The Internet Appendix (for Online Publication): "Firm-level Irreversibility"

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October 2024

Abstract

This Internet Appendix furnishes supplementary results for our manuscript "Firm-level Irreversibility" as well as Clementi and Palazzo's (2019) codes (annotated by us).

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A Supplementary Results

In this section we furnish the technical details of our reproduction and replication of CP's Table I.

A.1 Reproducing CP's Table I

Our reproduction sample in column "moments" in Panel B of Table 1 is 28.26% larger than CP's Table I data. Panel C identifies four discrepancies to reconcile the differences (column "all").

First, CP require a firm to be listed and traded continuously on one of the three major exchanges (NYSE, Amex, and NASDAQ) throughout its life to be included in their sample.[1] If a firm is ever suspended in trading, its entire history would be excluded from their sample. In column "moments" we keep the firm's available data during its normal trading periods. Also, if a firm starts small, first listed on, say, Philadelphia Stock Exchange, and only later moves to NYSE, such a firm would be excluded from CP's sample altogether. We instead keep the firm's data on NYSE. As shown in column "lifetime ex. code," their screen loses 8.74% of firm-quarters (from 379,923 to 346,710).

Second, CP go through an empty capital accumulation recursion to build net PPE by accumulating past changes in net PPE. This recursion is redundant (current net PPE is directly available in Compustat).[2] However, the recursion requires all historical data to be available, thereby losing 14.26% of firm-quarters from 379,923 to 325,746 in column "lifetime PPE."

Third, CP merge investment rates with monthly CRSP stock returns from 1979 to 2016 with a two-calendar-quarter lag. Specifically, CP merge investment rates from fiscal quarters ending in calendar quarter q with monthly stock returns from calendar quarter $q + 2$. Doing so loses investment rates from the first two quarters of 1978 and the last two quarters of 2016, which amount to 2.08% of firm-quarters (column "require returns").[3]

Fourth, CP adjust for inflation by deflating net PPE with an aggregate (nonresidential fixed assets) price deflator from BEA. Doing so does not change the sample size but reduces the mean

[1] See our annotation on p. 1 in the Internet Appendix D.3 on CP's "crsp_cleaning.do."

[2] See our annotation on p. 6 in the Internet Appendix D.1 on CP's "investment_rate_bea.do."

[3] See our annotation on p. 3 in the Internet Appendix D.5 on CP's "inv_rate_moments.do."

investment rate from 3.92% to 3.51%.[4] Doing so also shifts the entire investment rate distribution further leftward. As a result, the fraction of negative investment rates increases from 16.91% (column "moments" in Panel B) to 18.98% (column "deflate PPE" in Panel C).

Finally, column "all" in Panel C adjusts for all four discrepancies simultaneously and reproduces column "CP's data" almost exactly. Our reproduction (based on CP's description and codes) in column "all" has a sample size of 296,185 firm-quarters, close to 296,226 in CP's data. As for the investment rate distribution, our mean is 3.52% relative to CP's 3.47%. Our standard deviation is 9.44% relative to CP's 9.54%. Our skewness is 2.18, which is identical to CP's. Our fraction of negative investment rates is 18.33%, which is close to CP's 18.24%.

A.2 Replicating CP's Table I and Figure 1

In this subsection we provide more details on our replication than that in Section 3.1 in the main text. Table 2 in the main text shows the replication results, by fixing all the procedural issues and discrepancies identified in Section 2. We start with our reproduction in column "moments" in Table 1 that already adjusts for the discrepancies between CP's reporting and coding.

A.2.1 Quantifying the Cumulative Impact of the Three Design Issues

First, we fix CP's data error in the gross investment rates by changing BEA depreciation rates to accounting depreciation rates. Column "acct. δ" in Table 1 (the same column in Table 2 already performs this step. As in Tang (2009), our gross investment rate is $(\text{PPENTQ}_{it} - \text{PPENTQ}_{it-1})/\text{PPENTQ}_{it-1} + \delta_{it}$, in which PPENTQ is item PPENTQ, and δ_{it} is the accounting depreciation rate, calculated as the amount of depreciation and amortization (item DPQ) minus the amortization of intangibles (item AM divided by four, zero if missing), scaled by net PPE. In terms of timing, for 2002Q2, for example, we take period-t stock variables from the balance sheet for 2002Q1 and period-t flow variables from the income or cash flow statement for 2002Q2.

