Investment-cash flow sensitivity: Evidence from investment in identifiable intangible and tangible assets activities

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Abstract

In this study, we examine whether investments in fixed (identifiable) intangible assets and tangible assets are sensitive to cash flow and the extent to which this sensitivity differs for firms with different levels of financial constraints. Using both UK private and public firms' data, our overall analysis shows strong positive (negative) effects of cash flow on intangible assets (tangible assets) investments. When we split the data on the basis of listing status, we observe that cash flow is positively (negatively) and significantly related to intangible assets (tangible assets) investments for private firms but not so for public firms. In addition, we further observe that both public and private firms' investments follow a similar pattern when we split our data based on the availability of internal funds. Moreover, we also find that the sensitivity of investment (identifiable intangible assets) to cash flow is higher for young and large private firms but lower for small and old ones. Our results remain similar to other econometric specifications which account for possible endogeneity issues.

Keywords: Cash flow, tangible assets, intangible assets, UK.

JEL Classification: G32, G39

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1. Introduction

As part of the wider intellectual discourse around corporate finance, there is a growing body of studies that attempts to understand how cash flow affects various corporate behaviours (e.g., see Naoum & Papanastasopoulos, 2021; Lewellen & Lewellen, 2016; Hovakimian & Hovakimian, 2009; Almeida et al., 2004). For instance, theoretically, a firm with high cash flow (henceforth CF) would be expected to invest more than those with lower CF as a result of the low cost of capital associated with internally generated CF (Lewellen & Lewellen, 2016; Chen et al., 2016). However, empirical studies suggest that the cash flow–investment relationship remains controversial as evidence has mainly been mixed. For instance, while Fazzari et al. (1988) in their seminal paper provide evidence of a high level of investment–cash flow sensitivity (hereafter ICFS) for firms that face financing friction, Kaplan and Zingales (1997) provide contrasting evidence that demonstrates that financially unconstrained firms exhibit more ICFS than constrained firms. Chen and Chen (2012) extend the literature by offering evidence of declining sensitivity over time. They even claim that the ICFS has completely disappeared in recent times, although they are unable to provide any theoretical argument in support of this disappearance and term it as a puzzle. However, Moshirian et al. (2017) point out that this decline of sensitivity could be due to falling capital intensity and a rise in R&D investment in recent times. Interestingly, a parallel stream of research such as Faulkender and Petersen (2012), Lewellen and Lewellen (2016) and Kashefi-Pour et al. (2020) finds evidence of strong ICFS. Another piece of work, by Alti (2003), provides robust evidence of ICFS using a baseline case where there is no financial friction.

Although the ICFS literature has been growing over time, the consensus is far from conclusive. Moreover, this literature mostly considers tangible investment, leaving fixed or identifiable intangible assets (hereafter IA) virtually under-researched. This is against the backdrop that IA investment is becoming increasingly essential to many countries as there is abundant evidence to suggest that IA enhances labour productiveness, augments firms' CF and value (Adu-Ameyaw et al., 2022; Lim et al., 2020). Commensurate to this economic importance, investment in IA has been growing substantially over the years. For example, Corrado et al. (2016) report that the share of IA in GDP rose considerably during the period of 2000-2013 among advanced economies. For instance, the average contribution of such intangibles in US GDP is about 8.8% and for the UK it is about 9% for that period. Since the start of the new millennium, the investment in IA has outpaced investment in tangible assets (hereafter TA) both in the USA and the UK. Goodridge et al. (2016) report that UK investment in IA has been greater than that in TA from the onset of 2000s. In 2014, investment in TA was £121 billion whereas investment in IA in the same year was £133 billion. Given this apparent importance and growth of this activity in recent years, it is essential to explore the extent to which IA investment is sensitive to CF.

Thus, based on the information asymmetric (Myers & Majluf, 1984; Myers, 1984) and agency theoretic points of view (Jensen, 1986, 2001), we examine the sensitivity of investments (IA and TA) to changes in firm CF by using panel data of both public and private UK firms during 2006-2015. Examining the impact of CF on investment (i.e., IA and TA – ICFS) is crucial in that it provides a vital insight into how CF affects one of the key strategic decisions of firms. Next, we assess the extent to which ICFS is influenced by internal financial constraints faced by public and private firms. Additionally, we explore the degree to which ICFS is conditional on external financing constraints (i.e., firm size and age). Our study differs from prior works that variously examined investment in fixed IA and TA (Lim et al., 2020; Peter & Taylor, 2017; Almeida & Campello, 2007). For instance, Peter and Taylor (2017) look at the impact of growth opportunity on total investment (defined as IA plus physical assets). Others including Lim et al. (2020) also consider the impact of fixed IA on leverage. We extend the existing literature and make an important contribution to it by examining the sensitivity of IA investment to internal CF. More so, the noted controversy in the fixed TA–CF sensitivity literature (see Chen & Chen, 2012; Lewellen & Lewellen, 2016; Moshirian et al., 2017; Kashefi-Pour et al., 2020) furthers our incentive to re-investigate this issue in our present study. In fact, this study provides a complete view of investment–cash flow analysis by considering these two most important types of investment in a single study using a large dataset of UK public and private firms.

By way of a preview, results from our analysis indicate that CF exerts a positive impact on investment in IA, suggesting that firms with high CF are prone to increase their investment in such assets. When the sample is split based on the listing status (public and private), we find a positive coefficient on CF for both public and private firms but with only private ones exhibiting or showing statistical significance. This implies that the privately-held firms' IA investment is more sensitive to internally generated funds compared to that of the publicly-held firms. On investment in TA, we observe a statistically significant negative link with CF, and this decreasing effect is much more pronounced among privately-held firms than among public ones. This result further corroborates the decreasing sensitivity of TA–CF. Further, when the data is divided based on funds that are internally available to the firms (public or private), it is observed that the sensitivity of IA investment to CF completely disappears. That is, at higher CF levels, we see a statistically strong negative relationship between IA and CF for both public and private firms. However, at lower CF levels, firms' (public and private) IA activity shows an increasing relationship with CF. This evidence seems to suggest that, at lower CF levels, firms may become unattractive to debt markets, hence their reliance on internally generated funds to sponsor IA. On TA, we find a decreasing investment–cash flow relationship for lower CF firms but an increasing effect for those higher CF ones. More so, on the external financial constraints (using size and age as proxies), we find that, for smaller public firms, CF–IA investment sensitivity is positive but insignificant while the smaller private ones show a statistically significant negative effect. However, CF– IA investment sensitivity is positive and significant for larger private firms. Also, we find a lower TA–CF for privately-held firms. Further, we observe an increasing CF–IA investment relationship for younger private firms. This finding suggests that young private firms are prone to experience high financial constraints, hence sponsoring IA investment with internal CF.

We perform other tests to ascertain how robust our initial results are. First, we decompose our data into private and public firms and examine the CF–IA and TA investment sensitivity. Secondly, apart from using OLS estimation, we adopt a fixed effects (FE) model to counter any time-invariant covariates. Further, we deal with reverse causality and endogeneity by employing a predicted model, instrumental variable (IV) and simultaneous equation model (SEM). In all these tests and estimations, our results remain unchanged.

Our study makes the following contributions. First, we document that CF is a key determinant of investment in IA. By so doing, our paper builds on the firm CF literature (e.g., see Guizani, 2021; Stellian & Danna-Buitrago, 2020; Lewellen & Lewellen, 2016; Faulkender et al., 2012; Chay et al., 2009) and explores the CF–IA relationship and, particularly, examines the extent to which this relationship matters for both public and private firms. To the best of our knowledge, this is among the first studies to consider this relationship by using UK public and private firms. Again, we also contribute to the TA investment–CF sensitivity debates. We offer further corroborating evidence on the decreasing sensitivity of tangible assets to CF. Our next contribution is with respect to the role of internal financial constraint in the ICFS. Here, we reveal that the sensitivity of IA and TA investment to CF responds differently among financially constrained and unconstrained firms. This nuanced evidence has implications for the theoretical interpretation that higher sensitivity is an indication of financing constraints. We argue strongly that such an interpretation is limited to TA firms. Our next contribution stems from the role of external financial constraints (such as size and age) in the IA and TA investment–CF relationship. Specifically, we show that the IA–CF sensitivity is positive for young firms but negative for small ones. Thus, we demonstrate that increased asymmetric information strengthens (weakens) IA investment–CF sensitivity for those young (small) privately-held firms. This adds to the literature on IA by showing the extent to which young and small firms deploy internally generated funds when they face informational asymmetry problems. Overall, our study adds to the expanding literatures that look at the role of CF in influencing an important corporate policy – investment in IA and TA.

The rest of the article is organised as follows: we look at the related literature in section 2. Data and the empirical method used in the study are discussed in section 3. We present our results and discussion in section 4 and, finally, we conclude the study in section 5.

2. Related literature

The ICFS arises due to under- or over-investment problems, and this can be explained by two principal arguments: information asymmetry and agency conflict (Pawlina & Renneboog, 2005). The asymmetric information hypothesis (Myers & Majluf, 1984) postulates that there is always a considerable level of information asymmetry between corporate managers and investors. Corporate managers have better information about corporate prospects than outside investors, and therefore the return expectation for investment would be higher for the managers compared to the investors. This essentially means that managers would not be able to adequately obtain the required external funds for investment projects, which would lead to an under-investment problem. As the information asymmetry problem is significantly higher for IA investment, as suggested by Loumioti (2012), the under-investment problem should be more severe for IA, and therefore we should expect a higher level of ICFS for IA. In regard to the agency conflict hypothesis (Jensen, 1986, 2001), corporate managers' interests may not be fully aligned with those of the shareholders. Such a nonalignment of interests leads to differences in risk-taking appetite between the two groups (Eisenhardt, 1989). Shareholders may prefer risky investments in order to earn higher returns, but managers may avoid making risky investments, to protect their future position (Makadok, 2003). Thus, managers would only invest in risky intangibles if the internally generated CF was higher.

Scholarly evidence suggests that the distinctive nature of intangible investment makes such activity more susceptible to the asymmetric information problem, which can consequently lead to possible financing constraints (Brown et al., 2009). Unlike tangible investment, intangible-intensive firms often reveal minimal information on their operational activities for market consumption. This is because a firm's activities are often tacit and firm specific; that the firm mainly has a soft capital assets base; that there is low salvage value in the event of bankruptcy; and that the firm operates in secrecy, fearing imitation of its ideas. Thus, the minimal flow of information on such projects makes external financiers unwilling to finance them. However, given the relative value importance of fixed IA investment, i.e., to increase future CF (Corrado et al., 2009), it is plausible that the change in a firm's fixed IA investment should be more sensitive to internal CF if indeed information asymmetry exists in the financial markets. In addition, if the IA-intensive firm can reliably generate greater CF from its IA activities (e.g., Gourio & Rudanko, 2014; Corrado et al., 2009), then it is likely to be seen as low risk by lenders, thereby gaining the confidence of credit financiers (Lim et al., 2020). With this, it is reasonable that a rational risk-averse manager is more likely to employ internally generated funds for financing IA compared to tangible asset (TA) activity. Based on the above argument, we make a natural prediction that a firm's internal CF and IA investment are likely to be positively determined, all else being equal. Furthermore, the literature on the TA investment–CF linkage is inconclusive. For instance, while some empirical studies find an increasing sensitivity of TA–CF (e.g., Kashefi-Pour et al., 2020; Agca & Mozumdar, 2017; Lewellen & Lewellen, 2016; Chen et al., 2016; Guariglia & Carpenter, 2008; Guariglia, 2008), others including Moshirian et al. (2017) and Chen and Chen (2012) observe a decreasing linkage. The decreasing (disappearing) relationship has been attributed to the recent substantial spending on IA (Moshirian et al., 2017). The present study seeks to bring further clarity to this issue by investigating both IA and TA investment in a single study. This is important considering that the closely related research (Guariglia, 2008; Cleary et al., 2007; Almeida & Campello, 2007) has provided no conclusive evidence on the subject matter (ICFS) using different sample data. In particular, Cleary et al. (2007) analyse how firms' internal funds affect investment by using data from US firms. The authors find a strong negative association between them and attribute the mixed results reported in the literature to the restrictive assumptions often employed in other models. Pertaining to internal financial status, they observe that financially unconstrained firms display higher investment–cash flow but those constrained ones exhibit lower effects. Guariglia (2008) furthers the discussion on the sensitivity of investment to internal and external funds using UK unlisted firms. Employing a large panel data set, the author reports a U-shaped association between fixed tangible assets investment and internal cash but shows higher sensitivity for those young and small firms.

