

DO MARKETS PRICE CAPITAL INVESTMENT MORE THAN INNOVATION INTENSITY? EVIDENCE FROM U.S. AND CHINESE TECHNOLOGY AND SOFTWARE FIRMS, 2020–2024

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Abstract:

This paper examines the short-run associations of innovation intensity and capital investment intensity with firm performance in technology and software firms from the United States and China over 2020–2024. Using an annual firm-level panel and estimating firm fixed-effects models with year fixed effects and heteroskedasticity-robust standard errors clustered at the firm level, the analysis evaluates three outcomes: firm value (log market capitalisation), operating profitability, and net sales growth. Robustness is assessed across alternative investment proxies (intensity ratios versus log-level measures), alternative lag structures, and winsorisation procedures, while cross-country heterogeneity is examined through interaction models and marginal effects.

The findings indicate that innovation intensity is not associated with short-run performance in a uniform way across model specifications or outcome variables. In intensity-based specifications, lagged R&D intensity is negatively associated with firm value and is also linked to margin pressure in profitability models, although these relationships weaken under some alternative measurement choices. Cross-country heterogeneity is most visible in the valuation channel: capex intensity exhibits a significantly stronger positive marginal association with firm value for U.S. firms, whereas the firm-value association of R&D intensity does not differ significantly between the United States and China. Evidence of differential effects on sales growth across the two countries remains limited once firm heterogeneity and common year shocks are taken into account.

Overall, the results suggest that short-run market valuation is more consistently associated with capital investment than with innovation intensity, although several findings remain sensitive to measurement strategy and timing assumptions. The evidence therefore supports a cautious interpretation in which differences in investment pricing depend not only on the type of investment, but also on specification choice and institutional context.

Key words: R&D intensity; capex intensity; firm value; operating profitability; net sales growth; fixed effects; U.S.–China comparison; technology and software firms.

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1. INTRODUCTION

The digital economy has become a major engine of contemporary economic growth, with technology-intensive sectors continuing to outperform the broader economy. Recent OECD evidence shows that the ICT sector has expanded more rapidly than the overall economy, while the latest wave of AI-related venture capital has been concentrated primarily in the United States and China (OECD, 2024; WIPO, 2024a; WIPO, 2024b). At the same time, the Global Innovation Index continues to rank both economies among the world's leading innovation systems, underscoring their central role in shaping the global technology frontier (WIPO, 2024a; WIPO, 2024b; WIPO, 2024c). In this environment, understanding how capital markets and operating performance respond to different forms of corporate investment has become especially important for technology and software firms.

A central issue in the corporate finance and innovation literature is whether markets reward intangible investment in the same way they reward tangible capital formation. Prior studies show that research and development (R&D) can generate valuable intangible assets and future growth opportunities, yet the timing and uncertainty of those benefits make their short-run valuation difficult to assess (Griliches, 1981; Connolly & Hirschey, 1988; Lev & Sougiannis, 1996; Chan et al., 2001; Hall et al., 2005; Sandner & Block, 2011; Warusawitharana, 2015). Classic evidence suggests that R&D is value relevant, but also that its future payoffs are considerably more uncertain than those associated with capital expenditures (Lev & Sougiannis, 1996; Kothari et al., 2002). By contrast,

capital expenditure (capex) is often more visible, easier to verify, and more directly linked to productive capacity, which may make it easier for markets to price in the short run (Trueman, 1986; Abel & Eberly, 2011; Ullah et al., 2023).

These issues are especially salient in technology and software industries, where firms simultaneously invest in innovation, platform development, data infrastructure, and scaling capacity. The period 2020–2024 provides a particularly useful setting because it combines rapid digital expansion with substantial macro-financial volatility, post-pandemic adjustment, and shifts in investor sentiment. Under such conditions, the market may differentiate more sharply between investment types, assigning different short-run valuations to tangible scaling projects and innovation intensity.

Despite extensive research on innovation and investment, less is known about how R&D intensity and capex intensity compare within the same empirical setting, particularly in technology-related sectors and under a short horizon characterised by elevated uncertainty. In addition, limited evidence exists on whether these relationships differ systematically between the two leading technology economies, the United States and China. This study addresses that gap by examining publicly listed technology and software firms from the two countries over 2020–2024.

Using firm-level panel data and fixed-effects estimation, the study evaluates the association of R&D intensity and capex intensity with three key outcomes: firm value, operating profitability, and net sales growth. It also investigates whether these relationships differ systematically between U.S. and Chinese firms. By comparing two major innovation systems within the same broad sectoral space, the paper contributes to the literature on investment composition, market valuation, and short-run firm performance under conditions of elevated uncertainty.

The paper contributes in three ways. First, it examines R&D intensity and capex intensity jointly rather than in isolation, allowing a direct comparison between intangible and tangible investment channels. Second, it focuses on technology and software firms, where both forms of investment are strategically important and likely to carry different informational content. Third, it combines firm fixed effects, year fixed effects, clustered standard errors, and multiple robustness checks to assess whether the estimated relationships remain stable across alternative proxies and lag structures.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. INVESTMENT INTENSITY AND FIRM VALUE

A substantial body of research links innovation investment to firm value by emphasising knowledge creation, future product opportunities, and the accumulation of intangible assets. Early studies show that R&D is value relevant despite its conservative accounting treatment, suggesting that capital markets are able, at least to some extent, to recognise the future benefits embedded in innovation-related spending (Lev & Sougiannis, 1996; Chan et al., 2001; Hall et al., 2005; Hall & Oriani, 2006). Earlier foundational contributions similarly document positive associations between market value, R&D, and innovative assets (Griliches, 1981; Connolly & Hirschey, 1988; Doukas & Switzer, 1992). More recent evidence also indicates that R&D may enhance firm value by generating future growth opportunities and strategic flexibility (Warusawitharana, 2015; Tebourbi et al., 2020; Edacherian et al., 2024).

However, the valuation effect of R&D is not necessarily immediate or uniform. Because innovation outcomes are uncertain, long-horizon, and often difficult for outside investors to verify, markets may discount high R&D intensity, particularly under conditions of heightened macroeconomic uncertainty. Kothari et al. (2002) show that the future benefits of R&D are considerably more uncertain than those associated with capital expenditures. Related studies further suggest that the valuation relevance of R&D depends on profitability, institutional context, disclosure quality, and accounting treatment (Franzen & Radhakrishnan, 2009; Yang et al., 2019; Dinh et al.,

2022; Resutek, 2022). This implies that, even when innovation is strategically important, its short-run pricing may remain cautious and specification-sensitive.

The literature on capital expenditures points to a related but distinct valuation mechanism. Capex can signal expansion, productive capacity, and commitment to future scale, which may support firm value when investors interpret such spending as disciplined and growth-enhancing. Prior evidence documents a link between capital expenditures and firm value, although both the sign and magnitude of that relationship vary with context, governance, and the expected productivity of the investment (Trueman, 1986; Xing, 2008; Abel & Eberly, 2011; Nwaeze, 2005; Ullah et al., 2023). In technology sectors, this channel may be particularly important where firms invest in data centres, hardware ecosystems, network infrastructure, or scalable operational capacity.