Second, in column "no age>3" we remove the 12-quarter age screen from column "acct. δ" to

[4] See our annotation on p. 5 in the Internet Appendix D.1 on CP's "investment_rate_bea.do."

its left in Table 2, thereby showing the cumulative impact of fixing the first two design issues in CP. (In contrast, the columns in Table 1 only show the separate impact of each as in comparative statics.) Removing the age screen raises the sample size by 26.31% from 364,234 to 460,050 firm-quarters. The investment rate skewness rises from 3.37 to 4.18, and the 95th percentile from 25.7% to 32.67%. The negative investment fraction drops slightly from 6.08% to 6%.

Third, in column "with M&A" we further remove the 5% M&A screen from column "no age>3" to its left in Table 2, showing the cumulative impact of fixing all three design issues in CP. The sample size increases further by 3.42% to 475,788 firm-quarters. The investment rate skewness goes up further to 4.8, the 95th percentile to 36.23%, and the negative investment fraction drops to 5.89%.

Next, starting from column "with M&A", column "others" adjusts for small differences between CP's sampling and what we view as more standard practice. CP drop financials, utilities, and unclassified firms, while we drop financials, firms with negative book equity, and firm-quarters with negative or zero assets, net PPE, or sales. CP require nonmissing book-to-market, but we do not. The sample size rises further by 6.07% to 504,692 firm-quarters, largely because we include utilities.

The last step in our replication is to adjust for the treatment of outliers. CP drop firm-quarters in the top and bottom 0.5% of the pooled distribution of gross investment rates. In contrast, we consider winsorization as yielding more reliable investment rate moments. For the pooled firm-quarters of the fiscal quarters ending in a given calendar quarter, we winsorize gross investment rates at the 1%–99% level. Column "1%–99%" details the evidence. The investment rate skewness is 3.53, the 95th percentile 37.64%, and the fraction of negative investment rates 6.17%.

A.2.2 Scaling Investment Rates with Gross PPE

Bai et al. (2022) identify an essential tension in investment rate measurement. Within financial accounting, Tang's (2009) investment rate is most conceptually appropriate. Alas, because accounting depreciation rates are much higher than economic depreciation rates, net PPE tends to be much lower than the replacement cost of capital. Consequently, the investment rates scaled by net PPE tend to be much higher than BEA's aggregate estimates. A tension arises because the latter estimates seem more plausible in terms of economic magnitude. Many authors opt to scale instead by gross PPE to bring investment rates more in line with BEA's to alleviate the tension.

Bai et al. (2022) explain why. By integrating national accounting in BEA with financial accounting in Compustat, Bai et al. have constructed firm-specific current-cost capital stocks for the entire Compustat universe. Their table 8 shows that gross PPE is much closer to the replacement cost than net PPE. The ratio of the replacement cost divided by gross PPE is on average 0.98, but the average ratio divided by net PPE ratio is 2.11.

Intuitively, gross PPE is a historical-cost measure that ignores both depreciation and capital price inflation. As a proxy for the replacement cost of capital, ignoring depreciation creates an upward bias, while ignoring price inflation creates a downward bias. On average, the two biases largely offset each other in the data. Bai et al. show that the aggregate economic depreciation rate is 5.71% and the aggregate price inflation rate 4.14%. In contrast, net PPE is a historical-cost measure that uses aggressive accounting depreciation and ignores capital price inflation. Both create downward biases. As such, gross PPE is a better proxy for the replacement cost than net PPE.

In Table 2, the last column denoted "/gross PPE" shows the moments of gross investment scaled by gross PPE. Because of the lower coverage of item PPEGTQ, the sample size drops to 378,122 firm-quarters. The mean investment rate is 5.03% per quarter, and the standard deviation 9.48%. The skewness remains high, 3.59, and the negative investment fraction stays low, 4.94%.

A.2.3 Robustness

We perform a battery of robustness checks on our replication (with both net and gross PPE as capital as in the last two columns of Table 2. Without going through the details, we can report robustness from sample-split (in mid 1996), various M&A and age screens, as well as size split on market equity or capital. With net PPE as capital, the investment rate skewness ranges from 3.25 to 4.83, and the fraction of negative investment rates from 3.97% to 6.76%. With gross PPE, the skewness varies from 3.32 to 4.57, and the negative fraction 3.34% to 5.39%. Across all 20 robustness checks, the investment rate distribution is reliably asymmetric with a fat right tail.