In fact, our present paper differs from prior works (e.g., Guariglia 2008; Cleary et al., 2007) in different ways. First, firms with different listing status may tend to face different financial market constraints (Guariglia 2008; Saunders & Steffen, 2011), hence investment behaviour in IA among quoted and unquoted firms is likely to differ. Our novel dataset enables the study to further examine how these two separate entities' IA investment behaves relative to their internally generated funds. More so, it is further suggested that the way in which firms devote their internally generated funds to investment is dependent on the nature of the information asymmetric problem they face (Guariglia, 2008; Cleary et al., 2007; Carpenter & Petersen, 2002a, 2002b). That is, a firm experiencing a high asymmetric information problem may keep higher levels of internal CF to mitigate possible under-investment problems; likewise, lower levels of internal CF would be expected for those facing a minimal information asymmetric problem (Guariglia, 2000; Carpenter & Petersen, 2002b; Benito, 2005; Cleary et al., 2007). For instance, Cleary et al. (2007) argue that ICFS is driven by the cost and revenue effect. In this case, the cost effect arises when firms with greater levels of internal funds are found to experience an increasing investment–CF relationship; however, the revenue effect prevails for those firms with lower internal CF, suggesting a negative investment–CF relation. In fact, these predictions tend to show that the level of internal financial constraints that firms face may tend to have different impacts on the investment–CF relationship, particularly given the different listing status. Our varied sample observations enable us to specifically circumvent the limitation of data invariability highlighted by Cleary et al. (2007). In the same way, we further extend the work of Guariglia (2008) which only concentrated on fixed tangible assets of UK unquoted firms. Thus, we test whether high sensitivities of IA and TA investment to CF are an indicator of a firm experiencing financial constraints. Moreover, firms' specific attributes such as size, age, ownership structure, dividend pay-out and opaqueness are seen to impact their ability to raise external finance (Saunders & Steffen, 2011; Guariglia 2008; Fazzari et al., 1988). These firm-related features make a firm more sensitive to the impacts of information asymmetries, hence the need for the firm to adjust its internal financial policy to minimise possible under-investment in IA and TA. For instance, small firms are usually prone to information asymmetry effects because there is little public information about such firms, thus posing a challenge for financial markets to obtain information about them (Guariglia, 2008). Also, the intangibility of the assets is likely to further worsen asymmetric information problems for these firms compared to firms with TA (Brown et al., 2009). Therefore, accessing external finance may be difficult and expensive for firms with only IA (Bernanke et al., 1996), thereby making it likely for these firms to rely predominantly on internal funds. Based on this plausible assertion, we seek to provide additional evidence on how these firm-related characteristics, size and age (i.e., proxies for capturing the level of external financial constraints), affect how firms devote internal cash for IA and TA investment.

3. Data and estimation method

3.1. Data

In this study, we utilise UK data (both private & public firms) starting from 2006 to 2015. We acquired this data from the Amadeus database, which covers financial information for a number of European firms. The distinctive coverage of the database allows us to simultaneously analyse both public and private firms. We follow other studies (Lim et al., 2020; Guariglia, 2008; Cleary et al., 2007), and avoid the inclusion of financial and utilities firms in both the public and private sample firms employed in our analysis. Similar to Guariglia (2008), we do not include firms with less than three years of continuous data. In all, our data comes to 1,358 UK public companies showing 12,356 annual observations and a total of 604,369 annual observations on 61,278 UK private companies. Thus, our overall analysis is based on 616,725 annual observations of firms across 10 different industries over the sampled period.

3.2. Variable measurements

3.2.1. Dependent variable – IA and TA investment

Our main dependent variable – fixed IA investments – is identifiable non-monetary assets devoid of physical substance purchased by firms, which include brands, copyrights, patents and software. Thus, we measure our dependent as the ratio of total annual fixed/identifiable intangible assets to total assets, like Lim et al. (2020). We capture the sensitivity by using the annual ratio changes in values of IA investment, like Badertscher et al.'s (2013) approach. Also, the TA investment variable is measured as the ratio of total fixed tangible assets (i.e., net investment in property, plant and equipment) to a firm's overall assets, similar to prior work (Allayannis and Mozumdar, 2004). We capture the sensitivity using the annual ratio changes in TA investment.

3.2.2. Independent variable – cash flow

Our independent variable is CF measured as the ratio of free cash flow to the book value of total assets (Guariglia, 2008; O'Connor et al., 2013). For robustness purposes, we measured an alternative independent variable (CF2) as total income before extraordinary items (deferred tax, interest), plus depreciation and amortisation divided by total assets, consistent with prior research (Ascioglu et al., 2008; Chen & Chen, 2012). Again, we use annual ratio changes in the level of cash flow variable (CF or CF2) to capture the sensitivity.

3.2.3. Controls

We also include the following variables in our model as controls: leverage (LEV), firm size (SZ), sales growth (GR), net working capital (NWC), cash holdings (CH), firm years of operation (FA), non-debt tax shields (NDT) and profitability (PR). Again, we include industry and time fixed effects in the model. All the variables are defined in Table 1.

[Table 1 about here]

3.3 Model specification

We develop our empirical model to test our cash flow–investment (IA and TA) by stating our econometric model as:

$INV_{it} = \alpha + \beta_1 CF_{it} + \beta_2 laggedINV_{it} + \beta_3 Controls_{it} + \varepsilon_{it}$ ………………………………….. (1)

Where *INV* is either IA investment and/or *TA* investment defined in Table 1. Thus, we specify the individual model below:

$IA_{it} = \alpha + \beta_1 CF_{it} + \beta_2 laggedIA_{it} + \beta_3 Controls_{it} + \varepsilon_{it}$ ……………….………….…….. (1a)

$TA_{it} = \alpha + \beta_1 CF_{it} + \beta_2 laggedTA_{it} + \beta_3 Controls_{it} + \varepsilon_{it}$ ………………..………..….. (1b)

In estimating equations (1a) and (1b), we first employ OLS and FE techniques to analyse our sample. We lagged our independent variable by one year to reduce endogeneity problems. In addition, we also use more sophisticated estimators comprising predicted model, instrumental variable (*IV*) method and simultaneous equation model (SEM using a three-stage least squares, *3SLS*, technique) for robustness checks. The rationale for these further tests is that better firms may anticipate market friction and, as a result, prepare for it. More so, firms may use cash flow for multifaceted reasons: reduce debt, increase cash holdings, increase working capital, dividend pay-out, and share buy-backs (Lewellen & Lewellen, 2016; Allayannis & Mozumdar, 2004). These confounding factors are likely to affect the outcome of our main results. Therefore, we employ a relatively more robust specification such as predicted model, instrumental variable (*IV – using 2SLS*) and simultaneous equation model (*SEM*) techniques to make sure our base model does not suffer from endogeneity issues.

4. Results and discussion

4.1. Descriptive statistics and correlations matrix

Table 2 shows the descriptive statistics of the main variables used in our study. It is worth pointing out a few results here: CF shows an average of 0.001 with a standard deviation of 0.010 and the minimum and maximum values -0.030 and 0.030 respectively. CF2 also shows an average of 0.002 (standard deviation is 0.108) with minimum and maximum values of -0.963 and 0.967 respectively, exhibiting a reasonable degree of heterogeneity. IA investment shows an average value of -0.001 and a standard deviation of 0.052. Also, TA investment shows an average value of 0.164 and a 0.224 standard deviation. These variables have minimum and maximum values of -1.892 and 1.849 and 0.000 and 0.653 respectively. In short, the reported low values may reflect our measure of both dependent and independent variables (i.e., changes in yearly values).

Table 3 also shows the correlation matrix analysis for our sampled variables. Overall, the correlation matrix results, as well as the summary statistics, seems to show no serious concerns of multicollinearity, heterogeneity and/or limited variation.

[Tables 2 & 3 about here]

4.2. The effect of cash flow on investments

In Table 4, our baseline regression results show the effect of CF on IA and TA investment. We use two estimators to test our model, OLS and FE, and the findings of our fully specified models OLS (2 & 6) and FE (4 & 8) are reported in the specified Table 4. It is worth pointing out that our main results are based on FE models (4 & 8) because the OLS estimator may not be robust enough to deal with unobserved heterogeneity and possible endogeneity of regressors (see Guariglia & Carpenter, 2008; Brown & Petersen, 2009; Lewellen & Lewellen, 2016). As suggested by Brown and Petersen (2009), the standard technique to analyse investment–cash flow sensitivity is to run a fixed effect panel regression where investment is regressed on CF and other related determinants. Specifically, in models 4 and 8, the results show that CF has a positive and significant impact on IA investment. This impact remains significant after introducing conventional control variables into the fully specified model, Model 4. More specifically, the estimated coefficient is 0.088 (t-statistics 10.53), indicating that an increase in CF is associated with an increase in IA activity. This result supports our main prediction that the intrinsic nature of IA makes traditional loan acquisition difficult and expensive, thereby causing firm managers to sponsor IA investment from internally generated funds. In other words, the unique features (i.e., information asymmetry, high irreversibility, asset substitution and low collateral value concerns) associated with IA cause firms to store more internal funds in order to minimise IA under-investment resulting from possible financial market frictions (Brown et al., 2009; Borisova & Brown, 2013). However, our fully specified Model 8 results show a negative effect of CF on TA investment. The reported coefficient estimate is significantly negative at 1% confidence level, suggesting that higher firm CF leads to lower TA investment. This outcome is consistent with Chen and Chen (2012) but inconsistent with the view that capital tangible assets investment decisions of constrained firms are more sensitive to internally generated CF (Lewellen & Lewellen, 2016; Guariglia & Carpenter, 2008; Kaplan & Zingales, 1997).

In addition, we perform further similar analyses using an alternative measure of the independent variable CF2 and regress investment (i.e., *IA* and *TA*) on CF and other control variables. Again, in Table 5, the coefficient estimate on CF remains positive and statistically significant in models 1 & 2 (*IA*) but it is negative in models 3 & 4 (*TA*), providing further collaborative findings to what is already reported in models 4 and 8. Overall, our empirical analysis shows that the sensitivity of investment to CF differs among IA investment and TA investment.

[Table 4 about here]

[Table 5 about here]

4.3. Robustness tests

We perform further tests to show that the reported findings do not suffer from any endogeneity problems. This is plausible given that a firm may use internal CF to augment cash holdings or reduce outstanding debt as well as spending on share buy-backs and dividend payments (see Faulkender et al., 2012; Guariglia & Carpenter, 2008). Clearly, these confounding factors are likely to correlate with CF to affect investment (IA and TA) decisions. To deal with this possibility, we adopt relatively more robust specifications, predicted model, instrumental variable (*IV-2SLS*) model and simultaneous equation model (*SEM using 3SLS estimator*), to see if indeed our results still remain valid.

First, we adopt a predicted model approach to further test our investment–cash flow sensitivity. Here, we first regressed CF on lagged investment (*IA and TA*) and the control variables to derive the fitted values of CF which are included in the main investment (*IA and TA*) model. More specifically, in Table 6 the predicted model estimates for both *IA* (Model 1) and *TAN* (Model 2) show a positive and negative coefficient sign on CF, further confirming our main results in Table 4.