Taken together, the literature suggests that both innovation intensity and capital investment intensity may be associated with firm value, but not necessarily to the same degree in the short run. In periods characterised by uncertainty and common shocks, markets may respond more directly to tangible and scalable capital investment than to innovation spending whose benefits are more delayed and uncertain.

H1: R&D intensity and capex intensity are associated with firm value, but capex intensity may be priced more strongly than R&D intensity in the short run.

2.2. INVESTMENT INTENSITY AND OPERATING PROFITABILITY

The profitability channel is conceptually distinct from the valuation channel because both innovation investment and capital investment often impose current costs before their benefits are fully realised. R&D can depress short-run margins because resources are committed in the present while commercial returns remain delayed and uncertain. A number of studies show that R&D may reduce contemporaneous profitability even when it improves longer-run performance or contributes positively to market value (Eberhart et al., 2004; Kallunki et al., 2009; Warusawitharana, 2015; Karna et al., 2022; Resutek, 2022). Recent evidence likewise suggests that increases in R&D intensity may weaken short-run profitability despite potentially favourable longer-run capital-market implications (Karna et al., 2022).

Capex may generate a similar short-run trade-off. Large capital projects typically involve implementation costs, depreciation burdens, and operational adjustment pressures before efficiency gains emerge. Empirical research suggests that capital expenditures can weigh on near-term earnings, especially when projects require time to translate into productive returns or when firms operate under financial or competitive pressure (Kim et al., 2021; Fu et al., 2022; Lee et al., 2021). At the same time, the profitability implications of capex are unlikely to be uniform, as they may vary with financing conditions, managerial incentives, and investment opportunities (Abel & Eberly, 2011; Baker et al., 2016; Edmans et al., 2017).

In technology and software firms, these short-run pressures may be particularly pronounced because both innovation and scaling investments are often front-loaded, while operating payoffs materialise only gradually. The literature therefore supports the expectation that higher investment intensity, whether in R&D or capex, may be associated with weaker short-run operating profitability.

H2: R&D intensity and capex intensity are negatively associated with short-run operating profitability.

2.3. INVESTMENT INTENSITY AND NET SALES GROWTH

Investment can also affect firm performance through the revenue-growth channel. R&D may support future sales growth by enabling product innovation, quality improvement, ecosystem expansion, and faster adaptation to technological change. Capex can likewise contribute to revenue growth by increasing productive capacity, improving commercialisation capability, and supporting delivery infrastructure. In principle, both forms of investment may therefore stimulate subsequent net sales growth (Griliches, 1981; Hall et al., 2005; Warusawitharana, 2015; Tebourbi et al., 2020).

At the same time, the timing of these effects is unlikely to be uniform. Innovation-related payoffs often emerge with longer lags, while the growth effect of capex depends on demand conditions, execution quality, and competitive dynamics. As a result, any positive association with annual sales growth may be weaker, slower to appear, and more sensitive to model specification than the corresponding valuation effects (Kothari et al., 2002; Eberhart et al., 2004; Kim et al., 2021; Fu et al., 2022). This consideration is especially relevant in a short sample window, where annual growth rates may not fully capture the delayed benefits of investment.

Accordingly, although both innovation intensity and capex intensity are expected to support subsequent expansion, their measurable short-run effects on net sales growth may be modest and empirically sensitive.

H3: R&D intensity and capex intensity are positively associated with subsequent net sales growth.

2.4. U.S. – CHINA HETEROGENEITY

The United States and China provide a useful comparative setting because both are major technology powers, yet they differ substantially in financial structure, investor composition, innovation ecosystems, and broader market institutions. OECD evidence highlights the depth of private-sector R&D and venture-capital activity in the United States, while WIPO indicators place both economies among the world's leading innovation systems (OECD, 2024; WIPO, 2024a; WIPO, 2024b; WIPO, 2024c). These structural differences suggest that investment intensity may not be interpreted or priced in identical ways across the two countries.

One plausible expectation is that U.S. investors may respond more favourably to capex when it is interpreted as scalable, monetisable, and linked to growth-supporting infrastructure, whereas innovation spending may be treated more cautiously when short-run earnings visibility is weak. In China, by contrast, state influence, financing conditions, and market structure may contribute to a different pricing environment. Existing literature therefore supports examining not only the direct effects of investment intensity, but also whether those effects vary across institutional settings (Hall & Oriani, 2006; Baker et al., 2016; OECD, 2024).

This comparative perspective is particularly important in technology-related sectors, where the same level of investment intensity may carry different informational content depending on the surrounding capital-market and governance environment.

H4: The marginal effects of R&D intensity and capex intensity differ between U.S. and Chinese technology and software firms.

3. METHODOLOGY

3.1. SAMPLE AND DATA STRUCTURE

The empirical analysis is based on an annual firm-level panel of U.S. and Chinese firms operating in the software and technology-hardware segments over 2020–2024. The final sample comprises 223 unique firms and 1,115 firm-year observations, including 156 U.S. firms and 67 Chinese firms. The initial firm universe was identified using the 2025 EU Industrial R&D Investment Scoreboard as a practical sampling frame for large publicly listed firms in the relevant technology segments (European Commission, 2025). The Scoreboard was used solely to define a transparent and externally verifiable set of eligible firms, whereas all dependent variables, explanatory variables, and model estimations are based on annual firm-level observations for 2020–2024. This approach improves cross-country comparability and sample transparency, although it may also tilt the sample toward firms that remained sufficiently large and observable in the later reporting round. Accordingly, the panel is best interpreted as a structured sample of continuously traceable technology firms rather than as a complete census of all firms active during the study period.

Because the regression models employ one-period lags, the main specifications are estimated on 892 firm-year observations. Appendix A reports the list of sample firms by country. This panel structure is well suited to fixed-effects estimation because it follows the same firms over time and permits identification from within-firm variation in investment intensity and performance outcomes (Wooldridge, 2010; Baltagi, 2021). The focus on the United States and China is motivated by their central positions in the global innovation landscape and by meaningful institutional differences between their technology ecosystems, which make the comparison analytically informative (OECD, 2024; WIPO, 2024).

3.2. VARIABLE DEFINITIONS

The study employs three dependent variables that capture complementary dimensions of firm performance. Firm value is measured as the natural logarithm of market capitalisation. Operating profitability is measured as operating profit scaled by net sales. Net sales growth is measured as the one-year percentage change in net sales. Taken together, these indicators capture market valuation, current operating efficiency, and revenue expansion (Lev & Sougiannis, 1996; Chan et al., 2001; Warusawitharana, 2015).

The key explanatory variables are RDINT and CAPINT, defined respectively as R&D expenditure and capital expenditure scaled by net sales. The use of intensity ratios rather than raw investment levels improves comparability across firms of different sizes and is consistent with prior work on investment behaviour and firm performance. To mitigate simultaneity concerns, the baseline models employ one-year-lagged investment variables. In the robustness analysis, these measures are replaced with log-level investment proxies and growth-based investment specifications to assess whether the findings depend on the choice of proxy or timing convention (Kothari et al., 2002; Hall & Oriani, 2006; Kim et al., 2021; Karna et al., 2022).