We also show robustness across 19 NAICS nonfinancial sectors. With net PPE as capital, the investment rate skewness ranges from 1.81 to 10.83, with 4.61 in the full sample.[5] The fraction of negative investment rates varies from 3.18% to 11.18%, with 6.27% in the full sample. With gross PPE as capital, the skewness goes from 2.23 to 8.86, with 5.08 in the full sample, and the negative fraction from 2.79% to 9.8%, with 5.02% in the full sample. Across all 38 sector-deflator perturbations, the investment rate distribution is robustly asymmetric with a fat right tail.

Table A1 shows subsample analysis for the quarterly gross investment rates. Figures A1 and A2 plot the gross investment rate distributions across ten robustness checks with net and gross PPE as capital, respectively. Table A2 shows panel data moments of gross investment rates by NAICS sectors. Figures A3 and A4 plot the gross investment rate distributions across 19 NAICS nonfinancial sectors with net and gross PPE as capital, respectively.

B Reanalysis

The baseline investment model is as follows:

$$V(K_{it}, X_t, Z_{it}) = \max_{\{\chi_{it}\}} \left(\max_{\{I_{it}\}} \Pi_{it} - I_{it} - H_{it} + E_t \left[M_{t+1} V(K_{it+1}, X_{t+1}, Z_{it+1}) \right], 0 \right) \quad \text{(A1)}$$

$$\Pi_{it} = X_t Z_{it} K_{it}^{\alpha} - f \quad \text{(A2)}$$

$$\log(X_{t+1}) \equiv x_{t+1} = \overline{x}(1-\rho_x) + \rho_x x_t + \sigma_x \epsilon_{t+1}^x \quad \text{(A3)}$$

$$\log(Z_{it+1}) \equiv z_{it+1} = \rho_z z_{it} + \sigma_z \epsilon_{it+1}^z \quad \text{(A4)}$$

$$K_{it+1} = I_{it} + (1-\delta) K_{it} \quad \text{(A5)}$$

$$H_{it} = \frac{\theta_{it}}{2} \left(\frac{I_{it}}{K_{it}} - \delta \right)^2 K_{it} \quad \text{with } \theta_{it} \equiv \theta_U \mathbf{1}_{\{I_{it}/K_{it} \geq \delta\}} + \theta_D \mathbf{1}_{\{I_{it}/K_{it} < \delta\}} \quad \text{(A6)}$$

$$M_{t+1} = \beta \exp([\gamma_0 + \gamma_1 (x_t - \overline{x})](x_t - x_{t+1})) \quad \text{(A7)}$$

[5] Because some sectors can have only a small number of firms in a given quarter, we report panel data moments for sectors (as opposed to the time series averages of cross-sectional moments in the remainder of our study).

Firm i maximizes the market value, $V(K_{it}, X_t, Z_{it})$, in equation (A1). Π_{it} is operating profits, $\alpha \in (0,1)$ is the curvature parameter, $\delta \in (0,1)$ is the depreciation rate, $f > 0$ the fixed cost of production, K_{it} capital, X_t the aggregate productivity, Z_{it} firm-specific productivity, with ϵ^x_{t+1} and ϵ^z_{it+1} i.i.d. standard normal shocks uncorrelated for any i, and ϵ^z_{it+1} and ϵ^z_{jt+1} uncorrelated for any $i \neq j$. H_{it} is the asymmetric adjustment cost function, in which $\mathbf{1}_{\{\cdot\}}$ is the indicator that equals one if the event in $\{\cdot\}$ is true and zero otherwise, and $\theta_D > \theta_U > 0$ are constant parameters. M_{t+1} is the stochastic discount factor, in which $\beta \in (0,1)$, $\gamma_0 > 0$, and $\gamma_1 < 0$ are constant parameters.

When the inner maximand in equation (A1) is greater than or equal to zero, firm i stays in the economy. Evaluating the value function at the optimum yields $V_{it} = D_{it} + E_t[M_{t+1}V_{it+1}]$, in which $D_{it} \equiv \Pi_{it} - I_{it} - H_{it}$, and $E_t[M_{t+1}r^S_{it+1}] = 1$, in which $r^S_{it+1} \equiv V_{it+1}/(V_{it} - D_{it})$ is the stock return. When the inner maximand is negative, firm i exits at the beginning of t. We set its stock return over period $t-1$, r^S_{it}, to be a predetermined delisting return, denoted $\widetilde{R}$. The exit firm enters an immediate reorganization process. The current shareholders receive nothing and leave. New shareholders take over the firm's capital to form a new firm. For tractability, we assume that the reorganization process occurs instantaneously. At the beginning of period t, the exit firm is replaced by a new firm with a new firm-specific log productivity of $\bar{z}$, which is its unconditional mean.