Second, we provide further evidence by estimating an instrumental variable (*IV – 2SLS*) method. Thus, employing the instrumental variable approach, the model is able to account for possible changes associated with the use of a firm's CF. For instance, Fazzari and Petersen (1993) argue that firms tend to manage their internal funds to continuously keep activities smooth in the face of transitory finance shocks. Faulkender et al. (2012) also show that corporate officers manage CF to efficiently lower the cost of borrowing. This evidence shows possible simultaneity issues that are likely to affect managerial financing and investment decisions (Brown & Petersen, 2011; Almeida, Campello, & Gavao, 2010). In fact, such cases can lead to wrong inferences about the importance of financing constraints for investment decisions when less sophisticated (e.g., OLS, fixed effects) models are used. That is, employing an *IV-2SLS* approach, we can better deal with simultaneity concerns in the CF regression (i.e., first-stage) model. In the CF model, we include instruments which explain the firm's (public or private) decision to achieve optimal CF level and that the instruments should not directly explain investment (IA and or TA) decision except through the overall characteristics of the firm. For instance, Roberts and Whited (2013) suggest that the key feature for a valid instrument is that it should affect the dependent variable (i.e., *IA and TA*) only through its effect on the independent variable (CF) based purely on economic intuitions. As earlier indicated, firms can use CF for these reasons: increase cash holdings, invest in working capital, reduce debts, spend on dividends and share buy-backs. In fact, due to the nature of our data sample (public and private), we do not account for cash dividend pay-out and buy-back shares in the first-stage (CF) model as no such data is reported for private firms. More specifically, industry-median earnings or profits and industry-median growth are used as our instrumental variables, and they are relevant for the following economic reasons. First, managers with superior or exceptional ability can efficiently manage corporate resources (including internal cash) to achieve higher value for the owners. That is, given similar resources, corporate officers with superior ability should be able to generate higher profits than their peers in the same industry (Lee et al., 2018; Demerjian et al., 2012). Second, these corporate managers can identify industrial trends better, thus leading them to better predict product demand, adopt appropriate financing strategy (i.e.., adjusting internal cash) and invest in better growth opportunity projects. Of course, firms operating in high growth opportunity industries are likely to appoint officers with high managerial ability to manage their operation. Consistent with this view, some studies (e.g., Lee et al., 2018) find a strong link between managerial ability and growth opportunity and suggest that managers with superior ability are likely to identify opportunities. Building on this, we reason that industry growth opportunity and managerial ability (proxied as industry-median earnings/profits and industry-median growth respectively) are likely to affect how managers use internally generated CF to fund investment projects. Again, it is less likely that the industry-level instruments will have a direct effect on investment, particularly after accounting for industry and year fixed effect. It is also unlikely that the industry proxy will be impacted by any individual firm's policies and, hence, it is expected to be orthogonal to the residuals of the investment (*IA and TA*) regression model. Moreover, as such, satisfying these relevant conditions (i.e., economic reasons and validity), we expect the chosen instruments to be statistically significant and that the overall model should display a higher *F-statistic* (above 10 as a rule of thumb) figure. That is, in the first-stage regression, CF is regressed on IA, TA investment, instruments (*IND_PR* – industry-median earnings – and *IND_GR* – industry-median growth) together with other controlled regressors to obtain the 'purified CF variable' to be included in the main investment (*IA and TA*) regression model. The coefficient estimate of the purified CF is our key variable of interest.

Specifically, the empirical results of our instrumental variable regression are reported in Table 6 and a few things are worth pointing out regarding the validity of our chosen instruments and the overall model specification. To assess the validity of our adopted models, IA and TA, we report the following results: weak instruments identification tests (Craig-Donald Wald F-Statistic – 15.76 and 16.76, i.e., supporting the validity of the instruments), Sargan statistic of over-identification restrictions (which tests the null hypothesis that our instrumental variables are jointly exogenous – 85.68 and 68.51) and the endogeneity tests (122.04 and 5.40). These statistical reports indicate that our chosen instruments are appropriate (Sargan, 1958; Barth et al., 2013). Also, all the models show an F-statistic that is greater than Stock-Yogo's weak test critical values and Staiger and Stock's (1997) minimum critical value of 10 (as a rule of thumb), suggesting no apparent weak instrument problem. Further, the endogeneity test is also significant in all cases, providing enough evidence to reject the null hypothesis of exogeneity. Thus, our endogeneity check indicates that the independent variable (i.e., CF) is not exogenous, hence the need to resolve this endogeneity concern via instrumental variable (*IV-2SLS*) estimation (Baum et al., 2007; Xing et al., 2021).

More directly, the reported first-stage (CF) results show higher IA, TA, leverage, growth, firm age and profit but lower cash holdings, lower size, net working capital and growth (see Lewellen and Lewellen, 2016; Faulkender et al., 2012). Our instruments' (industry-median earnings and growth) coefficients are generally of the predicted sign, and it is statistically significant. Thus, we show the results of the main test together with our selected instruments *(IND_PR -0.045 stats -5.44 and IND_GR 2.149, stats 4.95*) coefficient and the *F-statistics* at the bottom of the instrumental variable regression (Table 6). The CF coefficient estimate is positive and statistically significant at the 1% level, suggesting that higher internal CF leads to more investment in IA but less in tangible assets activities.

Taken together, in Table 6, the results obtained using both the predicted model and instrumental variable (*IV-2SLS*) specifications further validate our main findings reported in Table 4.

Throughout our empirical analyses, we have employed different specification techniques to address the simultaneity and potential endogeneity issues associated with the financing and investment decisions of firms. Again, to further check the validity of our claim, we adopt a 3SLS technique to a simultaneous equation model to see if indeed IA and TA investment decisions are still sensitive to internal CF. Again, in Table 7, like what was observed before, we still find that CF has a positive (negative) effect on *IA* (*TA)* investment.

In short, based on the results obtained using these different econometric techniques, we can confidently conclude that firms with more internally generated CF tend to invest more in IA but less in TA investment.

[Table 6 about here]

[Table 7 about here]

4.4. Cash flow and investment – public vs. private firms

In this section, we examine whether the different listing status of firms affects how they sponsor different types of investment from the internally generated CF. This is because unquoted (private) firms tend to face different market challenges compared to quoted (public) ones. For instance, compared to publicly-held firms, privately-held firms often exhibit these characteristics: lower quality of accounting information disclosure (Ball & Shivakumar, 2005), pay higher information-based rent (Santos and Winton, 2008), have limited financing options (Badertscher et al., 2013), have higher costs of debt (Saunders and Steffen, 2011), and are more responsive to investment opportunities (Badertscher et al., 2013). Given these apparent characteristics, it is highly probable that private companies are more likely to adjust their internal financial policy to minimise the consequential impact of forgoing investment opportunities. Consistent with the above, we posit that, compared to public companies, private ones are more likely to sponsor these types of investment activities (i.e., IA and TA) from their internal CF due to possible financial inflexibility problems.

To perform this empirical test, we segregate the entire sample into public and private firms and estimate our baseline equation using a fixed-effect regression analysis to see how these firms' investment activities (*IA* and *TA*) behave relative to their CF.

Specifically, Table 8, models 1 & 4 and 7 & 10, reports the findings for the respective firms. For public firms (Model 1), the coefficient on CF is positive but statistically insignificant, while private ones (Model 7) show a significant positive coefficient on CF. The results tend to suggest that the sensitivity of IA investment to CF is more pronounced or manifested among private firms compared to public ones. This is unsurprising because unquoted (private) firms tend to face a higher financial inflexibility issue and higher costs of borrowing (Badertscher et al., 2013; Saunders and Steffen, 2011; Santos and Winton, 2008), and these financial constraints are likely to cause them to sponsor IA investment from their internally generated funds. However, the low reported statistical significance for public firms shows the lower sensitivity of IA investment to internal funds, supporting the financial flexibility power often enjoyed by these firms. Thus, IA are seen as collateralisable items, making it easy for these public firms to obtain external debt to finance IA activity (Lim et al., 2020). Moreover, with respect to TA investment, both public (Model 4) and private (Model 10) firms' results show a negative sign on CF with only private ones being statistically and economically significant. This strong negative TA investment–cash flow sensitivity suggests that an increase in CF leads to lower TA activities particularly for private firms. In short, our empirical evidence posits that private firms' investment activities are more sensitive to CF compared to public ones.

4.5. Cash flow and investment – the impact of internal financial constraints

The evidence in Table 8, models 1 and 7, shows that, compared to public firms, privately-held ones are more concerned about the presence of financial market frictions and that they are likely to rely on internal cash to support investment activities. In this section, we further narrow our analysis to how firms of each respective status specifically devote internal cash flow to minimise the possible financing constraints problem associated with investment. That is, for instance, if a public-listed firm is less concerned about the possible market financing frictions arising from the nature of its investment activity, it is more likely to deploy lower (negative) internal CF to such activity. Contrary, a private firm is more likely to deploy enough (positive) internal cash if it is more concerned about possible financing frictions arising from the investment nature in order to minimise under-investment in that activity. In other words, the degree of financial friction a firm faces depends on how it devotes its internal CF to mitigate its possible under-investment. In support of this view, Guariglia (2008), Cleary et al. (2007) and Benito (2005) contend that firms with fewer (more) financing constraints are likely to keep a low (high) internal CF, thereby observing low (high) investment–cash flow sensitivities. That is, less (more) financially constrained firms (public vs private) are likely to experience a lower (greater) investment–cash flow connection. More so, given that the nature of investment activities (fixed IA and TA) poses different risk-related problems to creditors and lenders, it is highly plausible that firms anticipating high (low) market frictions are likely to devote more (less) internally generated cash to prevent such activity. With this in mind, we empirically test whether CF has a differential impact on IA and TA investment, given the different degrees of financial constraints arising from the investment nature.

To achieve this purpose, we first categorise the firms into two (i.e., public and private) groups based on their listing status. This is done to achieve two main objectives: first, to minimise existing heterogeneity among public and private firms and, second, to understand if indeed our data is typically explained by the financial constraint argument or hypothesis (Guariglia, 2008; Fazzari et al., 1988). We follow prior works (Cleary et al., 2007; Guariglia, 2008), and split firms into four quartiles based on their CF and construct these two main dummy variables: NCF – represents CF of firms in the lower quartile (25^{th} percentile – negative CF values), which is equal to one (1), otherwise zero (0), whilst PCF shows those firms in the upper quartile (75^{th} percentile – positive CF values) and it is indicated by one (1), otherwise zero (0). To achieve our aim, we multiply these dummies by the CF values, i.e., interaction terms (*NCF or PCF x CF*), and include the interaction terms (*NCF*CF or PCF*CF*) together with the respective dummies, i.e., NCF and PCF, in the investment model (*IA* and *TA*). Thus, we specifically modify our main model to test the differential impact of the marginal effects of CF negative (NCF) and positive (PCF) dummies or interaction terms for each public and private firm. We show our results in Table 8, and all models include both year and firm fixed effects with standard errors clustered at the firm level.

In Table 8 of models 2 & 3, we observe that the coefficient associated with the interaction terms *CF*NCF* is positive while *CF*PCF* exhibits a negative sign, and both are statistically significant. Specifically, the positive estimate on the *CF*NCF* variable implies that public firms with lower or negative CF invest more in IA but those with sufficiently positive or higher CF (*CF*PCF*) tend to decrease investment in such activity. That is, *IA*–CF sensitivity is positive for more financially constrained (lower CF) firms but negative for those less constrained (higher CF) ones. Thus, those most constrained firms may experience restricted access to external financing and tend to rely more on internal CF, positing higher *IA*–CF sensitivity. Further, the results show that the less constrained firms may not keep higher CF to mitigate possible internal financial constraints or frictions associated with IA investment. An explanation can be that higher CF (public) firms easily attract bond market confidence because they are seen as less risky by investors, which ultimately causes these firms to be less dependent on internally generated CF to fund IA activity. Also, fixed IA serve collateral purposes, thereby enabling those firms to easily fund IA investment from other external sources (Lim et al., 2020). Thus, these firms are likely to have a large share of debt which depletes CF, albeit higher debt servicing payment, thereby making it unlikely for them to sponsor fixed IA using internally generated CF. Similarly, in models 8 & 9, the privately-held constrained firms with sufficiently negative (*CF*NCF*) CF values increase IA activity, while those with sufficiently positive (*CF*PCF*) CF values also strongly show a drop in IA activity. That is, IA investment decisions of most constrained private firms show higher sensitivity to internally generated CF, but those of the least constrained ones display a lower effect. This indicates that those firms with a higher CF do not extremely keep the CF above the optimal level, to mitigate possible under-investment in IA.

Moreover, in models 5 & 6, the publicly-held firms with sufficiently negative (*CF*NCF*) CF values significantly show a negative sign on TA investment, while those with sufficiently positive (*CF*PCF*) CF values show a positive sign. Thus, the coefficient estimates are -0.742 (t-statistics -1.96) and 0.585 (t-statistics 1.50) for the most constrained (*CF*NCF*) and least constrained (*CF*PCF*) firms respectively. This suggests that those public firms with negative

CF show lower TA investment–cash flow sensitivity. However, those with positive CF display an increasing connection of TA investment to internal CF. The only caveat of this finding is that the estimate missed out on its statistical significance. Similarly, for those privately-held firms in models 11 & 12, we find the coefficient estimates to be *CF*NCF -0.*417 (t-statistics -2.41) *and CF*PCF* 0.663 (t-statistics 3.87) respectively. The results suggest that private firms with sufficiently negative CF values show lower TA investment–CF sensitivity but higher sensitivity is shown by those with sufficiently positive CF, consistent with Guariglia (2008).

