant	0.021 (0.032)	0.008 (0.032)
R-squared	0.056	0.062
Observations	4,649	4,649

Notes: Table 7 reports the results from fixed-effects regressions examining the relationship between alternative measures of cashflow uncertainty, financing constraints, and tangible investment. Column (1) includes the industry-adjusted cashflow uncertainty measure calculated as the standard deviation of a firm's deviation from its industry's average cashflow (see Equations 8 and 9). Column (2) introduces an interaction term between cashflow uncertainty and a financing constraint dummy (Fincon), which equals 1 for firms identified as financially constrained (based on the Z-score threshold) and 0 otherwise. Firm-level controls include Marginal Q (MQ), cash holdings (Cash), leverage (Lev), return on equity (ROE), firm size (Size), and firm Age. Standard errors are robust to heteroscedasticity and clustered at the firm level. R-squared values indicate model fit across specifications.

Table 8 Alternative Measures of Financing Constraints

VARIABLES	(2) HP-index	(3) WW-index
Dep Variable: <i>Inew_{tang_{i,t}}</i>		
$\sigma_{i,t}^{CF}$	0.050*** (0.015)	0.042*** (0.010)
FC	0.003 (0.004)	0.009 (0.016)
$\sigma_{i,t}^{CF*FC}$	-0.036** (0.018)	-0.045*** (0.015)
MQ	0.001 (0.003)	0.001 (0.003)
Cash	-0.132*** (0.009)	-0.132*** (0.009)
Lev	-0.011 (0.007)	-0.011 (0.007)
ROE	0.001 (0.003)	0.001 (0.003)
Size	-0.003 (0.004)	-0.003 (0.004)
Constant	0.017 (0.032)	0.021 (0.032)
R-squared	0.057	0.058
Observations	4,649	4,649

Notes: Table 8 presents the results of robustness checks using alternative proxies for financing constraints, specifically, the Hadlock and Pierce (HP) and Whited and Wu (WW) indexes. The dependent variable is the tangible investment rate. Column (2) uses the HP index, while Column (3) applies the WW index as the financing constraint indicator (denoted as FC). The dependent variable is expected new tangible investment (*Inew_{tang_{i,t}}*). The regression model includes variables cashflow uncertainty ($\sigma_{i,t}^{CF}$), growth opportunities (*MQ_{i,t}*), cash holdings (Cash), firm size (Size), leverage (Lev), return on equity (*ROE_{i,t}*), and age of the firm (Age). Significance levels are indicated by *, **, and *** representing the 10%, 5%, and 1% levels, respectively.

Table 9 Cashflow uncertainty and Investment in Tangible Assets Overidentification IV Regressions

VARIABLES	(1) $\sigma_{i,t}^{CF}$	(2) $Inew_{tang_{i,t}}$	(3) $\sigma_{i,t}^{CF}$	(4) $Inew_{tang_{i,t}}$
$\sigma_{i,t}^{CF}$		-0.041** (0.020)		1.514 (1.085)
Fincon			-0.000*** (0.000)	0.123* (0.070)
$\sigma_{i,t}^{CF} * Fincon$			0.000*** (0.000)	-2.809* (1.474)
MQ	0.005*** (0.001)	0.003* (0.002)	-0.000*** (0.000)	0.004 (0.002)
Cash _{i,t}	-0.014** (0.006)	-0.158*** (0.013)	-0.000*** (0.000)	-0.148*** (0.021)
Size _{i,t}	-0.028*** (0.002)	0.005 (0.004)	-0.000*** (0.000)	-0.044* (0.026)
Lev _{i,t}	0.006*** (0.001)	0.001 (0.003)	0.000*** (0.000)	-0.010 (0.008)
ROE _{i,t}	0.007*** (0.000)	0.002* (0.001)	0.000*** (0.000)	0.004 (0.005)
Age	0.000*** (0.000)	0.000 (0.000)	-0.000*** (0.000)	0.000** (0.000)
Constant	-0.018*** (0.001)	-0.014* (0.008)	-0.000*** (0.000)	-0.108*** (0.041)
R-squared	0.128	0.035	0.296	0.064
Observations	11,385	6,565	11,385	6,565

Notes: Table 9 presents overidentification IV regression results examining the relationship between cashflow uncertainty and investment in tangible assets. The dependent variable is expected new tangible investment ($Inew_{tang_{i,t}}$). The regression model includes variables cashflow uncertainty ($\sigma_{i,t}^{CF}$), growth opportunities (MQ_{i,t}), cash holdings (Cash), firm size (Size), leverage (Lev), return on equity (ROE_{i,t}), and the firm's age (Age). The Significance levels are indicated by *, **, and ***, representing the 10%, 5%, and 1% levels, respectively.

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