B.1 Predetermined Parameters

There are in total 14 parameters, $\{\beta,\ \gamma_0,\ \gamma_1,\ \alpha,\ \overline{x},\ \rho_x,\ \sigma_x,\ \delta,\ \widetilde{R},\ \rho_z,\ \sigma_z,\ f,\ c^+,\ c^-\}$. Following Bloom (2009), we calibrate a set of predetermined parameters but estimate the key parameters via simulated method of moments (SMM).

We work in monthly frequency. We set $\beta = 0.9999$, $\gamma_0 = 18$, and $\gamma_1 = -450$, which yield an average Sharpe ratio of 0.34 per annum, an average interest rate of 0.67%, and an interest rate volatility of 3.31%. We update the King-Rebelo (1999) estimates of persistence and conditional volatility of productivity shocks. We retrieve from FRED the time series of private nonfarm business multifactor productivity constructed by BLS in the annual 1963–2021 sample.[6] We fit a linear time trend to the log productivity and use the residuals to estimate the persistence, ρ_x, and the conditional volatility, σ_x. In the annual frequency, ρ_x is 0.72117 and σ_x 0.01643. The implied quarterly estimates are 0.92153 and 0.009212, and monthly 0.97313 and 0.005463, respectively.[7]

The curvature parameter, α, is 0.7. In the 1963–2021 sample, the average (performance-related) delisting return in CRSP is -24.53%, to which we set $\widetilde{R}$. Bai et al. (2022) estimate the median firm-level economic depreciation rate as 6.86% per annum. We set δ to be 6.86%/12. The persistence, ρ_z, and conditional volatility, σ_z, of firm-specific productivity, z_{it}, affect the cross-sectional dispersion similarly. We fix $\rho_z = 0.97$ per Imrohoroglu and Tuzel (2014) but estimate σ_z. We set $\overline{x} = -3.98$ to yield a large enough long-term average capital to ensure a stable investment rate distribution.

B.2 SMM Estimation and Tests

We estimate $\mathbf{c} \equiv (\sigma_z, f, \theta_U, \theta_D)$, in which σ_z is the conditional volatility of firm-specific productivity, f the fixed cost of production, θ_U the upward and θ_D downward adjustment cost parameters. We target seven data moments, $\mathbf{\Psi_d}$, four annual investment rate moments (the volatility 37.63%, skewness 3.35, autocorrelation 33.58%, and the fraction of negative investment rates 5.65%) from Bai et al. (2022) (extended through 2021) and three return moments (the average value premium 0.38% per month, and the volatility 55.68% and skewness 1.43 of annual stock excess returns). The 0.38% per month ($t = 2.12$) is from Kenneth French's data library in the 1963–2021 sample. The estimate is 0.34% ($t = 1.81$) in the q-data library due to sampling differences. We use 0.38% because it represents a slightly higher hurdle for our model to match.

We solve the model via value function iteration. We simulate $S = 500$ panels of size $(N, T + b)$, in which $N = 3,500$ is the number of firms, $T = 59 \times 12 = 708$ the number of months, and $b = 300$ the burn-in. Following Bloom et al. (2018), we set the diagonal elements of the weighting matrix, $\mathbf{W}$, to $1/(\mathbf{\Psi_d})^2$ and the off-diagonal elements to zero. The SMM estimator thus minimizes the sum

[6] https://fred.stlouisfed.org/series/MFPNFBS

[7] Heer and Maussner (2009, p. 549–550) offer the formulas that convert the estimates between frequencies.

of squared percentage deviations of the model moments from the data moments.

Table A3 shows the estimation and tests. Costly reversibility is highly significant. The downward adjustment cost parameter, θ_D, is 102.26 ($t = 30.86$), but the upward adjustment cost parameter, θ_U, is only 0.14 ($t = 1.42$). Operating leverage is also significant. The fixed cost of production, f, is 0.0496 ($t = 3.8$). The conditional volatility of firm-specific productivity is 0.215 ($t = 8.45$).

The baseline model does a good job in matching the moments in terms of economic magnitude. The average value premium is 0.4% per month, which is close to 0.38% in the data. The fraction of negative investment rates is 5.84% in the model, which is close to 5.65% in the data. The stock return volatility and skewness are also close. However, the model understates the investment rate volatility, 23.8% versus 37.6% per annum, but overstates its skewness, 4.78 versus 3.35. Finally, the SMM test is powerful enough to reject the model with the overidentification test.