Overall, our evidence shows that IA investment–CF sensitivities are higher for more financially constrained public and private firms and are lower for those less constrained ones. This is consistent with a view that investment decisions of the most financially constrained firms are more sensitive to internally generated CF than those of lesser financially constrained ones (Hubbard, 1998; Brown et al., 2009). However, TA investment–CF sensitivities are negative (lower) for more financially constrained entities and are positive (higher) for those less constrained. Thus, the reported differing effects of financing constraints on ICFS (i.e., *IA - CF* and *TA – CF*) show support for Cleary et al.'s (2007) revenue and cost effect hypothesis. It suggests that firms with lower CF would need to invest more (*IA – CF*) to generate enough revenue to prevent default risk; however, those with higher CF tend to avoid high borrowing, high repayment cost and the risk of default, thereby exhibiting positive TA – CF sensitivity. Both public and private firms strategically deploy CF to mitigate the implications of these effects.

[Table 8 about here]

4.6. Cash flow and investment – the impact of external financing constraints

So far, our analysis reveals the role of a firm's internal CF status in influencing investment activities. Furthering this proposition, the literature shows that the level of financing constraints may be affected by the firm's specific characteristics. The prior studies have variously used different measures including dividend pay-out ratio, share buy-backs, firm age, firm size, Kaplan-Zingales Z_{FC} index and Cleary's Z_{FC} index) to categorise firms based on their a priori degree of financing difficulties (Cleary, 1999; Allayannis & Mozumdar, 2004; Guariglia, 2008). Among these measures, two widely used proxies are dividend pay-out and firm age, with higher values suggesting lower investment–cash flow sensitivity (Cleary, 1999; Guariglia, 2008). Therefore, given the nature of our datasets (public and private, i.e., where private firms have no information on dividend pay-out and share buy-backs), we use firm age and size to proxy for a firm's a priori financing behaviour, which is in line with existing research (e.g., Guariglia, 2008).

4.6.1 Cash flow and investment – the impact of firm size

Here, we extend our baseline specification by investigating the extent to which firm size (i.e., external financial constraint) matters in the investment–CF sensitivity. That is, firm size has been found to provide different information to the market and such information is likely to affect how firms finance different types of investment (*IA* and *TA*) from the internally generated funds (Guariglia & Carpenter, 2008; Guariglia, 2008; Allayannis & Mozumdar, 2004). For example, compared with large firms, small firms are prone to asymmetric information issues because they often suffer from high idiosyncratic risk, lower salvage value, short lifespan and higher bankruptcy costs (Schiantarelli, 1996; Guariglia, 2008). Consequently, small firms are more susceptible to sponsoring investment policies from their internally generated CF. We use firm size (SZ) to represent external financial constraints (Guariglia, 2008; Almeida et al., 2004). Here, we use a simple measuring technique where one firm's size is compared with other firms in the same industry each year. Specifically, we define small (SSZ) firm years as $Small_{it}$=1, otherwise 0 for those firms whose total assets in year *t* are in the lowest (25^{th}) quartile of the assets' distribution. Also, large (LSZ) firm years are defined as $Large_{it}$=1, otherwise 0 for those firm years with assets in the highest (75^{th}) quartile of the distribution. We interact these dummies with CF values and include both small and large dummies as well as their interaction terms in the investment (*IA and TA*) regression equations.

Table 9 of models 1 and 5 shows the estimates of the interaction terms for both public and private firms. The results for models 1 and 5 show that the interaction terms for public and private small firms display a negative sign, with only private ones exhibiting statistical significance. Thus, privately-held small (*CF*SSZ*) firms with a high internal CF are likely to have lower spending on IA investment, implying that these (small) firms with IA investment are less sensitive to financing frictions arising from possible asymmetric information issues, which is contrary to our expectation. However, for large (*CF*LSZ*) firms, a different pattern is observed in models 2 and 6, where the interaction term coefficients are respectively 0.046 (public) and 0.116 (private), with only private firms showing statistical significance. This suggests that large private firms with high internal CF may prefer to spend more on IA activity. That is, the positive significant coefficient finding for privately-sized firms suggests that IA investment decisions are more sensitive to financing constraint problems than they are for the publicly-sized ones. A possible explanation can be attributed to the nature or characteristics of IA (i.e., highly risky projects, reveal minimal information to creditors or high information asymmetry), making it difficult for creditors to support these firms' intangible investment. Combining this with the expensive borrowing costs often faced by private firms, managers of IA-intensive private firms may tend to finance such activity through internally generated funds to avoid possible under-investment. However, a relatively reported lower magnitude effect on IA for large public firms could be explained by the different financing options (i.e., bank loans, borrow from bond markets and issuing equity) often enjoyed by these firms. That is, the financial flexibility benefits coupled with relatively low borrowing costs often enjoyed by these firms make them less reliant on internal CF to fund such investment activity. Our evidence further confirms the collateralisation characteristics of IA (see Lim et al., 2020). This shows bond markets or creditors' willingness to lend to IA firms, making these firms less reliant on internally generated CF.

Furthermore, models 3 & 4 and 7 & 8 report the results of TA investment for both public and private firms. Specifically, in models 3 and 7, the interaction term (*CF*SSZ)* shows a negative sign, suggesting a lower TA investment–CF sensitivity for these small firms. Thus, the coefficient estimates are -0.241 (*t-statistics -0.85*) and -0.266 (*t-statistics -2.16*) for public and private firms respectively. The statistically significant negative coefficient on privately-held small (*CF*SSZ*) firms suggests that these entities are likely to lower TA investment as their internal CF increases. This is not surprising, given that small entities often have high IA and lower pledgeable or TA in their accounting books. This is contrary to Guariglia and Carpenter (2008), who find an increasing physical asset–cash flow sensitivity for small public firms. However, for large (*CF*LSZ*) firms, we observe in models 4 and 8 that the interaction term coefficients are -0.215 (public) and 0.106 (private), but they are both statistically insignificant, indicating that TA investment to CF is less sensitive among large firms. A possible explanation is that these firms are likely to possess large pledgeable assets, making it easier and less costly for them to use debt to fund investment activities, thereby relying less on internal CF.

[Table 9 about here]

4.6.2 Cash flow and investment – the impact of firm age

Another important asymmetric information issue faced by firms, and one which can shape the cash flow–investment relationship, is the age of the firm. This is because credit lenders or suppliers often consider the firm's life cycle as an important safeguard for lending. For instance, compared with old firms, young firms are likely to experience high information asymmetric problems because market participants and other creditors may be unwilling to supply credit to them with their short track records (Guariglia, 2008; Schiantarelli, 1996). Again, young firms often have low tangible assets in place and the nature of their assets is often embedded in both human capital and organisational competence. This, in turn, can make external financing extremely difficult. One way available to these young firms is to sanction IA and TA investment activities from the internally generated CF in order to minimise possible under-investment resulting from the financing constraints. In line with the above argument, we test the possibility that an increasing cash flow–investment (*IA and TA*) linkage is more strengthened for younger firms compared to older ones. Similar to prior works (e.g. Guariglia, 2008; Fazzari et al., 1988), we use a firm's life cycle or age as a proxy for the degree of external financial constraints and it is measured as follows: we consider a firm as young (YFA) for those firm years whose age in year *t* falls in the lowest (25^{th}) quartile of the distribution, while the old (OFA) firm years are those with age in the highest (75^{th}) quartile of the distribution. We use these dummies to represent young ($Young_{it}$=1, otherwise 0) and old (Old_{it}=1, otherwise 0) firms respectively. We then interact young and old dummies with CF values to obtain interaction terms. Our baseline specification is modified to include both young and old and their interaction terms in the regression models. Accordingly, our analysis is based on the two dimensions of our sample data (public and private firms). Table 10 of models 1-8 reports the coefficient estimates of the interaction terms for the two main samples: public and private firms. Specifically, for young (CF*YFA) firm years (models 1 and 5), the coefficient estimate of the interaction term for public firms is poorly determined in Model 1, while the interaction term for private ones (Model 5) displays a strong positive effect on IA investment. The results show that an increase in CF leads to a rise in IA investment for private-young firms, implying that, unlike public-young firms, private-young firms are likely to experience a severe asymmetric and or financing problem and that they rely more on internal CF to fund IA investment. For old (CF*OFA) firms (models 2 & 6), we observe that the coefficients of the interaction terms are 0.447 (t-statistics 1.89) and -0.102 (t-statistics -5.90) for the respective public and private firms. This suggests that public-old firms are likely to be more prone to age anomalies and that they use more internal CF to support IA investment. This can be partly attributed to the fact that, as firms become older and bigger, information disparity among managers and lenders increases. Such poor information flow is further worsened when lenders are unable to secure their interests against the firm's assets (i.e., as in the case of *IA*), thereby making it difficult for the firm to secure external funds. Hence, the only cost-effective way is for the old public-firms to use internal cash to finance such IA activity. However, the drop in IA investment associated with private-old firms shows lower internal CF dependence for these firms. A possible reason could be that private-old firms are likely to establish a closer relationship with their fund suppliers (Ball & Shivakumar, 2005), thereby giving them the leeway to easily raise external funds to sponsor IA activity. Thus, the resulting financial flexibility makes IA investment insensitive to CF behaviour.

Moreover, models 3 & 7 and 4 & 8 show TA investment results for both public and private firms. Specifically, in models 3 & 7, the interaction term coefficient (*CF*YFA*) shows positive and negative signs for public (0.268 t-statistics 1.02) and private (-0.111 t-statistics -0.74) firms respectively, but these estimates are statistically insignificant. On the other hand, for old firms, the estimates on *CF*OFA* for publicly-held (-0.188) and privately-held (0.141) firms are also both statistically insignificant. The reported findings show that the number of firm years of incorporation is less sensitive to TA investment decisions regarding internal CF.

The overall evidence appears to suggest an increasing sensitivity of IA investment to internally generated CF for both young public and private firms, but a decreasing effect is observed for those old firms. Thus, the intangibility nature of IA investment for young firms is more sensitive to financing constraints arising from asymmetric information problems. However, TA investment–CF sensitivity is less manifested for the years of firm incorporation.

[Table 10 about here]

4.7. Further robustness tests

Throughout our empirical analysis, we have used several different specifications including fixed effect (FE), predicted value model, instrumental variable (using 2SLS) and the simultaneous equation model (using 3SLS) to test ICFS (baseline model). Our findings remain qualitatively unchanged using these different estimators. However, in sections 4.5 and 4.6 (Table 8 – 10 results), we used a fixed effect estimator to analyse internal and external financing constraints faced by firms. In this section, we further employed an instrumental variable – using a 2SLS estimator, a relatively more sophisticated technique – to analyse both internal and external constraints indicators. That is, in testing the financial constraints hypotheses, we separately included the interaction terms NCF*CF and PCF*CF (internal constraints) and SSZ*CF, LSZ*CF and YFA*CF and OFA*CF (for external constraints) in the second stage of the two-stage regression equation (2SLS) together with the dummies and other controls. For brevity, we only report the second-stage (*IA* and *TA*) regression results for internal constraints (Table 11) and external constraints size and age (tables 12 and 13). In short, the reported results for internal financial constraints in Table 11 are qualitatively similar to those in Table 8. Again, the external constraints result in tables 12 and 13 are largely like those in tables 9 and 10. Overall, our results further corroborate the reported earlier ones.

[Tables 11, 12 & 13 about here]

5. Conclusion

The debate on investments–internally generated CF sensitivity still remains unresolved. In general, the ICFS has been mainly explained by using information asymmetry (Myers & Majluf, 1984; Myers, 1984) and agency conflict (Jensen, 1986, 2001). Chowdhury et al. (2016) state that, in an imperfect market, the presence of information asymmetry and agency cost would increase the cost of external financing. Consequently, firms would depend more on internally generated funds to support their investment. In the case of IA investment, both information asymmetry and agency conflict would be higher (Makadok, 2003) and therefore ICFS should be higher as well. However, Lim et al. (2020) argue that IA investment behaves more like TA investment due to the market-based valuation of the former. This has widened the acceptability of IA as collateral for external debt financing, and therefore firms can finance this activity through debt (Loumioti, 2012) rather than relying on internal cash flow. Moreover, recent findings of a gradual fall of ICFS both in the US (Moshirian et al., 2017) and the UK markets coupled with a rise in IA activity (Goodridge et al., 2016) provide reasons to explore this relationship from the context of investments in IA as well as TA.