The models also include lagged firm-level controls. Firm scale and operating size are proxied by the natural logarithm of net sales and the natural logarithm of employees. In addition, year fixed effects are included to absorb shocks common to all firms in a given year, including post-pandemic adjustment, financing conditions, and changes in technology-market sentiment (Wooldridge, 2010; Baltagi, 2021).

3.3. BASELINE MODEL

The baseline empirical specification is estimated using a firm fixed-effects model with year fixed effects:

$$Y_{it} = \beta_1 RDINT_{i,t-1} + \beta_2 CAPINT_{i,t-1} + \gamma X_{i,t-1} + \alpha_i + \lambda_t + \varepsilon_{it}$$

where Y_{it} denotes, alternatively, log market capitalisation, operating profitability, or net sales growth for firm i in year t . $RDINT_{i,t-1}$ and $CAPINT_{i,t-1}$ denote lagged R&D intensity and lagged capex intensity, respectively. $X_{i,t-1}$ is a vector of lagged firm-level control variables, including the natural logarithm of net sales and the natural logarithm of employees. α_i captures firm fixed effects, λ_t captures year fixed effects, and ε_{it} is the idiosyncratic error term. The coefficients β_1 and β_2 measure the within-firm associations between the lagged investment variables and firm performance.

Firm fixed effects are appropriate because they absorb unobserved, time-invariant firm characteristics such as business model, managerial style, listing environment, and product positioning. This is especially important in technology sectors, where persistent cross-firm heterogeneity could otherwise bias pooled estimates. Year fixed effects control for shocks common to all firms in a given year. Standard errors are clustered at the firm level to account for

heteroskedasticity and serial correlation within firms over time (Arellano, 1987; Petersen, 2009; Wooldridge, 2010).

3.4. INTERACTION MODEL FOR U.S. – CHINA HETEROGENEITY

To examine whether the investment–performance relationship differs between U.S. and Chinese firms, the study estimates the following interaction model:

$$Y_{it} = \beta_1 RDINT_{i,t-1} + \beta_2 CAPINT_{i,t-1} + \delta_1 (RDINT_{i,t-1} \times US_i) + \delta_2 (CAPINT_{i,t-1} \times US_i) + \gamma X_{i,t-1} + \alpha_i + \lambda_t + \varepsilon_{it}$$

where US_i is an indicator equal to one for U.S. firms and zero for Chinese firms. Because US_i is time-invariant, its standalone effect is absorbed by firm fixed effects and is therefore not separately identified. However, its interactions with the time-varying investment variables remain identifiable. The interaction coefficients δ_1 and δ_2 indicate whether the marginal effects of lagged R&D intensity and lagged capex intensity differ for U.S. firms relative to Chinese firms, conditional on the same set of lagged controls used in the baseline specification.

3.5. ROBUSTNESS PROCEDURES

Several robustness procedures are implemented to assess the stability of the main findings. First, the analysis compares intensity-based specifications with log-level specifications for the investment variables. Second, alternative lag structures, including one-year and two-year lags, are estimated to test whether the results are sensitive to timing assumptions. Third, growth-based versions of R&D and capex are estimated to determine whether changes in investment, rather than investment intensity itself, drive the observed relationships. Fourth, alternative winsorisation rules are applied to limit the influence of extreme observations, which is particularly important for valuation and growth variables in technology samples (Kothari et al., 2002; Petersen, 2009; Wooldridge, 2010).

Overall, this empirical design allows the study to examine whether within-firm changes in innovation intensity and capital investment intensity are associated with changes in valuation, profitability, and sales growth, while controlling for persistent firm heterogeneity and common annual shocks.

4. RESULTS

4.1. DESCRIPTIVE STATISTICS AND DIAGNOSTICS

Table no. 1. Descriptive Statistics

Variable	N	Mean	SD	Min	Max
Market capitalisation (€ million)	1,115	51,019.68	246,347.20	95.41	3,164,133.00
Operating profitability (%)	1,115	0.12	33.08	-399.82	67.95
Net sales growth (%)	1,115	17.74	24.45	-50.93	143.24
R&D intensity (% of net sales)	1,115	20.55	14.70	0.56	173.63
Capex intensity (% of net sales)	1,115	5.36	8.95	0.02	138.72
Net sales (€ million)	1,115	10,052.00	34,664.59	56.80	376,393.30
Employees	1,115	17,775.69	38,342.03	310	281,192

Source: Author's calculations based on JRC Scoreboard raw data

Notes: This table reports the number of observations (N), mean, standard deviation, minimum, and maximum for the main variables used in the analysis. Firm value is proxied by market capitalisation. Operating profitability is measured as operating profit scaled by net sales. Net sales

growth is the one-year percentage change in net sales. R&D intensity and capex intensity are measured as percentages of net sales. Descriptive statistics are reported for the raw firm-level variables.

Table no. 2. Correlation Matrix

Variable	1	2	3	4	5	6	7
1. Market capitalisation (€ million)	1.000						
2. Operating profitability (%)	0.176	1.000					
3. Net sales growth (%)	0.081	-0.077	1.000				
4. R&D intensity (% of net sales)	-0.096	-0.535	0.127	1.000			
5. Capex intensity (% of net sales)	0.050	-0.040	-0.025	0.081	1.000		
6. Net sales (€ million)	0.826	0.181	-0.014	-0.173	0.077	1.000	
7. Employees	0.507	0.195	-0.085	-0.241	0.169	0.763	1.000

Source: Author's calculations based on JRC Scoreboard raw data

Notes: This table reports Pearson pairwise correlations among the main dependent variables, investment proxies, and control variables. Correlations are computed using pairwise complete observations. For presentation purposes, only the lower triangle of the matrix is reported.

Table no. 2 shows that pairwise correlations are generally moderate. The strongest positive correlations are observed between market capitalisation and net sales, and between net sales and employees, which is expected for firm-size-related measures.

Table no. 3. Variance Inflation Factors (VIF)

Term	GVIF	Df	GVIF ^{1/(2*Df)}	GVIF_adj
R&D intensity (% of net sales)	1.390	1	1.179	1.179
Capex intensity (% of net sales)	1.086	1	1.042	1.042
log(Net sales)	6.278	1	2.506	2.506
log(Employees)	6.373	1	2.524	2.524
Region	1.467	1	1.211	1.211
Year	1.048	4	1.006	1.006

Source: Author's calculations based on JRC Scoreboard raw data

Notes: This table reports variance inflation factors (VIF) from an OLS specification including the main regressors and fixed-effects proxies. For factor variables, generalized VIF (GVIF) is reported. The adjusted GVIF values indicate that multicollinearity is not severe.

Table no. 3 indicates that multicollinearity is not a major concern. Although the raw GVIF values for log (net sales) and log(employees) are higher, their adjusted GVIF values remain modest.