In untabulated results, the fraction of inactive investment rates is 19.4% in the model. Although substantially higher than 2.88% in the data (Bai et al. 2022), it represents an improvement relative to Cooper and Haltiwanger (2006). Their Table 3 reports this fraction to be between 58.8% to 69% across their model specifications. The better fit originates from our adjustment cost function, which centers the asymmetry around the "normal" investment rate of δ (as opposed to zero).

The remaining data-model gap is likely due to capital heterogeneity. Capital is homogeneous in the model but heterogeneous in the data. Firms face different adjustment costs when constructing a new building versus buying new laptops. Smoothing over heterogeneous capital goods likely yields a lower fraction of inactive investment rates in the data, but this smoothing is absent in the model. For this reason, Cooper and Haltiwanger (2006) do not target the fraction of inactive investment rates in their estimation. We follow the same practice. In addition, we assume the same normal investment rate (depreciation rate) for all firms, but δ likely varies across firms and over time in the data.

More important, we conduct two comparative statics: (i) symmetric adjustment costs, by lowering θ_D to 0.1385; and (ii) a low fixed cost of production, $f = 0.025$. In each experiment, we only change the parameter in question, while keeping all the other parameters unchanged.

The first experiment has a dramatic impact on the average value premium and the investment rate moments. The fraction of negative investment rates, rises from 5.65% to 41.17%, the investment rate skewness drops from 4.78 to 2.29, and the volatility jumps from 23.8% to 663%. Most important, the value premium falls from 0.4% per month to −0.51%.

The experiment of lowering f from 0.0496 to 0.025 shows the impact of operating leverage in the model. The average value premium falls from 0.4% to 0.05% per month, and the stock return volatility from 45.5% to 29.8% per annum. However, the investment rate moments are less sensitive.

C A Meta-study on the Asymmetry Mechanism

Table A4 lists 28 theoretical articles in asset pricing that have been published since 1999. All feature costly reversibility in their models, in which the asymmetry causal mechanism plays a role.

D CP's Codes, Annotated

At the end of this document, we append CP's codes, annotated by us, in five files. The pages are numbered separately (starting from page 1) within each file for ease of references.

D.1 investment_rate_bea.do

D.2 accounting_data_cleaned.do

D.3 crsp_cleaning.do

D.4 merge_crsp_compustat.do

D.5 inv_rate_moments.do

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Table A1 : Robustness, Quarterly Gross Investment Rates in Compustat, 1978Q1–2016Q4

In Panel A, the gross investment rate is $(\text{PPENTQ}_{it} - \text{PPENTQ}_{it-1})/\text{PPENTQ}_{it-1} + \delta_{it}$, in which PPENTQ is capital (net PPE, item PPENTQ), and δ_{it} is the accounting depreciation rate (the amount of depreciation and amortization [item DPQ] minus the amortization of intangibles [item AM divided by four, zero if missing] scaled by net PPE). In Panel B, the gross investment rate is $(\text{PPENTQ}_{it} - \text{PPENTQ}_{it-1} + \text{DPQ}_{it} - \text{AM}_{it}/4)/\text{PPEGTQ}_{it-1}$, in which PPEGTQ is gross PPE (item PPEGTQ). All moments are in percent, except for the number of firm-quarters (#obs.) and skewness (skew). ρ_1 is the cross-sectional correlation between the investment rates and one-quarter-lagged values. f_- is the fraction of negative investment rates (below −1%), and f_0 the fraction of inactive investment rates (between −1% and 1%). $f^-_{0.2}$ the fraction of negative investment spikes (below −20%), and $f^+_{0.2}$ the fraction of positive investment spikes (above 20%). $(I-\text{CAPX})/K \leq 15\%$ excludes firm-quarters in which the difference between gross investment and capital expenditure (CAPX) is higher than 15% of capital. CAPX is item CAPXQ minus item SPPEQ calculated from year-to-date figures (we set missing SPPEQ to zero). $(I-\text{CAPX})/K \leq 5\%$ excludes firm-quarters in which $I-\text{CAPX}$ is higher than 5% of capital. Age> 3 excludes the first 12 quarters for a given firm, and Age> 5 the first 60 quarters. For size classification, we use the NYSE breakpoints and split all fiscal quarters ending in a calendar quarter into two groups based on the beginning-of-quarter market equity or capital. In all experiments, we continue to winsorize each quarter at the 1%–99% level in the full sample to ensure comparability across subsamples. Except for #obs., all other moments are time series averages of the cross-sectional moments.