Indeed, while there are strong theoretical reasons to hypothesise the connection, prior empirical studies that have looked at tangible investment and intangible (research & development) investment have provided no conclusive evidence (see Lewellen and Lewellen, 2016; Brown et al., 2012; Guariglia, 2008). Given the primary concentration of these studies on *TA* and research and development investment, however, little is known about fixed IA investment–cash flow sensitivity. Thus, in this study, we provide complete evidence on firm investment by examining the sensitivity of IA and TA investment to CF using panel data of UK public and private firms. Using both quoted and unquoted firms affords us a unique opportunity to carefully test the sensitivity of IA and TA investments to internal CF in a single study. With our unique dataset, this study seeks to overcome the data invariability concerns raised by Cleary et al. (2007). Our empirical results show a higher (lower) IA (TA) investment–internal CF sensitivity in the entire sample. With respect to private firms, we observed that the increased sensitivity of IA investment to internal fund is more pronounced compared to public ones, postulating that high financial inflexibility is often faced by unquoted firms. These findings depict that IA investment has become an increasingly important activity and an avenue for innovation and growth (Goodridge et al., 2016). We also find a strong lower TA investment–cash flow sensitivity for privately-held firms. Furthermore, we explore how the cash flow–investment (*IA and TA*) relationship differs for firms facing different levels of financial constraints. These tests seek to further enhance our understanding of how financial constraints affect the assumed sensitivities. Our results show that internally constrained firms do not particularly keep higher CF levels to mitigate the financing frictions associated with the nature of IA activity. Overall, this insight adds to the existing debate or controversy about whether a strong cash flow–investment (i.e., *IA and TA*) linkage is an indication of suspected firm internal financing constraints (Guariglia, 2008; Allayannis & Mozumdar, 2004; Fazzari et al., 1988). In particular, this fresh evidence offers a new dimension in the literature to suggest that higher CF levels of IA-intensive firms do not support the financially constrained argument. In other words, intangible assets ICFS is not an appropriate interpretation of internal financing constraints, as our finding shows. Thus, based on the theoretical interpretation of internal financing constraints (i.e., higher CF leads to more investment and vice versa), we discovered that lower (higher) CF firms invest more (less) in IA, which is contrary to this expectation. Moreover, we also report additional evidence that suggests that large firms (both quoted and unquoted) with substantial CF spend more on IA activities; however, no such results were found for TA. Also, we find that young private firms with high CF spend more on IA but the older private ones lower or decrease spending on such investment activity. Old public firms also show an increasing IA investment–CF sensitivity. In addition, we observe further that the size anomaly has no significance in the TA investment–CF sensitivity.

Overall, using comprehensive public and private firms' data, we provide new evidence to show how a firm's investment decisions, especially those from IA and TA, are significantly dependent on internally generated CF. Our findings provide further evidence on important but unresolved financing constraints and ICFS. Specifically, we show that higher sensitivity as indicative of internal financial constraints is mainly limited to TA firms. Thus, our in-depth analysis brings some clarity into the literature by suggesting that firm managers strategically deploy internal funds based on the anticipated cost and revenue effects associated with the firm's type of investment. Lastly, we further demonstrate that increased informational asymmetry strengthens (weakens) IA investment–CF sensitivity for those young (small) privately-held firms. In short, we contribute to the ICFS literature by showing the extent to which the presence and importance of financing frictions matter. More generally, our study is among the first studies to explore the relation of CF and IA investment by advancing the 'financial friction hypothesis' to explain corporate innovative divestiture.

Acknowledgement

We are thankful to the anonymous reviewers and the editors of the *International Journal of Finance and Economics* for their comments on improving the quality of this manuscript.

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Table 1: Description of variables

Dependent Variable	**Description**	**Literature**
Identifiable intangible assets investment (IA)	Identifiable intangible assets scaled by total assets	Lim et al., 2020; Peters and Taylor, 2017.
Tangible assets investment (TA)	Tangible assets (defined as net property, plant and equipment) scaled by total assets	Lee et al., 2018; Lewellen and Lewellen, 2016.
Independent variable		
Free cash flow (CF)	Free cash flow scaled by total assets	Peters and Taylor, 2017; O'Connor et al., 2013.
Cash flow (CF2)	EBITDA scaled total assets	Peters and Taylor, 2017; Ascioglu et al., 2008.
Control variables		
Leverage (LEV)	Total debt scaled total assets	Khan et al., 2021; Ben Jabeur, 2021.
Firm size (SZ)	Natural logarithm of total assets	Danso et al., 2021a, 2021b; Saravia et al., 2021.
Growth (*GR*)	Log of ($sales_t$/lagged sales)	Lim et al., 2020; Borisova and Brown, 2013.
Net working capital (NWC)	Net working capital – cash equivalent/total assets	Lewellen and Lewellen, 2016.
Cash holdings (CH)	Cash holdings scaled by total assets.	Xiong et al., 2022; Lim et al., 2020.
Firm years (FA)	Firm number of years of operation	Borisova and Brown, 2013.
Non-debt tax shields (NDT)	Depreciation scaled by total assets	Danso et al., 2021a.
Profitability (PR)	Profit for the period scaled by total assets	Lewellen and Lewellen, 2016.

Table 2: Descriptive statistics

	Panel A: All Firms								Panel B: Public Firms			Panel C: Private Firms			Panel D: Diff in Means (t-test)	
	Mean	St. Dev.	Min.	Max.	25%	50%	75%	N	Mean	50%	St. Dev.	Mean	50%	St. Dev.		
IA	-0.001	0.052	-1.892	1.849	0.000	0.000	0.000	522148	0.002	0.000	0.120	-0.001	0.000	0.049	0.003***	***[2.91]***
TA	0.164	0.224	0.000	0.653	0.000	0.041	0.265	616725	0.165	0.032	0.190	0.131	0.042	0.224	0.034***	***[19.68]***
CF	0.001	0.010	-0.030	0.030	0.000	0.000	0.000	522148	-0.000	0.000	0.010	0.000	0.000	0.010	-0.000***	***[3.39]***
CF2	0.002	0.108	-0.963	0.964	-0.010	0.000	0.013	522148	-0.001	0.000	0.118	0.002	0.000	0.108	-0.003***	***[-3.89]***
LEV	0.257	0.258	0.000	0.653	0.001	0.168	0.523	616725	0.144	0.068	0.180	0.260	0.171	0.259	-0.116***	***[-70.09]***
SZ	7.228	1.084	0.000	11.80	6.758	7.229	7.745	616724	7.765	7.752	1.117	7.217	7.223	1.080	0.548***	***[54.02]***
GR	1.005	0.079	0.127	8.040	0.995	1.003	1.012	400598	1.008	1.003	0.097	1.005	1.003	0.078	0.003***	***[3.31]***
NWC	0.785	0.016	0.783	1.254	0.783	0.783	0.784	616725	0.783	0.783	0.006	0.785	0.783	0.016	-0.001***	***[-24.92]***
CH	0.113	0.181	-0.059	0.857	0.000	0.031	0.145	616725	0.167	0.083	0.207	0.112	0.030	0.180	0.054***	***[28.91]***
FA	20.00	20.716	1.00	104.00	6.00	13.00	26.00	616725	23.00	12.00	28.634	20.00	13.00	20.517	3.767***	[14.43]
NDT	0.024	0.050	0.000	1.00	0.000	0.008	0.032	616725	0.047	0.020	0.111	0.024	0.008	0.047	0.023***	***[23.24]***
PR	0.046	0.061	0.000	0.186	0.000	0.015	0.074	616633	0.042	0.018	0.055	0.046	0.015	0.061	-0.004***	***[-7.79]***
N	**616725**								**12,356**			**604,369**				

This table presents the descriptive statistics for the entire data used for the study. The sample comprises all UK firms (public and non-public) over the period 2006 to 2015. The variable descriptions are provided in Table 1 above.

Table 3: Correlations matrix

	IA	TA	CF	CF2	LEV	SZ	GR	NWC	CH	FA	NDT	PR
IA	1.00											
TA	-0.15*	1.00										
CF	0.04*	-0.02*	1.00									
CF2	0.01*	-0.02*	0.50*	1.00								
LEV	-0.01*	0.01*	0.02*	0.00*	1.00							
SZ	0.01*	0.01*	-0.00	-0.01*	0.24*	1.00						
GR	0.03*	-0.01*	0.08*	0.11*	0.01*	0.07*	1.00					
NWC	0.00	-0.03*	-0.00	-0.00	0.08*	-0.01*	-0.00	1.00				
CH	-0.02*	-0.03*	0.02*	0.03*	-0.23*	-0.24*	0.00	-0.06*	1.00			
FA	0.01*	-0.01*	-0.02*	-0.00	-0.11*	0.13*	-0.02*	-0.04*	-0.04*	1.00		
NDT	-0.07*	-0.03*	0.03*	0.05*	0.05*	-0.05*	0.01*	-0.05*	0.00	0.02*	1.00	
PR	0.01*	-0.00	-0.03*	-0.03*	-0.13*	-0.07*	-0.00	-0.02*	0.16*	0.03*	0.05*	1.00

This table presents the correlation matrix for the sample data. The sample and variable definitions are as described in Table 1. * Indicates significance at 1% level.

Table 4: The effects of cash flow on investment

	Identifiable intangible assets (IA) investment				*Tangible assets (TA) investment*			
	(OLS 1)	**(OLS 2)**	**(FE 3)**	**(FE 4)**	**(OLS 5)**	**(OLS 6)**	**(FE 7)**	**(FE 8)**
	IA	**IA**	**IA**	**IA**	**TA**	**TA**	**TA**	**TA**
CF	0.180***	0.121***	0.164***	0.088***	-0.471***	-0.390***	-0.477***	-0.306***
	(16.97)	(9.91)	(22.55)	(10.53)	(-19.98)	(-7.33)	(-13.76)	(-6.10)
Lagged IA		-0.112***		-0.210***				
		(-10.59)		(-104.28)				
LEV		-0.002***		-0.000		-0.002		-0.005
		(-4.15)		(-0.01)		(-1.34)		(-1.03)
SZ		-0.021*		-0.104***		-0.061		-0.227
		(-1.91)		(-2.82)		(-0.94)		(-1.03)
GR		-0.003*		-0.003**		0.003		0.008
		(-1.64)		(-2.20)		(0.35)		(0.87)
NWC		0.003		-0.016*		0.512*		1.237***
		(0.25)		(-1.75)		(1.88)		(21.89)
CH		0.007***		0.018***		0.033***		0.081***
		(13.37)		(17.54)		(4.17)		(12.91)
FA		0.000***		0.001***		-0.000		0.002*
		(19.66)		(2.98)		(-0.76)		(1.83)
NDT		-0.085***		-0.102***		-0.030		-0.015
		(-15.07)		(-38.38)		(-0.61)		(-0.94)
PR		0.005***		-0.003		-0.006		0.011
		(3.04)		(-1.19)		(-0.65)		(0.85)
Lagged TA						-0.447		-0.463***
						(-1.46)		(-249.23)
Cons	0.003**	0.017	0.003***	0.073***	0.026***	-0.340	0.035***	-0.847***
	(2.44)	(1.35)	(3.33)	(2.88)	(6.08)	(-1.51)	(7.55)	(-5.53)
Year	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	NO	NO	YES	YES	NO	NO
N	**522148**	**285031**	**522148**	**285031**	**522148**	**285031**	**522148**	**285031**
R^2	**0.002**	**0.023**	**0.001**	**0.051**	**0.001**	**0.201**	**0.001**	**0.219**

The table shows the OLS and FE estimation results of the effects of cash flow (CF) on IA and TA investment. The FE regression analyses are our main results whilst OLS is used as additional results. The regressions include year and firm fixed effects. All variable definitions are described in Table 1. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Table 5: The effects of cash flow on investment