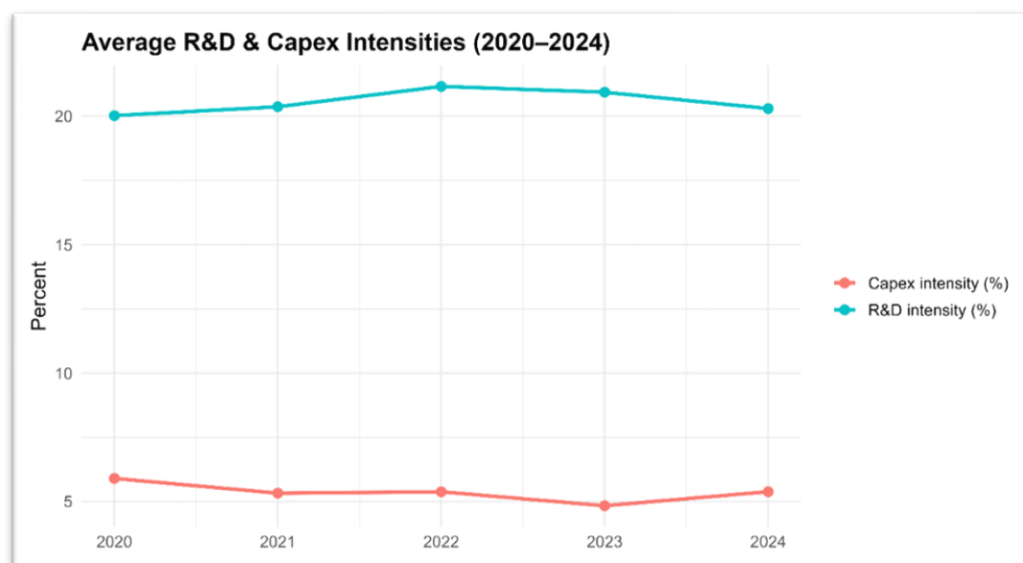


Figure no. 1. Average R&D and Capex Intensities, 2020–2024.

This figure shows the average evolution of R&D intensity and capex intensity over 2020–2024, providing descriptive context for the subsequent fixed-effects analysis.

4.2. H1: INVESTMENT INTENSITIES AND FIRM VALUE (MARKET CAPITALISATION)

Table no. 4. Main Regression Results and Robustness Checks

Variables	(1) H1A Firm Value (Log-levels)	(2) H1B Firm Value (Intensity)	(3) H2A Profitability (Log-levels)	(4) H2B Profitability (Intensity)	(5) H3A Sales Growth (Log-levels)	(6) H3B Sales Growth (Intensity)
Lagged ln(R&D)	-0.193 (0.163)		0.042 (4.608)		3.305 (4.663)	
Lagged ln(Capex)	0.036 (0.039)		-3.216** (1.482)		-2.830** (1.425)	
Lagged R&D intensity		-0.019** (0.007)		-0.230 (0.244)		0.564** (0.219)
Lagged Capex intensity		0.009 (0.008)		-0.214 (0.218)		-0.336 (0.265)
Lagged ln(Net sales)	0.366** (0.160)	0.113 (0.151)	27.205*** (4.849)	16.418*** (3.652)	-43.759*** (5.458)	-27.751*** (4.741)
Lagged ln(Employees)	-0.258 (0.203)	-0.196 (0.181)	-17.154*** (5.024)	-11.318*** (3.393)	-3.733 (5.033)	-7.299 (4.737)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustered robust SE	Yes	Yes	Yes	Yes	Yes	Yes

Source: Author's calculations based on JRC Scoreboard raw data.

Notes: This table reports firm fixed-effects regressions with year fixed effects and firm-clustered robust standard errors. Columns (1), (3), and (5) use lagged log-level investment measures, whereas columns (2), (4), and (6) use lagged intensity measures. The main specifications are estimated on a balanced lagged panel of 892 firm-year observations from 223 firms. Standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table no. 4 reports the baseline firm fixed-effects results and robustness checks using alternative lagged investment measures. For firm value, the log-level models do not provide evidence that markets systematically reward lagged R&D or capex, while the intensity specification suggests that higher lagged R&D intensity is associated with lower short-run firm value. For profitability, only lagged capex in the log-level model is statistically significant and negative. For sales growth, the intensity specification shows a positive and significant effect of lagged R&D intensity, whereas lagged capex is negative and significant in the log-level model. These findings indicate that the estimated relationship between investment and performance is not invariant to measurement choice, and that relative investment intensity may capture economically different effects from absolute investment levels.

Figure no. 2 visually compares the H1 robustness results across alternative lagged investment proxies, contrasting log-level and intensity specifications.

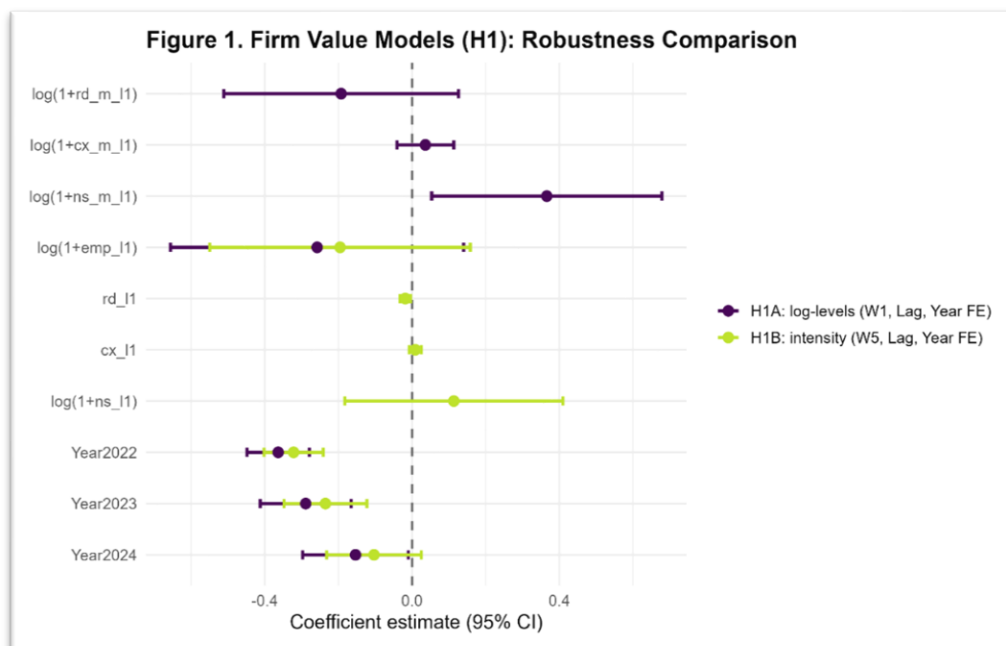


Figure no. 2. Firm Value Models (H1): Robustness Comparison

This figure compares coefficient estimates and 95% confidence intervals from the H1 firm-value models using alternative lagged investment proxies, namely log-level and intensity specifications.