	#obs.	mean	std	skew	ρ_1	f_-	f_0	$f^+_{0.2}$	$f^-_{0.2}$	5th	50th	95th
Panel A: Gross investment rates scaled by net PPE												
Full sample	509,788	9.89	18.14	3.53	31.73	6.17	8.57	11.92	1.02	−2.31	5.29	37.64
1978Q1–1996Q2	227,561	9.50	17.97	3.64	27.04	6.22	8.60	11.16	1.08	−2.47	5.02	36.13
1996Q3–2016Q4	282,227	10.25	18.29	3.44	35.90	6.12	8.55	12.60	0.96	−2.16	5.53	39.00
$(I-\text{CAPX})/K \leq 15\%$	482,963	7.67	13.24	3.71	35.10	6.40	8.96	8.28	1.05	−2.53	4.95	26.25
$(I-\text{CAPX})/K \leq 5\%$	448,354	6.96	12.84	3.95	34.92	6.76	9.52	6.90	1.12	−2.91	4.54	24.21
Age>3 years	425,637	8.39	15.78	3.97	28.66	6.25	8.95	9.18	0.98	−2.33	4.85	29.92
Age>5 years	370,480	7.98	15.09	4.14	27.84	6.10	8.88	8.31	0.92	−2.16	4.71	27.91
Small ME	405,379	10.38	19.11	3.32	31.13	6.76	9.56	13.27	1.14	−2.94	5.37	40.95
Big ME	103,625	7.79	12.59	4.68	31.70	3.97	5.04	6.47	0.49	−0.27	5.03	24.30
Small net PPE	415,226	10.99	19.44	3.25	32.04	6.40	8.83	14.02	1.10	−2.57	5.93	42.33
Big net PPE	94,562	5.03	8.82	4.83	13.93	5.22	7.75	2.75	0.60	−1.42	3.73	14.56
Panel B: Gross investment rates scaled by gross PPE												
Full sample	378,122	5.03	9.48	3.59	34.52	4.94	18.08	4.82	0.12	−1.10	2.61	19.50
1978Q1–1996Q2	177,858	5.32	10.25	3.72	30.84	5.15	16.42	5.13	0.19	−1.29	2.73	20.64
1996Q3–2016Q4	200,264	4.77	8.78	3.48	37.75	4.74	19.58	4.54	0.05	−0.93	2.50	18.47
$(I-\text{CAPX})/K \leq 15\%$	359,691	4.02	7.20	3.73	42.38	5.10	18.81	2.84	0.12	−1.21	2.46	14.30
$(I-\text{CAPX})/K \leq 5\%$	335,805	3.69	6.95	3.93	42.20	5.35	19.87	2.57	0.12	−1.37	2.30	13.17
Age>3 years	318,797	4.02	7.67	4.17	27.63	4.90	19.26	2.95	0.10	−1.07	2.37	14.07
Age>5 years	279,275	3.73	7.13	4.41	25.34	4.76	19.66	2.50	0.09	−0.98	2.29	12.70
Small ME	297,353	5.21	9.95	3.40	34.51	5.39	19.88	5.37	0.13	−1.36	2.56	21.12
Big ME	80,204	4.20	6.81	4.37	31.28	3.34	12.35	2.60	0.05	−0.18	2.66	13.60
Small gross PPE	305,230	5.53	10.16	3.32	35.62	5.08	18.61	5.65	0.13	−1.19	2.80	22.05
Big gross PPE	72,892	2.86	5.00	4.57	17.79	4.34	16.93	1.24	0.06	−0.85	2.12	8.35

Table A2 : Panel Data Moments of Quarterly Gross Investment Rates by NAICS Sectors, 1978Q1–2016Q4