	Alternative cash flow (CF2) measure			
	(OLS 1)	**(FE 2)**	**(OLS 3)**	**(FE 4)**
	IA	**IA**	**TA**	**TA**
CF	0.005***	0.004***	-0.058***	-0.052***
	(3.38)	(5.01)	(-3.91)	(-10.46)
Lagged IA	-0.112***	-0.210***		
	(-10.58)	(-104.24)		
LEV	-0.002***	0.000	-0.001	-0.001
	(-3.77)	(0.25)	(-0.68)	(-0.28)
SZ	-0.021*	-0.104***	-0.059	-0.219
	(-1.92)	(-2.83)	(-0.89)	(-0.99)
GR	-0.003*	-0.003**	0.001	0.006
	(-1.66)	(-2.26)	(0.07)	(0.62)
NWC	0.003	-0.017*	0.511*	1.236***
	(0.24)	(-1.78)	(1.87)	(21.88)
CH	0.007***	0.018***	0.033***	0.079***
	(13.35)	(17.45)	(4.15)	(12.67)
FA	0.000***	0.001***	-0.000	0.002*
	(19.70)	(2.98)	(-0.74)	(1.84)
NDT	-0.085***	-0.101***	-0.032	-0.020
	(-15.08)	(-38.27)	(-0.64)	(-1.25)
PR	0.005***	-0.003	-0.006	0.013
	(3.25)	(-1.15)	(-0.60)	(0.95)
Lagged TA			-0.447	-0.463***
			(-1.47)	(-249.26)
Cons	0.017	0.074***	-0.338	-0.851***
	(1.37)	(2.90)	(-1.50)	(-5.55)
N	**285031**	**285031**	**285031**	**285031**
R^2	**0.023**	**0.051**	**0.201**	**0.220**

The table shows the OLS and FE estimation results of the effects of cash flow (CF) on IA and TA investment. Our presented regression results are for both OLS & FE. The regressions include year and firm fixed effects. All variable definitions are described in Table 1. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Table 6: Cash flow – investment

	Predicted model		*Instrumental variable IV-using 2SLS method*			
	(Model 1)	**(Model 2)**	**(2nd Stage)**	**(1st Stage)**	**(2nd Stage)**	**(1st Stage)**
	IA	**TA**	**IA**	**CF**	**TA**	**CF**
CF	10.06***	-51.56**	7.048***		-8.085**	
	(14.68)	(-2.02)	(5.94)		(-2.32)	
Lagged IA	-0.110***		-0.123***	0.002***		0.002***
	(-10.86)		(-30.97)	(3.37)		(3.37)
LEV	-0.003***	0.008	-0.020***	0.003***	0.018*	0.003***
	(-7.30)	(1.41)	(-6.22)	(28.08)	(1.92)	(28.08)
SZ	-0.003	-0.115	-0.025	0.001	-0.057	0.001
	(-0.24)	(-1.58)	(-0.80)	(0.20)	(-0.60)	(0.20)
GR	0.003	-0.026	0.013***	-0.002***	-0.015	-0.002***
	(1.03)	(-1.10)	(3.59)	(-7.24)	(-1.39)	(-7.24)
NWC	-0.003	0.546*	0.024**	-0.003**	0.490***	-0.003**
	(-0.28)	(1.91)	(2.09)	(-2.47)	(14.05)	(-2.47)
CH	0.001	0.0627***	0.010***	-0.001***	0.030***	-0.001***
	(0.95)	(3.39)	(9.98)	(-2.87)	(9.25)	(2.87)
FA	0.000***	-0.000*	0.000***	0.000***	-0.000	0.000***
	(22.19)	(-1.65)	(6.66)	(3.26)	(-0.68)	(3.26)
NDT	-0.077***	-0.037	-0.076***			
	(-14.47)	(-0.72)	(-21.25)			
PR	0.020***	-0.093**	-0.023***	0.004***	0.025	0.004***
	(10.85)	(-2.37)	(-4.20)	(11.77)	(1.51)	(11.37)
Lagged TA		-0.442		0.000*	-0.446***	0.000*
		(-1.46)		(1.86)	(-232.01)	(1.86)
IND_PR				-0.045***		-0.045***
				(-5.44)		(-5.44)
IND_GR				2.149***		2.149***
				(4.95)		(4.95)
Cons	-0.026**	-0.146	-0.743**	-2.152***	-0.743**	-2.152***
	(-2.11)	(-0.65)	(-1.95)	(-4.95)	(-1.95)	(-4.95)
Year	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
N	**275892**	**275892**	**285031**	**285031**	**285031**	**285031**
***R*²**	**0.050**	**0.224**		**0.02**		**0.02**
F-Statistics			**15.76*** **		**16.76*** **	
Sargan stat			**85.68**		**68.51**	
Endogeneity tests			**122.04*** **		**5.40**	

In the predicted model, we regress cash flow – CF (independent variable) – on its determinants (LEV, SZ, GR, NWC, CH, FA, PR, IA and TA) to obtain predicted values of cash flow (i.e., lagged value of cash flow) which is included in the investment (IA – intangible asset – and tangible assets – TA) model as a predictor. The instrumental variable (IV Model) employs a two-stage least squares (2SLS) technique where the cash flow model is regressed on changes in leverage (LEV), size (SZ), growth (GR), networking capital (NWC), cash holdings (CH), firm age (FY), earnings (PR), investments – IA and TA – and the chosen instruments – industry earnings (IND_PR) and industry growth (IND_GR). Our instrumental variables coefficient estimates for IND_PR -0.045 (t-statistics -5.44) and 2.149 (t-statistics 4.95) with the overall model f-statistics are 15.76 and 16.76 (i.e., above the rule of thumb of 10), indicating our model is well specified. The models included fixed effects in all estimations. The reported t-statistics based on robust standard errors are within parentheses. Variable definitions are described in Table 1. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Table 7: Cash flow – investment (structural equation model – SEM – using 3SLS)

	(2^{nd} Stage) IA	(1^{st} Stage) CF	(2^{nd} Stage) TA	1^{st} Stage CF
CF	6.963***		-7.883**	
	(5.86)		(-2.26)	
Lagged IA	-0.124***	0.002***		0.003***
	(-31.23)	(5.42)		(6.66)
LEV	-0.019***	0.003***	0.017*	0.003***
	(-6.13)	(29.50)	(1.86)	(29.53
SZ	-0.026	0.001	-0.055	0.001
	(-0.85)	(0.22)	(-0.59)	(0.22)
GR	0.013***	-0.002***	-0.015	-0.002***
	(3.54)	(-7.72)	(-1.35)	(7.75)
NWC	0.023**	-0.002	0.493***	-0.002*
	(1.95)	(-1.61)	(14.12)	(-1.91)
CH	0.010***	-0.000***	0.030***	-0.000***
	(8.87)	(-2.68)	(9.31)	(2.82)
FA	0.000***	0.000***	-0.000	0.000***
	(6.65)	(3.28)	(-0.68)	(3.25)
NDT	-0.084***		-0.032***	
	(-36.84)		(-3.06)	
PR	-0.023***	0.004***	0.024	0.004***
	(-4.13)	(11.83)	(1.46)	(11.89)
Lagged TA		0.001***	-0.446***	0.001***
		(15.05)	(-232.01)	(4.09)
IND_PR		-0.014**		-0.034***
		(-2.11)		(-4.51)
IND_GR		0.643*		1.603***
		(1.79)		(3.65)
Cons	-0.004	-0.642*	-0.318***	-1.605***
	(-0.17)	(-1.78)	(-4.67)	(-3.64)
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
N	**285031**	**285031**	**285031**	**285031**
Chi2	**4144.17**	**2056.57**	**64753.32**	**1841.97**
P-value	**0.0000**	**0.0000**	**0.0000**	**0.0000**

The simultaneous equation model (SEM) uses a three-stage least squares (3SLS) technique where cash flow and investment (IA and TA) are simultaneously regressed on changes in leverage (LEV), size (SZ), growth (GR), networking capital (NWC), cash holdings (CH), firm age (FY), earnings (PR), investments – IA and TA – and the chosen instruments – industry earnings (IND_PR) and industry growth (IND_GR). The coefficient estimates for the instruments: IND_PR -0.014 (t-statistics -2.11) and 0.643 (t-statistics 1.79) and -0.034 (t-statistics -4.51) and 1.603 (t-statistics 3.65) and are statistically significant. The chi-square (*Chi2*) and P-values indicate our overall model is well specified. The models included fixed effects in all estimations. The reported t-statistics based on robust standard errors are within parentheses. Variable definitions are described in Table 1. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Table 8: Cash flow – investment: public vs private and internal financial constraints effects

	Public firms						*Private firms*					
	(FE 1)	**(FE 2)**	**(FE 3)**	**(FE 4)**	**(FE 5)**	**(FE 6)**	**(FE 7)**	**(FE 8)**	**(FE 9)**	**(FE 10)**	**(FE 11)**	**(FE 12)**
	IA	**IA**	**IA**	**TA**	**TA**	**TA**	**IA**	**IA**	**IA**	**TA**	**TA**	**TA**
CF	0.106	0.055	0.838	-0.028	-0.366	-0.234	0.083***	0.018*	0.214***	-0.321***	-0.266*	-0.625***
	(1.00)	(0.16)	(1.37)	(-0.27)	(-1.09)	(-0.68)	(10.37)	(1.80)	(9.49)	(-6.24)	(-1.82)	(-4.33)
Lagged IA	-0.149***	-0.150***	-0.150***				-0.214***	-0.214***	-0.214***			
	(-12.21)	(-12.31)	(-12.31)				(-104.6)	(-104.5)	(-104.5)			
LEV	0.014	0.015	0.015	-0.009	-0.011	-0.011	-0.001	-0.000	-0.000	-0.007	-0.008	-0.007
	(1.00)	(1.12)	(1.12)	(-0.70)	(-0.80)	(-0.80)	(-0.59)	(-0.46)	(-0.47)	(-1.32)	(-1.51)	(-1.47)
SZ	0.082***	0.082***	0.082***	0.029***	0.029***	0.029***	0.009***	0.009***	0.008***	0.031***	0.031***	0.031***
	(13.93)	(13.93)	(13.91)	(5.09)	(5.12)	(5.12)	(19.53)	(19.27)	(19.17)	(10.91)	(11.05)	(11.08)
GR	-0.014	-0.015	-0.015	0.027**	0.028**	0.027**	-0.005***	-0.005***	-0.005***	-0.001	-0.001	-0.001
	(-1.02)	(-1.07)	(-1.09)	(2.05)	(2.08)	(2.07)	(-3.23)	(-3.25)	(-3.24)	(-0.12)	(-0.08)	(-0.09)
NWC	0.163	0.171	0.171	2.056***	2.049***	2.048***	-0.019**	-0.019**	-0.019**	1.231***	1.232***	1.232***
	(0.44)	(0.46)	(0.46)	(5.65)	(5.63)	(5.63)	(-2.13)	(-2.15)	(-2.16)	(21.51)	(21.53)	(21.53)
CH	0.206***	0.205***	0.205***	0.185***	0.185***	0.186***	0.014***	0.014***	0.014***	0.083***	0.083***	0.083***
	(16.41)	(16.32)	(16.33)	(15.31)	(15.37)	(15.38)	(13.67)	(13.57)	(13.57)	(12.72)	(12.85)	(12.82)
FA	-0.002	-0.002	-0.002	0.002	0.002	0.002	0.001***	0.001***	0.001***	0.003**	0.002*	0.002*
	(-0.91)	(-1.00)	(-0.95)	(0.82)	(0.87)	(0.88)	(3.73)	(3.89)	(3.89)	(1.99)	(1.84)	(1.85)
NDT	-0.022	-0.021	-0.020	-0.046***	-0.047***	-0.047***	-0.105***	-0.105***	-0.105***	0.008	0.009	0.008
	(-1.61)	(-1.51)	(-1.48)	(-3.59)	(-3.69)	(-3.68)	(-38.18)	(-38.12)	(-38.10)	(0.48)	(0.49)	(0.46)
PR	-0.011	-0.008	-0.009	0.031	0.029	0.029	-0.003	-0.002	-0.002	0.011	0.008	0.008
	(-0.39)	(-0.29)	(-0.33)	(1.09)	(1.05)	(1.04)	(-1.30)	(-1.14)	(-1.16)	(0.80)	(0.56)	(0.61)
NCF		0.009			0.001			-0.001**			-0.008**	
		(1.13)			(0.09)			(-2.03)			(-2.52)	
CF*NCF		0.657*			-0.742**			0.157***			-0.417**	
		(1.69)			(-1.96)			(5.82)			(-2.41)	
PCF			-0.007			-0.004			-0.002***			-0.001
			(-0.84)			(-0.48)			(-3.87)			(-0.24)
CF*PCF			-1.214***			0.585			-0.187***			0.663***
			(-3.03)			(1.50)			(-6.97)			(3.87)
Lagged TA				-0.198***	-0.198***	-0.198***				-0.463***	-0.464***	-0.464***
				(-16.04)	(-16.05)	(-16.04)				(-246.34)	(-246.37)	(-246.36)
Cons	-0.719**	-0.728**	-0.715**	-1.856***	-1.855***	-1.851***	-0.053***	-0.052***	-0.050***	-1.203***	-1.198***	-1.205***
	(-2.35)	(-2.38)	(-2.34)	(-6.23)	(-6.23)	(-6.21)	(-5.85)	(-5.66)	(-5.52)	(-20.61)	(-20.50)	(-20.61)
N	**7359**	**7359**	**7359**	**7359**	**7359**	**7359**	**277672**	**277672**	**277672**	**277672**	**277672**	**277672**
R^2	**0.106**	**0.108**	**0.108**	**0.105**	**0.106**	**0.106**	**0.054**	**0.054**	**0.054**	**0.220**	**0.220**	**0.220**