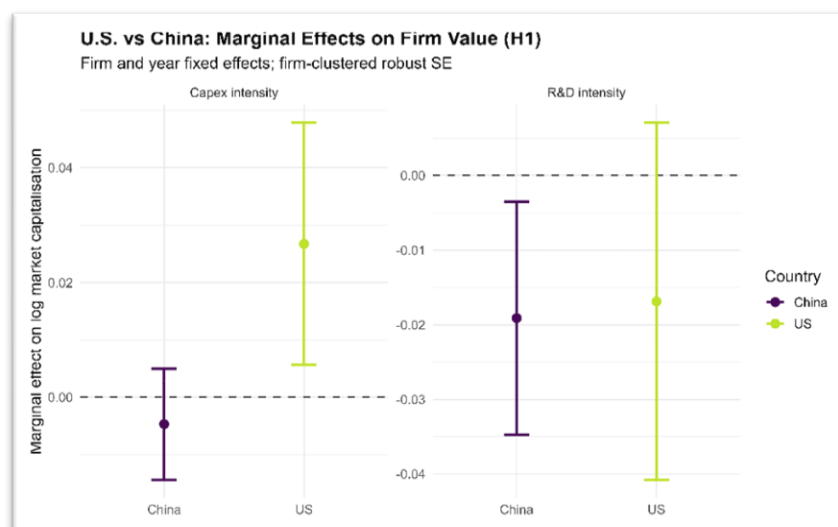


Figure no. 3. U.S. – China Marginal Effects on Firm Value (H1)

This figure compares the estimated marginal effects of capex intensity and R&D intensity on firm value for U.S. and Chinese firms. Estimates are based on firm and year fixed effects with firm-clustered robust standard errors; bars indicate 95% confidence intervals.

Figure no. 3 illustrates cross-country heterogeneity in firm value by comparing the marginal effects of capex intensity and R&D intensity for U.S. and Chinese firms. The figure shows that capex intensity is associated with a more positive marginal effect in U.S. firms, whereas the estimated effects of R&D intensity are negative in both countries and display wider confidence intervals.

Figure no. 3 reports marginal effects by country derived from the interaction model. The results indicate that the marginal effect of R&D intensity on firm value does not differ significantly between U.S. and Chinese firms, as the interaction term between R&D intensity and the U.S. indicator

is statistically insignificant. By contrast, the marginal effect of capex intensity is significantly stronger in U.S. firms, consistent with the positive and statistically significant interaction term between capex intensity and the U.S. indicator. The corresponding interaction coefficients are reported in Table no. 5.

Table 5. U.S. – China Interaction Model for Firm Value (H1)

Variable	Estimate	Std. Error
R&D intensity (%)	-0.019**	(0.008)
Capex intensity (%)	-0.005	(0.005)
ln(Net sales)	0.320**	(0.152)
ln(Employees)	0.459***	(0.160)
Year 2021	0.208***	(0.046)
Year 2022	-0.212***	(0.067)
Year 2023	-0.132*	(0.071)
Year 2024	-0.057	(0.091)
R&D intensity × US	0.002	(0.009)
Capex intensity × US	0.031***	(0.010)

Source: Author's calculations based on JRC Scoreboard raw data

Notes: This table reports the interaction specification used to test U.S. – China heterogeneity in firm value (H1). The country indicator (U.S.) is time-invariant and therefore absorbed by firm fixed effects, while interaction terms with investment intensities remain identifiable. The model is estimated on a balanced lagged panel of 892 firm-year observations from 223 firms. Robust standard errors are clustered at the firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table no. 5 shows that the marginal effect of R&D intensity on firm value does not differ significantly between U.S. and Chinese firms, as the interaction term between R&D intensity and the U.S. indicator is statistically insignificant. By contrast, the interaction term for capex intensity is positive and highly significant, indicating that the firm-value effect of capex intensity is stronger in U.S. firms than in Chinese firms. The baseline coefficient for R&D intensity remains negative and significant, whereas the baseline coefficient for capex intensity is not statistically significant. Overall, the results suggest that cross-country heterogeneity in firm value is driven mainly by differences in how markets price capital investment rather than innovation intensity.

4.3. H2: INVESTMENT INTENSITIES AND OPERATING PROFITABILITY

Profitability regressions are reported in Table 4 under alternative proxy definitions. In the log-level specification (H2A), lagged ln(Capex) is negatively associated with profitability ($\beta = -3.216$, $p = 0.030$), while lagged ln(Net sales) is positively associated with profitability and lagged ln(Employees) is negatively associated with profitability (both $p < 0.01$). In the intensity specification (H2B), the investment-intensity coefficients are not statistically significant, although the size proxies and year effects remain economically and statistically meaningful.

Cross-country heterogeneity in profitability responses is illustrated in Figure no. 4. The pattern suggests that the profitability association of R&D intensity may be more adverse in U.S. firms than in Chinese firms, whereas the cross-country difference in the capex effect appears limited.

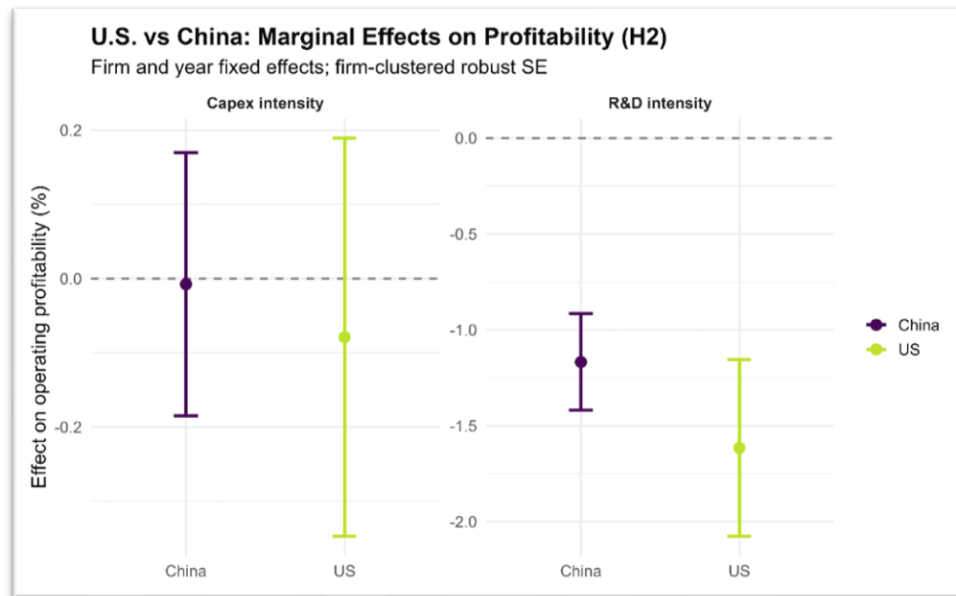


Figure no. 4. U.S.–China Marginal Effects on Profitability (H2)

This figure compares the estimated marginal effects of capex intensity and R&D intensity on operating profitability for U.S. and Chinese firms. Estimates are based on firm and year fixed effects with firm-clustered robust standard errors; bars indicate 95% confidence intervals.

Figure no. 4 illustrates cross-country heterogeneity in profitability responses. The estimated effect of capex intensity appears close to zero in China and more negative in U.S. firms, although the confidence intervals are wide. For R&D intensity, the estimated profitability effect is negative in both countries and appears somewhat more adverse in the United States, consistent with the visual pattern shown in Figure no. 4.