In Panel A, the gross investment rate is $(\text{PPENTQ}_{it} - \text{PPENTQ}_{it-1})/\text{PPENTQ}_{it-1} + \delta_{it}$, in which PPENTQ is capital (net PPE, item PPENTQ), and δ_{it} is the accounting depreciation rate, calculated as the amount of depreciation and amortization (item DPQ) minus the amortization of intangibles (item AM divided by four, zero if missing) scaled by net PPE. In Panel B, the gross investment rate is $(\text{PPENTQ}_{it} - \text{PPENTQ}_{it-1} + \text{DPQ}_{it} - \text{AM}_{it}/4)/\text{PPEGTQ}_{it-1}$, in which PPEGTQ is gross PPE (item PPEGTQ) as capital. All moments are in percent, except for the number of firm-quarters (#obs.) and skewness (skew). ρ_1 is the cross-sectional correlation between the investment rates and one-quarter-lagged values. f_- is the fraction of negative investment rates (below -1%), and f_0 the fraction of inactive investment rates (between -1% and 1%). $f^-_{0.2}$ the fraction of negative investment spikes (below -20%), and $f^+_{0.2}$ the fraction of positive investment spikes (above 20%). In all experiments, we continue to winsorize each quarter at the 1%–99% level in the full sample to ensure comparability across sectors. Because some NAICS sectors have a small number of firms in a given quarter, we report panel data moments, as opposed to the time series averages of cross-sectional moments in Table S1.

	#obs.	mean	std	skew	ρ_1	f_-	f_0	$f^+_{0.2}$	$f^-_{0.2}$	5th	50th	95th
	Panel A: Gross investment rates, scaled by net PPE											
Full sample	509,788	10.41	20.38	4.61	34.95	6.27	8.56	12.89	1.09	−2.23	5.31	40.02
Agriculture, forestry, fishing, and hunting	1,666	5.96	17.65	5.75	6.69	9.48	13.21	5.34	1.62	−4.98	3.21	20.91
Mining	27,368	8.05	19.64	4.41	12.36	11.18	12.70	9.83	2.16	−8.79	4.34	33.92
Utilities	21,853	3.44	9.22	10.83	18.10	3.18	9.38	1.59	0.39	0.15	2.44	7.92
Construction	7,125	11.23	21.94	3.91	30.26	8.59	8.69	15.05	1.60	−5.87	6.22	41.37
Nondurable goods	88,110	9.21	19.44	4.83	32.28	5.80	9.67	10.21	0.90	−1.61	4.51	36.83
Durable goods	159,967	9.93	18.31	4.77	27.75	5.86	8.05	12.05	0.93	−1.74	5.56	35.90
Wholesale trade	22,088	11.24	21.81	4.12	25.32	6.58	7.81	14.03	1.23	−2.62	5.69	44.74
Retail trade	31,250	8.84	15.69	5.83	32.17	4.77	6.56	8.60	0.66	−0.80	5.71	27.90
Transportation and warehousing	14,333	7.22	15.76	5.85	18.59	6.78	12.28	7.23	0.82	−2.16	4.00	25.38
Information	48,289	16.98	27.92	3.69	44.99	6.12	4.67	24.88	1.35	−2.57	9.18	65.25
Real estate and rental and leasing	4,583	12.82	27.46	4.17	35.56	10.87	11.63	17.22	1.83	−6.25	6.04	53.27
Professional, scientific, and technical services	26,658	14.75	23.89	3.81	33.49	6.15	5.96	21.15	1.26	−2.36	8.64	55.00
Management of companies and enterprises	106	10.45	16.96	1.81	22.12	6.60	10.38	17.92	0.00	−6.90	4.07	56.00
Administrative and waste management services	13,345	13.63	23.63	3.96	29.66	6.27	5.46	17.68	1.36	−2.55	7.93	50.05
Educational services	2,535	12.15	19.91	4.10	19.16	5.96	4.85	15.07	1.03	−2.07	7.43	43.23
Health care and social assistance	11,887	12.66	22.33	3.70	22.59	6.78	7.14	17.18	1.33	−3.46	6.92	48.96
Arts, entertainment, and recreation	4,875	9.40	22.46	4.79	15.42	7.63	16.64	11.79	1.33	−3.60	3.64	40.88
Accommodation and food services	13,073	6.77	15.62	5.35	22.42	8.54	13.17	6.96	1.25	−3.95	3.85	25.14
Other services, except government	2,954	9.66	20.96	4.37	15.90	8.06	9.72	10.97	1.32	−3.19	4.85	37.59