The effects of cash flow on IA and TA investment distinguishing firm-year observation on the basis of listing status and internal financial constraints. We use interaction terms, measured as cash flow ratio (CF) multiplied by negative (NCF) and positive (PCF) cash flow dummies, i.e., CF*NCF / CF*PCF interaction terms. Models 1, 2 & 3 and 7, 8 & 9 are for public and private firms' investment in IA, while models 4, 5 & 6 and 10, 11 & 12 are for public and private firms' tangible assets (TA) investment. The regressions include year and firm fixed effects. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Table 9: Cash flow – investment: size effects

	Public firms				***Private firms***			
	(FE 1) IA	**(FE 2) IA**	**(FE 3) TA**	**(FE 4) TA**	**(FE 5) IA**	**(FE 6) IA**	**(FE 7) TA**	**(FE 8) TA**
CF	0.095	0.084	0.013	0.072	0.105***	0.059***	-0.260***	-0.342***
	(0.82)	(0.58)	(0.11)	(0.51)	(11.49)	(6.55)	(-4.44)	(-5.92)
Lagged IA	-0.150***	-0.150***			-0.214***	-0.214***		
	(-12.24)	(-12.25)			(-104.6)	(-104.9)		
LEV	0.013	0.014	-0.009	-0.009	-0.001	-0.004	-0.007	-0.007
	(0.96)	(1.02)	(-0.71)	(-0.72)	(-0.56)	(-0.58)	(-1.31)	(-1.34)
SZ	0.087***	0.089***	0.034***	0.025***	0.009***	0.008***	0.030***	0.029***
	(13.51)	(14.30)	(5.36)	(4.15)	(18.11)	(17.91)	(9.81)	(9.70)
GR	-0.014	-0.014	0.027**	0.027**	-0.005***	-0.005***	-0.001	-0.001
	(-1.01)	(-1.06)	(2.08)	(2.05)	(-3.23)	(-3.24)	(-0.12)	(-0.12)
NWC	0.128	0.183	2.025***	2.046***	-0.019**	-0.019**	1.231***	1.230***
	(0.34)	(0.49)	(5.56)	(5.62)	(-2.13)	(-2.15)	(21.51)	(21.50)
CH	0.207***	0.206***	0.185***	0.185***	0.014***	0.014***	0.082***	0.083***
	(16.44)	(16.41)	(15.32)	(15.33)	(13.63)	(13.64)	(12.69)	(12.72)
FA	-0.002	-0.002	0.002	0.002	0.001***	0.001***	0.003**	0.003**
	(-0.90)	(-0.93)	(0.83)	(0.83)	(3.69)	(3.71)	(1.97)	(1.97)
NDT	-0.023*	-0.022	-0.046***	-0.046***	-0.105***	-0.105***	0.009	0.008
	(-1.69)	(-1.61)	(-3.60)	(-3.62)	(-38.14)	(-38.13)	(0.50)	(0.51)
PR	-0.011	-0.012	0.031	0.031	-0.003	-0.003	0.011	0.011
	(-0.37)	(-0.43)	(1.09)	(1.12)	(-1.28)	(-1.27)	(0.82)	(0.80)
SSZ	0.016*		0.015*		0.000		-0.002	
	(1.89)		(1.79)		(0.02)		(-0.70)	
CF*SSZ	0.089		-0.241		-0.096***		-0.266**	
	(0.31)		(-0.85)		(-4.99)		(-2.16)	
LSZ		-0.025***		0.014**		0.001**		0.008**
		(-3.47)		(1.97)		(2.23)		(2.06)
CF*LSZ		0.046		-0.215		0.116***		0.106
		(0.22)		(-1.04)		(5.86)		(0.84)
Lagged TA			-0.198***	-0.198***			-0.463***	-0.463***
			(-16.01)	(-16.06)			(-246.34)	(-246.34)
Cons	-0.731*	-0.777*	-1.867***	-1.824***	-0.0540***	-0.0514***	-1.198***	-1.190***
	(-2.39)	(-2.54)	(-6.26)	(-6.11)	(-5.84)	(-5.61)	(-20.24)	(-20.28)
N	**7359**	**7359**	**7359**	**7359**	**277672**	**277672**	**277672**	**277672**
R^2	**0.106**	**0.108**	**0.105**	**0.106**	**0.054**	**0.054**	**0.220**	**0.220**

The effects of cash flow (CF) on IA and TA investment: distinguishing firm-year observation on the basis of the external financial constraints – size effects. We use interaction terms, measured as cash flow (CF) multiplied by small-SSZ and large-LSZ size effects: CF*SSZ & CF*LSZ interaction terms. Models 1 & 2 and 3 & 4 are for public firms' (IA and TA) investment, while models 5 & 6 and 7 & 8 are private firms' investment in IA and TA respectively. The regressions include year and firm fixed effects. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Table 10: Cash flow – investment: age effects

	Public firms				*Private firms*			
	(FE 1)	**(FE 2)**	**(FE 3)**	**(FE 4)**	**(FE 5)**	**(FE 6)**	**(FE 7)**	**(FE 8)**
	IA	**IA**	**TA**	**TA**	**IA**	**IA**	**TA**	**TA**
CF	0.127	0.017	0.080	0.023	0.068***	0.116***	-0.305***	-0.366***
	(1.07)	(0.13)	(0.69)	(0.19)	(7.78)	(11.88)	(-5.49)	(-5.87)
Lagged IA	-0.149***	-0.149***			-0.214***	-0.214***		
	(-12.21)	(-12.18)			(-104.63)	(-104.59)		
LEV	0.013	0.013	-0.009	-0.009	-0.001	-0.001	-0.007	-0.007
	(0.98)	(0.98)	(-0.67)	(-0.70)	(-0.62)	(-0.61)	(-1.32)	(-1.32)
SZ	0.082***	0.082***	0.029***	0.029***	0.009***	0.009***	0.031***	0.031***
	(13.91)	(13.92)	(5.11)	(5.10)	(19.63)	(19.47)	(10.89)	(10.92)
GR	-0.014	-0.015	0.027**	0.027**	-0.005***	-0.005***	-0.001	-0.001
	(-1.03)	(-1.06)	(2.08)	(2.08)	(-3.37)	(-3.24)	(-0.10)	(-0.11)
NWC	0.163	0.169	2.055***	2.054***	-0.019**	-0.019**	1.231***	1.231***
	(0.44)	(0.45)	(5.65)	(5.64)	(-2.17)	(-2.14)	(21.51)	(21.51)
CH	0.206***	0.206***	0.185***	0.185***	0.014***	0.014***	0.083***	0.083***
	(16.41)	(16.39)	(15.31)	(15.32)	(13.67)	(13.67)	(12.72)	(12.72)
FA	-0.002	-0.002	0.002	0.002	0.001***	0.001***	0.003**	0.003**
	(-0.92)	(-0.87)	(0.84)	(0.78)	(3.93)	(3.74)	(1.96)	(1.99)
NDT	-0.022	-0.022	-0.046***	-0.046***	-0.105***	-0.105***	0.008	0.008
	(-1.60)	(-1.61)	(-3.60)	(-3.58)	(-38.11)	(-38.17)	(0.47)	(0.48)
PR	-0.011	-0.011	0.030	0.031	-0.003	-0.003	0.011	0.011
	(-0.38)	(-0.39)	(1.07)	(1.10)	(-1.41)	(-1.30)	(0.81)	(0.80)
YFA	-0.001		0.001		0.003***		-0.003	
	(-0.18)		(0.26)		(7.59)		(-1.11)	
CF*YFA	-0.106		0.268		0.108***		-0.111	
	(-0.39)		(1.02)		(4.66)		(-0.74)	
FA		-0.003		0.005		0.001**		-0.003
		(-0.39)		(0.58)		(2.07)		(-0.81)
CF*OFA		0.447*		-0.188		-0.102***		0.141
		(1.89)		(-0.81)		(-5.90)		(1.28)
Lagged TA			-0.198***	-0.198***			-0.463***	-0.463***
			(-16.04)	(-16.04)			(-246.34)	(-246.34)
Cons	-0.717**	-0.724**	-1.859***	-1.854***	-0.055***	-0.053***	-1.201***	-1.203***
	(-2.34)	(-2.37)	(-6.23)	(-6.22)	(-6.08)	(-5.85)	(-20.57)	(-20.61)
N	**7359**	**7359**	**7359**	**7359**	**277672**	**277672**	**277672**	**277672**
R^2	**0.106**	**0.106**	**0.105**	**0.105**	**0.054**	**0.054**	**0.220**	**0.220**

The effects of cash flow (CF) on IA and TA investment: distinguishing firm-year observation on the basis of the external financial constraints – age effects. We use interaction terms, measured as cash flow (CF) * young (YFA) and old (OFA) firm age effects: CF*YFA & CF*OFA interaction terms. Models 1 & 2 and 3 & 4 are for public firms' (IA and TA) investment, while models 5 & 6 and 7 & 8 are private firms' investment in IA and TA respectively. The regressions include year and firm fixed effects. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Further robustness test: instrumental variable – IV using 2SLS