4.4. H3: INVESTMENT INTENSITIES AND NET SALES GROWTH

Sales-growth models are reported in Table 4 using the two alternative proxy families. In the log-level specification (H3A), lagged $\ln(\text{Capex})$ is negatively associated with net sales growth ($\beta = -2.830$, $p = 0.047$), while lagged $\ln(\text{Net sales})$ is strongly negative ($p < 0.001$), consistent with a base-effect mechanism. In the intensity specification (H3B), lagged R&D intensity is positively associated with sales growth ($\beta = 0.564$, $p = 0.010$), whereas capex intensity is not statistically significant. Year fixed effects for 2022–2024 are economically large and statistically significant in the intensity model, indicating broad growth headwinds in the post-2021 period.

Cross-country heterogeneity in growth responses is illustrated in Figure no. 5. The estimated marginal effects appear broadly similar across U.S. and Chinese firms, implying no clear U.S. – China difference in the sales-growth response to these investment intensities once firm fixed effects and year shocks are taken into account.

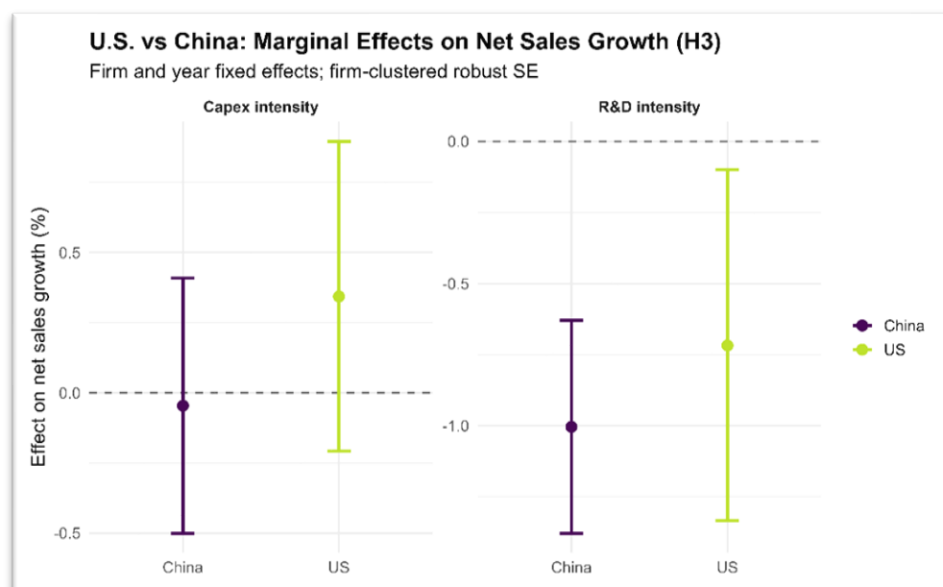


Figure no. 5. U.S. – China Marginal Effects on Net Sales Growth (H3).

This figure compares the estimated marginal effects of capex intensity and R&D intensity on net sales growth for U.S. and Chinese firms. Estimates are based on firm and year fixed effects with firm-clustered robust standard errors; bars indicate 95% confidence intervals.

Figure no. 5 illustrates cross-country heterogeneity in net sales growth responses. Although the point estimates differ somewhat between U.S. and Chinese firms, the confidence intervals overlap substantially, suggesting limited evidence of cross-country divergence in the growth response.

4.5 H4: SUMMARY OF US – CHINA HETEROGENEITY

Overall, the U.S.–China comparison indicates that cross-country heterogeneity is concentrated primarily in the firm-value channel. Specifically, capex intensity exhibits a significantly stronger positive marginal association with firm value in U.S. firms, whereas the association between R&D intensity and firm value does not differ significantly across the two countries (Table no. 5; Figure no. 3). For profitability, Figure no. 4 suggests that the association between R&D intensity and profitability may be somewhat more adverse in U.S. firms, while Figure no. 5 indicates no clear cross-country differences in net sales growth responses. Taken together, these results suggest that differences between the two markets appear more pronounced in how capital investment is priced than in how short-run R&D intensity is valued over the 2020–2024 period.

4.6. ADDITIONAL ROBUSTNESS CHECKS

To ensure that the main conclusions are not driven by timing assumptions or by the choice of denominator in the intensity measures, Table 6 reports additional robustness checks based on longer lags and growth-based investment specifications.

Table no. 6. Additional Robustness Checks

Specification	Outcome	Variable	Estimate	Std. Error
Lag(2) intensity	Firm value	R&D intensity (t-2)	-0.0117	(0.0119)
Lag(2) intensity	Firm value	Capex intensity (t-2)	-0.0071	(0.0081)
Lag(2) intensity	Profitability	R&D intensity (t-2)	0.6509*	(0.2906)
Lag(2) intensity	Profitability	Capex intensity (t-2)	-0.6855**	(0.2403)
Lag(2) intensity	Net sales growth	R&D intensity (t-2)	0.3812	(0.2882)
Lag(2) intensity	Net sales growth	Capex intensity (t-2)	-0.3717	(0.3601)
Growth-based	Firm value	R&D growth (t-1)	0.0012	(0.0012)
Growth-based	Firm value	Capex growth (t-1)	0.0002	(0.0003)
Growth-based	Profitability	R&D growth (t-1)	-0.1107***	(0.0301)
Growth-based	Profitability	Capex growth (t-1)	0.0110†	(0.0061)
Growth-based	Net sales growth	R&D growth (t-1)	-0.0770*	(0.0384)
Growth-based	Net sales growth	Capex growth (t-1)	-0.0055	(0.0082)

Source: Author's calculations based on JRC Scoreboard raw data

Notes: This table reports additional robustness checks based on alternative timing assumptions and investment definitions. The first set of specifications uses lagged intensity measures with a two-period lag and variables winsorised at 5%. The second set uses one-period lagged growth rates in R&D and capex. All models include firm fixed effects and year fixed effects, with heteroskedasticity-robust standard errors clustered at the firm level. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table no. 6 shows that the main conclusions are broadly robust to alternative timing assumptions and investment definitions. In the lagged intensity models, the main firm-value and sales-growth results weaken, whereas the profitability results remain economically meaningful. In the growth-based specifications, neither R&D growth nor capex growth is significantly related to firm value, while profitability is negatively associated with R&D growth and only weakly positively associated with capex growth. For net sales growth, lagged R&D growth is negative and statistically significant, whereas capex growth remains insignificant. Overall, the additional robustness checks indicate that the profitability and growth effects of innovation and capital investment are sensitive to measurement choice, while the firm-value results remain less stable across alternative specifications.

4.7. ADDITIONAL SECTOR HETEROGENEITY: SOFTWARE VS TECHNOLOGY HARDWARE

Table no. 7. Sector Heterogeneity (Software vs Technology Hardware): Interaction Terms Only

Model	Interaction term	Estimate	Std. Error
H1: Firm value	R&D intensity × Hardware	-0.009	(0.009)
H2: Profitability	R&D intensity × Hardware	0.642*	(0.254)
H3: Sales growth	R&D intensity × Hardware	-0.638†	(0.366)

Source: Author's calculations based on JRC Scoreboard raw data

Notes: The reference category is Software & Computer Services. Because sector affiliation is typically time-invariant at the firm level, the standalone sector indicator is absorbed by firm fixed effects; Table no. 7 therefore reports interaction terms only, capturing differential marginal effects for Technology Hardware & Equipment firms relative to the software reference group. All models include firm fixed effects and year fixed effects, with heteroskedasticity-robust standard errors clustered at the firm level. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table no. 7 reports additional sector-heterogeneity tests comparing Technology Hardware & Equipment firms with the reference category Software & Computer Services. The results show no statistically significant sector difference in the association between R&D intensity and firm value. By contrast, the interaction term is positive and significant for profitability, indicating that the profitability effect of R&D intensity is stronger in hardware firms. For net sales growth, the

interaction term is negative and marginally significant, suggesting that the short-run growth response to R&D intensity may be weaker in hardware than in software firms.

5. DISCUSSIONS

5.1. INTERPRETING THE FIRM-VALUE CHANNEL UNDER THE 2020–2024 SHOCK ENVIRONMENT

The firm-value results indicate that, over 2020–2024, equity markets did not consistently assign a higher valuation to greater innovation intensity in the short run. In the intensity-based specification, lagged R&D intensity is negatively associated with firm value, whereas in the log-level specification the R&D coefficient becomes statistically insignificant and firm value loads more strongly on lagged net sales. This pattern suggests that intensity measures may partly capture denominator effects and short-run margin pressure, rather than a pure innovation effect.

The year fixed effects further point to a pronounced common valuation shock around 2022–2023, implying that macro-financial conditions played an important role in shaping market valuations during this period. Against this backdrop, the clearest U.S.–China heterogeneity appears in the capex channel: capex intensity is associated more strongly with firm value in U.S. firms, whereas the valuation effect of R&D intensity does not differ significantly across the two countries. One possible interpretation is that, in periods of elevated uncertainty, U.S. capital markets place greater weight on tangible scaling and capacity expansion, while R&D intensity is perceived as more uncertain and longer-horizon, and is therefore less readily capitalised into market value.

5.2. PROFITABILITY AND GROWTH: SHORT-RUN TRADE-OFFS AND LIMITED CROSS-COUNTRY DIVERGENCE

The profitability results are consistent with a short-run investment trade-off. In the log-level models, higher lagged capex is negatively associated with operating profitability, suggesting that capital deployment may impose near-term cost pressures before efficiency gains are realised. The interaction estimates also indicate that the profitability association of R&D intensity is more negative for U.S. firms than for Chinese firms, although this effect is only marginally significant. This may reflect differences in how innovation spending translates into short-run margins across the two institutional settings.

By contrast, the sales-growth results are more sensitive to specification choice, and the U.S.–China interaction terms are not statistically significant. Once firm fixed effects and common year shocks are taken into account, the marginal growth response to investment intensities is difficult to detect using annual growth rates over a relatively short five-year window. Taken together, the evidence suggests that the most robust cross-country difference in this study lies in the valuation channel, particularly in the pricing of capex intensity, whereas innovation intensity appears more closely associated with short-run margin pressure and shows limited evidence of differential growth payoffs across the two countries during 2020–2024.

Additional sector-level tests add further nuance to these findings. They suggest that the profitability effect of R&D intensity is stronger in hardware firms, while the short-run growth response appears weaker than in software firms. This pattern is consistent with differences in product cycles, capital requirements, and the timing with which innovation spending is translated into observable operating outcomes across technology subsectors.

This study makes three contributions to the literature. First, it brings R&D intensity and capex intensity into a common empirical framework and compares their short-run associations with firm value, profitability, and sales growth within the same sectoral setting. Second, it provides a direct U.S.–China comparison in technology and software firms, thereby showing whether the investment–performance relationship differs across two major but institutionally distinct innovation environments. Third, it demonstrates that the short-run interpretation of investment effects is sensitive

to measurement choice, lag structure, and outlier treatment, which is important for understanding how financial markets and operating outcomes respond to innovation-related investment under conditions of elevated uncertainty.

6. CONCLUSIONS

This study examines how R&D intensity and capex intensity are associated with firm value, operating profitability, and sales growth in technology and software firms in the United States and China over the period 2020–2024. Using firm fixed-effects models with year fixed effects and firm-clustered robust standard errors, and complementing the baseline analysis with a range of robustness checks, the study provides evidence on how different forms of investment are reflected in short-run market valuation and operating outcomes.

The findings indicate that the short-run associations between investment intensity and firm performance are not uniform across outcomes or specifications. In several models, higher R&D intensity is associated with weaker short-run valuation or profitability outcomes, whereas capex-related effects are more clearly visible in the firm-value channel, particularly for U.S. firms. By contrast, the evidence for differential sales-growth effects remains limited once firm fixed effects and common year shocks are taken into account.

The study contributes to the literature in three ways. First, it examines innovation intensity and capital investment intensity within a unified firm-level framework, allowing a direct comparison of their short-run associations with valuation and operating performance. Second, it provides evidence from a U.S.–China comparison in technology-related sectors, highlighting how institutional and capital-market context can shape the interpretation of investment signals. Third, it shows that short-run conclusions are sensitive to measurement strategy, lag structure, and outlier treatment, underscoring the importance of specification design in empirical research on investment and firm performance.

Taken together, the results suggest that, under conditions of elevated uncertainty and common macro-financial shocks, differences in market pricing are associated not only with the type of investment—innovation versus capital expenditure—but also with the environment in which firms operate. In this setting, tangible investment appears to be more consistently associated with equity valuations, whereas the short-run response to innovation intensity is less stable and likely reflects the uncertain timing of innovation payoffs. This study is subject to several limitations. Most importantly, the relatively short five-year window constrains the ability to observe longer-horizon returns to innovation and may also reduce statistical power in the interaction analysis. In addition, intensity-based measures may partly reflect denominator effects linked to sales dynamics rather than pure investment effects. A further limitation concerns sample construction. Because the initial firm universe was identified from the 2025 EU Industrial R&D Investment Scoreboard as a sampling frame and then traced backward over 2020–2024, the sample may under-represent firms that exited earlier or were not sufficiently visible in the later reporting round. The findings should therefore be interpreted as evidence for a stable panel of observable technology firms rather than as a fully exhaustive representation of the sector. Future research could extend the sample horizon, incorporate additional innovation-output measures such as patents or citations, and examine alternative valuation indicators in order to provide a broader assessment of how capital markets respond to innovation-related investment.