Table 11: Cash flow – investment: internal financial constraints

	Public firms						Private firms					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
	IA	**IA**	**IA**	**TA**	**TA**	**TA**	**IA**	**IA**	**IA**	**TA**	**TA**	**TA**
CF	17.91***	18.03***	18.05***	-6.436**	-6.414**	-6.429**	9.762***	9.787***	9.789***	-53.59**	-53.76*	-53.68**
	(5.59)	(5.63)	(5.65)	(-2.60)	(-2.59)	(-2.60)	(13.84)	(13.79)	(13.80)	(-2.00)	(-1.99)	(-1.99)
Lagged IA	-0.095***	-0.096***	-0.095***				-0.110***	-0.110***	-0.110***			
	(-4.69)	(-4.73)	(-4.71)				(-9.88)	(-9.88)	(-9.88)			
LEV	-0.002	-0.000	-0.000	0.009	0.008	0.008	-0.003***	-0.003***	-0.003***	0.009	0.009	0.009
	(-0.24)	(-0.03)	(-0.01)	(1.18)	(1.07)	(1.04)	(-8.01)	(-7.93)	(-7.93)	(1.38)	(1.36)	(1.39)
SZ	0.009***	0.008***	0.008***	0.001	0.001	0.001	0.001***	0.001***	0.001***	-0.001	-0.001	-0.001
	(5.61)	(5.31)	(5.31)	(0.49)	(0.68)	(0.68)	(6.44)	(6.44)	(6.37)	(-0.51)	(-0.50)	(-0.48)
GR	0.002	0.001	0.002	0.009	0.009	0.009	0.003	0.003	0.003	-0.028	-0.028	-0.028
	(0.12)	(0.07)	(0.08)	(0.47)	(0.48)	(0.47)	(1.05)	(1.03)	(1.04)	(-1.13)	(-1.12)	(-1.12)
NWC	0.240**	0.219**	0.221**	0.587*	0.598*	0.599*	-0.003	-0.003	-0.003	0.544*	0.547*	0.546*
	(2.52)	(2.29)	(2.31)	(1.64)	(1.67)	(1.67)	(-0.30)	(-0.32)	(-0.30)	(1.89)	(1.90)	(1.90)
CH	0.068***	0.067***	0.067***	0.059***	0.060***	0.060***	-0.001	-0.001	-0.000	0.063***	0.063***	0.063***
	(7.50)	(7.36)	(7.39)	(6.78)	(6.86)	(6.87)	(-0.42)	(-0.47)	(-0.44)	(3.44)	(3.42)	(3.43)
FA	0.000***	0.000***	0.000***	-0.000	-0.000	-0.000	0.000***	0.000***	0.000***	-0.000*	-0.000*	-0.000*
	(5.58)	(5.54)	(5.53)	(-1.21)	(-1.17)	(-1.17)	(21.16)	(21.11)	(21.11)	(-1.67)	(-1.67)	(-1.67)
NDT	-0.058**	-0.057**	-0.056**	-0.034**	-0.034**	-0.034**	-0.078***	-0.079***	-0.078***	-0.038	-0.036	-0.038
	(-2.05)	(-2.01)	(-1.97)	(-2.02)	(-2.07)	(-2.08)	(-15.68)	(-15.67)	(-15.63)	(-0.67)	(-0.63)	(-0.66)
PR	0.029	0.021	0.022	-0.014	-0.008	-0.008	0.021***	0.021***	0.021***	-0.095**	-0.092**	-0.093**
	(1.52)	(1.04)	(1.12)	(-0.80)	(-0.47)	(-0.44)	(11.12)	(10.99)	(11.07)	(-2.29)	(-2.21)	(-2.18)
NCF		0.016***			-0.007*			0.001**			-0.007*	
		(4.27)			(-1.91)			(2.22)			(-1.72)	
CF*NCF		0.323*			-0.313*			-0.013			-0.027	
		(1.71)			(-1.82)			(-0.79)			(-0.17)	
PCF			0.006			-0.008**			-0.001*			-0.002
			(1.59)			(-2.00)			(-1.64)			(-0.81)
CF*PCF			-0.666***			0.350*			-0.023			0.241
			(-3.78)			(1.90)			(-1.61)			(1.27)
Lagged TA				-0.142***	-0.142***	-0.142***				-0.442	-0.442	-0.442
				(-6.11)	(-6.11)	(-6.10)				(-1.46)	(-1.46)	(-1.46)
Cons	-0.329***	-0.323**	-0.317**	-0.382	-0.386	-0.386	-0.033***	-0.034***	-0.033***	-0.207	-0.205	-0.209
	(-2.87)	(-2.81)	(-2.76)	(-1.32)	(-1.33)	(-1.33)	(-3.64)	(-3.68)	(-3.57)	(-0.94)	(-0.93)	(-0.95)
N	**7152**	**7152**	**7152**	**7152**	**7152**	**7152**	**268740**	**268740**	**268740**	**268740**	**268740**	**268740**
R^2	**0.081**	**0.084**	**0.084**	**0.049**	**0.050**	**0.050**	**0.051**	**0.051**	**0.051**	**0.225**	**0.225**	**0.225**

The instrumental variable (IV Model) employs a two-stage least squares (2SLS) technique where the cash flow model is regressed on changes in leverage (LEV), size (SZ), growth (GR), networking capital (NWC), cash holdings (CH), firm age (FY), earnings (PR), investments – IA and TA – and the chosen instruments – industry earnings (IND_PR) and industry growth (IND_GR) to obtain predicted values of CF to be included in the second-stage regression together with the internal constraints proxies CF*NCF and CF*PCF and controls. The models included fixed effects in all estimations. The key variables of interest are the interaction terms: CF*NCF and CF*PCF. The reported t-statistics based on robust standard errors are within parentheses. Variable definitions are described in Table 1. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Table 12: Cash flow – investment (instrumental variable using 2SLS): size effects

	Public Firms				Private Firms			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
	IA	**IA**	**TA**	**TA**	**IA**	**IA**	**TA**	**TA**
CF	17.90***	17.96***	-6.405**	-6.416**	9.779***	9.753***	-53.62**	-53.66**
	(5.60)	(5.61)	(-2.59)	(-2.59)	(13.84)	(13.81)	(-2.00)	(-2.00)
Lagged IA	-0.094***	-0.095***			-0.110***	-0.110***		
	(-4.66)	(-4.67)			(-9.88)	(-9.88)		
LEV	-0.001	-0.002	0.008	0.009	-0.003***	-0.003***	0.009	0.009
	(-0.08)	(-0.23)	(1.06)	(1.16)	(-7.94)	(-8.02)	(1.39)	(1.38)
SZ	0.008***	0.008***	0.001	-0.001	0.001***	0.001***	-0.002	0.0001
	(5.58)	(4.18)	(1.21)	(-0.31)	(6.68)	(5.03)	(-0.76)	(0.12)
GR	0.002	0.002	0.009	0.009	0.003	0.003	-0.028	-0.028
	(0.11)	(0.10)	(0.47)	(0.47)	(1.04)	(1.05)	(-1.13)	(-1.13)
NWC	0.241**	0.238**	0.586*	0.585	-0.003	-0.003	0.544*	0.544*
	(2.53)	(2.51)	(1.64)	(1.63)	(-0.30)	(-0.30)	(1.89)	(1.89)
CH	0.069***	0.068***	0.058***	0.060***	-0.000	-0.000	0.063***	0.063***
	(7.33)	(7.51)	(6.67)	(6.75)	(-0.46)	(-0.40)	(3.43)	(3.43)
FA	0.000***	0.000***	-0.000	-0.000	0.000***	0.0001***	-0.000*	-0.000*
	(5.60)	(5.56)	(-1.24)	(-1.27)	(21.18)	(21.15)	(-1.66)	(-1.67)
NDT	-0.057**	-0.058**	-0.034**	-0.034**	-0.078***	-0.078***	-0.038	-0.038
	(-2.00)	(-2.05)	(-2.02)	(-2.02)	(-15.68)	(-15.67)	(-0.67)	(-0.66)
PR	0.029	0.029	-0.013	-0.015	0.021***	0.021***	-0.095**	-0.095**
	(1.45)	(1.52)	(-0.75)	(-0.84)	(11.15)	(11.10)	(-2.28)	(-2.28)
SSZ	-0.004		0.005		0.001**		-0.002	
	(-0.78)		(1.13)		(2.55)		(-1.17)	
CF*SSZ	-0.306		-0.433		-0.063***		0.073	
	(-0.78)		(-1.58)		(-3.23)		(0.45)	
LSZ		0.001		0.003		-0.0001		-0.002
		(0.34)		(0.97)		(-0.45)		(-0.95)
CF*LSZ		-0.104		-0.006		0.027		0.194
		(-0.73)		(-0.03)		(1.03)		(0.96)
Lagged TA			-0.143***	-0.142***			-0.442	-0.442
			(-6.12)	(-6.11)			(-1.46)	(-1.46)
Cons	-0.324**	-0.325**	-0.388	-0.373	-0.0348***	-0.0337***	-0.199	-0.213
	(-2.82)	(-2.83)	(-1.34)	(-1.29)	(-3.78)	(-3.70)	(-0.89)	(-0.99)
N	7152	7152	7152	7152	268740	268740	268740	268740
R^2	0.082	0.081	0.050	0.049	0.051	0.051	0.225	0.225

The instrumental variable (IV Model) employs a two-stage least squares (2SLS) technique where the cash flow model is regressed on changes in leverage (LEV), size (SZ), growth (GR), networking capital (NWC), cash holdings (CH), firm age (FY), earnings (PR), investments – IA and TA – and the chosen instruments – industry earnings (IND_PR) and industry growth (IND_GR) to obtain predicted values of CF to be included in the second-stage regression together with the internal constraints proxies CF*SSZ and CF*LSZ and controls. The models included fixed effects in all estimations. The key variable of interests are the interaction terms: CF*SSZ and CF*LSZ. The reported t-statistics based on robust standard errors are within parentheses. Variable definitions are described in Table 1. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**

Table 13: Cash flow – investment (instrumental variable using 2SLS): age effects

	Public firms				Private firms			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
	IA	**IA**	**TA**	**TA**	**IA**	**IA**	**TA**	**TA**
CF	18.05***	17.88***	-6.483**	-6.452**	9.827***	9.773***	-53.73**	-53.60**
	(5.62)	(5.58)	(-2.62)	(-2.61)	(13.88)	(13.83)	(-2.00)	(-2.00)
Lagged IA	-0.095***	-0.095***			-0.111***	-0.110***		
	(-4.68)	(-4.68)			(-9.97)	(-9.88)		
LEV	-0.001	-0.002	0.009	0.009	-0.003***	-0.003***	0.009	0.009
	(-0.15)	(-0.26)	(1.14)	(1.15)	(-7.24)	(-7.90)	(1.32)	(1.38)
SZ	0.008***	0.009***	0.001	0.001	0.001***	0.001***	-0.001	-0.001
	(5.57)	(5.60)	(0.52)	(0.52)	(6.65)	(6.45)	(-0.54)	(-0.52)
GR	0.003	0.003	0.009	0.009	0.005	0.003	-0.031	-0.028
	(0.14)	(0.13)	(0.48)	(0.46)	(1.60)	(1.04)	(-1.21)	(-1.13)
NWC	0.235**	0.241**	0.589*	0.587*	-0.002	-0.003	0.543*	0.544*
	(2.48)	(2.54)	(1.65)	(1.64)	(-0.21)	(-0.30)	(1.89)	(1.89)
CH	0.068***	0.068***	0.059***	0.059***	-0.000	-0.000	0.063***	0.063***
	(7.49)	(7.52)	(6.79)	(6.77)	(-0.45)	(-0.44)	(3.44)	(3.43)
FA	0.000***	0.000***	-0.000	-0.000	0.000***	0.000***	-0.000	-0.000
	(4.40)	(3.46)	(-0.97)	(-0.24)	(15.30)	(14.78)	(-1.41)	(-1.38)
NDT	-0.057**	-0.058**	-0.034**	-0.034**	-0.078***	-0.078***	-0.039	-0.038
	(-2.01)	(-2.05)	(-2.04)	(-2.03)	(-15.63)	(-15.68)	(-0.68)	(-0.67)
PR	0.029	0.029	-0.014	-0.014	0.020***	0.021***	-0.095**	-0.095**
	(1.49)	(1.52)	(-0.80)	(-0.81)	(10.89)	(11.13)	(-2.27)	(-2.28)
YFA	-0.007*		0.002		-0.005***		0.007***	
	(-1.76)		(0.44)		(-17.21)		(4.62)	
CF*YFA	-0.120		0.126		-0.035		0.202	
	(-0.41)		(0.35)		(-1.01)		(0.83)	
OFA		0.001		-0.002		0.001***		-0.001
		(0.36)		(-0.72)		(3.07)		(-0.28)
CF*OFA		0.206		0.071		-0.033**		0.011
		(1.41)		(0.37)		(-2.24)		(0.08)
Lagged TA			-0.142***	-0.142***			-0.442	-0.442
			(-6.11)	(-6.11)			(-1.46)	(-1.46)
Cons	-0.320**	-0.330**	-0.385	-0.382	-0.034***	-0.033***	-0.206	-0.207
	(-2.79)	(-2.88)	(-1.33)	(-1.32)	(-3.73)	(-3.62)	(-0.94)	(-0.94)
N	**7152**	**7152**	**7152**	**7152**	**268740**	**268740**	**268740**	**268740**
R^2	**0.082**	**0.081**	**0.049**	**0.049**	**0.052**	**0.051**	**0.225**	**0.225**

The instrumental variable (IV Model) employs a two-stage least squares (2SLS) technique where the cash flow model is regressed on changes in leverage (LEV), size (SZ), growth (GR), networking capital (NWC), cash holdings (CH), firm age (FY), earnings (PR), investments – IA and TA – and the chosen instruments – industry earnings (IND_PR) and industry growth (IND_GR) to obtain predicted values of CF to be included in the second-stage regression together with the internal constraints proxies CF*YFA and CF*OFA and controls. The models included fixed effects in all estimations. The key variable of interests are the interaction terms: CF*YFA and CF*OFA. The reported t-statistics based on robust standard errors are within parentheses. Variable definitions are described in Table 1. *, ** and * indicate statistical significance at the 10%, 5% and 1% levels respectively.**