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APPENDIX A. SAMPLE FIRMS INCLUDED IN THE STUDY

Final sample: 223 unique firms (156 U.S. firms; 67 Chinese firms)

No.	U.S. firms	No.	U.S. firms	No.	U.S. firms	No.	Chinese firms	No.	Chinese firms
1	3D SYSTEMS	53	DOMO	105	PAGERDUTY	1	360 SECURITY TECHNOLOGY	53	TIANJIN 712 COMMUNICATION & BROADCASTING
2	ACI WORLDWIDE	54	DOUBLEVERIFY	106	PALANTIR TECHNOLOGIES	2	AI SINO	54	TONGFU MICROELECTRONICS
3	ADOBE	55	DROPBOX	107	PALO ALTO NETWORKS	3	ALIBABA GROUP HOLDING	55	TOPSEC TECHNOLOGIES
4	ADTRAN	56	DUOLINGO	108	PARADE TECHNOLOGIES	4	ANKER INNOVATIONS TECHNOLOGY	56	TRAVELSKY TECHNOLOGY
5	ADVANCED MICRO DEVICES	57	DYNATRACE	109	PAYCOM SOFTWARE	5	ASIAINFO TECHNOLOGIES	57	TSINGHUA TONGFANG
6	AKAMAI TECHNOLOGIES	58	E2OPEN PARENT	110	PAYLOCITY HOLDING	6	BAIDU	58	TUYA
7	ALARM.COM	59	ELECTRONIC ARTS	111	PEGASYS	7	BAOSHENG SCIENCE AND TECHNOLOGY	59	UNISPLENDOR
8	ALPHA AND OMEGA SEMICONDUCTOR	60	ENTEGRIS	112	PINTEREST	8	BILIBILI	60	VENUSTECH
9	ALPHABET	61	EXTREME NETWORKS	113	PROCORE TECHNOLOGIES	9	CAMBRICON TECHNOLOGIES	61	VTECH
10	ALTAIR ENGINEERING	62	FAIR ISAAC	114	PROGRESS SOFTWARE	10	CHINA NATIONAL SOFTWARE & SERVICE	62	WUXI TAIJI INDUSTRY LIMITED
11	AMBARELLA	63	FASTLY	115	PROS	11	CHINA RAILWAY SIGNAL & COMMUNICATION	63	XD INC.
12	AMERICAN WELL	64	FIVE9	116	PTC	12	CHINA TELECOM	64	XIAOMI
13	AMKOR TECHNOLOGY	65	FORMFACTOR	117	PURE STORAGE	13	CHINA TRANSINFO TECHNOLOGY	65	YONYOU NETWORK TECHNOLOGY
14	ANALOG DEVICES	66	FORTINET	118	Q2 HOLDINGS	14	DAWNING INFORMATION INDUSTRY	66	ZHIHU
15	ANSYS	67	GODADDY	119	QORVO	15	DHC SOFTWARE	67	ZTE
16	APPFOLIO	68	GOODRX	120	QUALCOMM	16	DIGITAL CHINA		
17	APPIAN	69	GUIDEWIRE SOFTWARE	121	RAMBUS	17	FUJIAN STAR-NET COMMUNICATION		
18	APPLE	70	HARMONIC	122	RAPID7	18	G-BITS NETWORK TECHNOLOGY		

19	APPLIED MATERIALS	71	HEWLETT PACKARD ENTERPRISE	123	RIBBON COMMUNICATIONS	19	GIANT NETWORK GROUP		
20	APPROVIN	72	HP	124	RINGCENTRAL	20	GLODON		
21	ARISTA NETWORKS	73	HUBSPOT	125	SCHRODINGER	21	GRG BANKING EQUIPMENT		
22	ASANA	74	IMPINJ	126	SEMTECH	22	GUANGZHOU HAIGE COMMUNICATIONS		
23	AUTODESK	75	INFINERA	127	SENTINELONE	23	HENG TONG OPTIC-ELECTRIC		
24	BENTLEY SYSTEMS	76	INTEL	128	SERVICENOW	24	HUA HONG SEMICONDUCTOR		
25	BIGCOMMERCE	77	INTUIT	129	SILICON LABORATORIES	25	HUAWEI INVESTMENT & HOLDING		
26	BLACKBAUD	78	JACK HENRY & ASSOCIATES	130	SKYWORKS SOLUTIONS	26	HYTERA COMMUNICATIONS		
27	BLACKLINE	79	JAMF	131	SNAP	27	IFLYTEK		
28	BOX	80	JUNIPER NETWORKS	132	SNOWFLAKE	28	JCET GROUP		
29	BROADCOM	81	KLA	133	SOLARWINDS	29	JOYY		
30	BUMBLE	82	LAM RESEARCH	134	SS&C TECHNOLOGIES	30	KINGDEE INTERNATIONAL SOFTWARE		
31	C3.AI	83	LATTICE SEMICONDUCTOR	135	SYNAPTICS	31	KINGSOFT		
32	CADENCE DESIGN SYSTEMS	84	LEIDOS	136	SYNOPSYS	32	KINGSOFT CLOUD		
33	CALIX	85	LIVEPERSON	137	TAKE-TWO INTERACTIVE SOFTWARE	33	LENOVO		
34	CARGURUS	86	LIVERAMP HOLDINGS	138	TENABLE HOLDINGS	34	NARI TECHNOLOGY		
35	CERENCE	87	MANHATTAN ASSOCIATES	139	TERADATA	35	NAVINFO		
36	CHEGG	88	MATCH GROUP	140	TERADYNE	36	NETDRAGON WEBSOFT		
37	CIENA	89	MAXLINEAR	141	TEXAS INSTRUMENTS	37	NETEASE		
38	CIRRUS LOGIC	90	MERCURY SYSTEMS	142	TRADE DESK	38	NEUSOFT		
39	CISCO SYSTEMS	91	MICROCHIP TECHNOLOGY	143	TWILIO	39	NEWLAND DIGITAL TECHNOLOGY		
40	CLOUDFLARE	92	MICRON TECHNOLOGY	144	TYLER TECHNOLOGIES	40	NINESTAR		
41	COHU	93	MICROSOFT	145	UBER TECHNOLOGIES	41	NSFOCUS TECHNOLOGIES		
42	COMMVAULT SYSTEMS	94	MICROSTRATEGY	146	UIPATH	42	QI AN XIN TECHNOLOGY		
43	COMPASS	95	MKS INSTRUMENTS	147	VARONIS SYSTEMS	43	SANGFOR TECHNOLOGIES		

44	CONFLUENT	96	MONGODB	148	VEEVA SYSTEMS	44	SHENZHEN KINGDOM SCI-TECH		
45	CORNING	97	MONOLITHIC POWER SYSTEMS	149	VERINT SYSTEMS	45	SHENZHEN SUNWAY COMMUNICATION		
46	COURSERA	98	NETAPP	150	VERISIGN	46	SHENZHEN TRANSSION HOLDINGS		
47	CROWDSTRIKE HOLDINGS	99	NETSCOUT SYSTEMS	151	VIASAT	47	SILERGY		
48	CSG SYSTEMS INTERNATIONAL	100	NUTANIX	152	VIAVI SOLUTIONS	48	SINOSOFT		
49	DATADOG	101	NVIDIA	153	WESTERN DIGITAL	49	SUZHOU DONGSHAN PRECISION MANUFACTURING COPANY		
50	DELL TECHNOLOGIES	102	OKTA	154	WORKDAY	50	TCL ELECTRONICS		
51	DIGITALOCEAN	103	ON SEMICONDUCTOR	155	WORKIVA	51	TENCENT		
52	DOCUSIGN	104	ORACLE	156	ZSCALER	52	THUNDER SOFTWARE TECHNOLOGY		

Source: Author's compilation based on official company filings and annual reports.