	#obs.	mean	std	skew	ρ_1	f_-	f_0	$f_{0.2}^+$	$f_{0.2}^-$	5th	50th	95th
Panel B: Gross investment rates, scaled by gross PPE												
Full sample	378,122	5.48	11.42	5.08	38.93	5.02	17.78	5.54	0.13	−1.01	2.62	21.61
Agriculture, forestry, fishing, and hunting	1,185	3.74	10.32	4.94	15.10	8.69	21.01	3.54	0.42	−3.03	1.92	14.40
Mining	24,128	5.09	11.81	4.09	19.15	9.80	20.70	6.06	0.41	−4.88	2.48	23.46
Utilities	20,904	2.27	4.94	8.86	10.46	2.79	19.75	1.01	0.06	0.15	1.68	5.37
Construction	4,629	5.67	11.64	3.93	23.02	7.84	15.62	6.26	0.19	−3.27	2.94	22.83
Nondurable goods	65,213	4.59	9.90	5.26	33.72	4.36	20.51	4.32	0.10	−0.67	2.24	17.82
Durable goods	119,041	4.93	9.91	5.42	32.77	4.38	18.95	4.39	0.11	−0.68	2.55	18.21
Wholesale trade	15,581	6.20	12.63	4.28	30.09	5.62	15.46	6.82	0.13	−1.42	2.94	25.89
Retail trade	21,442	5.44	10.12	5.85	41.50	3.82	13.47	4.33	0.07	−0.36	3.18	18.04
Transportation and warehousing	12,343	4.56	9.49	5.67	27.01	5.66	19.05	3.65	0.09	−1.37	2.54	16.13
Information	32,373	9.38	16.90	3.97	50.66	4.76	11.20	11.93	0.14	−0.85	4.23	38.21
Real estate and rental and leasing	3,592	6.57	13.45	4.46	19.10	9.69	18.40	7.57	0.25	−4.18	3.30	26.52
Professional, scientific, and technical services	18,304	7.53	13.82	4.48	36.68	5.04	12.86	8.53	0.18	−1.05	3.87	29.42
Management of companies and enterprises	79	5.52	10.68	2.23	16.46	7.59	18.99	10.13	0.00	−5.84	2.37	36.57
Administrative and waste management services	9,814	7.32	14.05	4.50	30.88	5.33	11.50	7.91	0.16	−1.23	3.69	28.47
Educational services	1,752	7.15	12.21	3.82	22.51	5.14	11.13	7.82	0.23	−1.10	4.11	25.29
Health care and social assistance	8,704	7.51	13.67	3.67	29.57	6.32	12.07	9.09	0.22	−2.08	3.71	31.24
Arts, entertainment, and recreation	3,882	6.18	13.90	4.30	21.33	6.31	24.45	8.04	0.28	−1.99	2.36	29.60
Accommodation and food services	9,279	4.71	10.37	4.92	31.40	7.04	20.83	4.47	0.23	−2.43	2.44	18.72
Other services, except government	2,074	5.64	12.64	3.99	20.14	7.52	17.65	6.12	0.34	−2.77	2.63	23.46

Table A3 : SMM Estimation and Tests, 1963–2021

We estimate the upward (θ_U) and downward (θ_D) adjustment cost parameters, the fixed cost of production (f), and the conditional volatility of firm-specific productivity shocks (σ_z) to target seven data moments. The moments include four moments of annual gross investment rates (the time series averages of cross-sectional standard deviation, std, skewness, skew, autocorrelation, ρ_1, and the fraction of negative investment rates, f_-), and three return moments (the time series averages of cross-sectional standard deviation, std, and skewness, skew, of annual stock excess returns, as well as the average value premium, $\overline{R}_{\text{H}-\text{L}}$, in monthly percent). Panel A reports the parameter estimates and their t-values. Panel B shows the test of overidentification, including the test statistic, χ^2; the degree of freedom, d.f.; and the p-value of the χ^2 statistic. Panel C shows the data and model moments as well as the t-values of their individual differences.

	Panel A: Parameter estimates				Panel B: The χ^2 test		
	θ_U	θ_D	f	σ_z	χ^2	d.f.	p-value
Estimate	0.1385	102.2631	0.0496	0.2152	103.10	3	0.00
t-value	1.4201	30.8570	3.8001	8.4534			

Panel C: Individual moments and the significance of their model errors

	Gross investment rates				Returns		
	std	skew	ρ_1	f_-	std	skew	$\overline{R}_{\text{H}-\text{L}}$
Data	0.3763	3.3518	0.3358	0.0565	0.5568	1.4325	0.3789
Model	0.2376	4.7773	0.3024	0.0584	0.4545	1.2970	0.4038
t(Diff)	4.00	−8.39	1.89	−6.90	2.12	1.73	−3.21

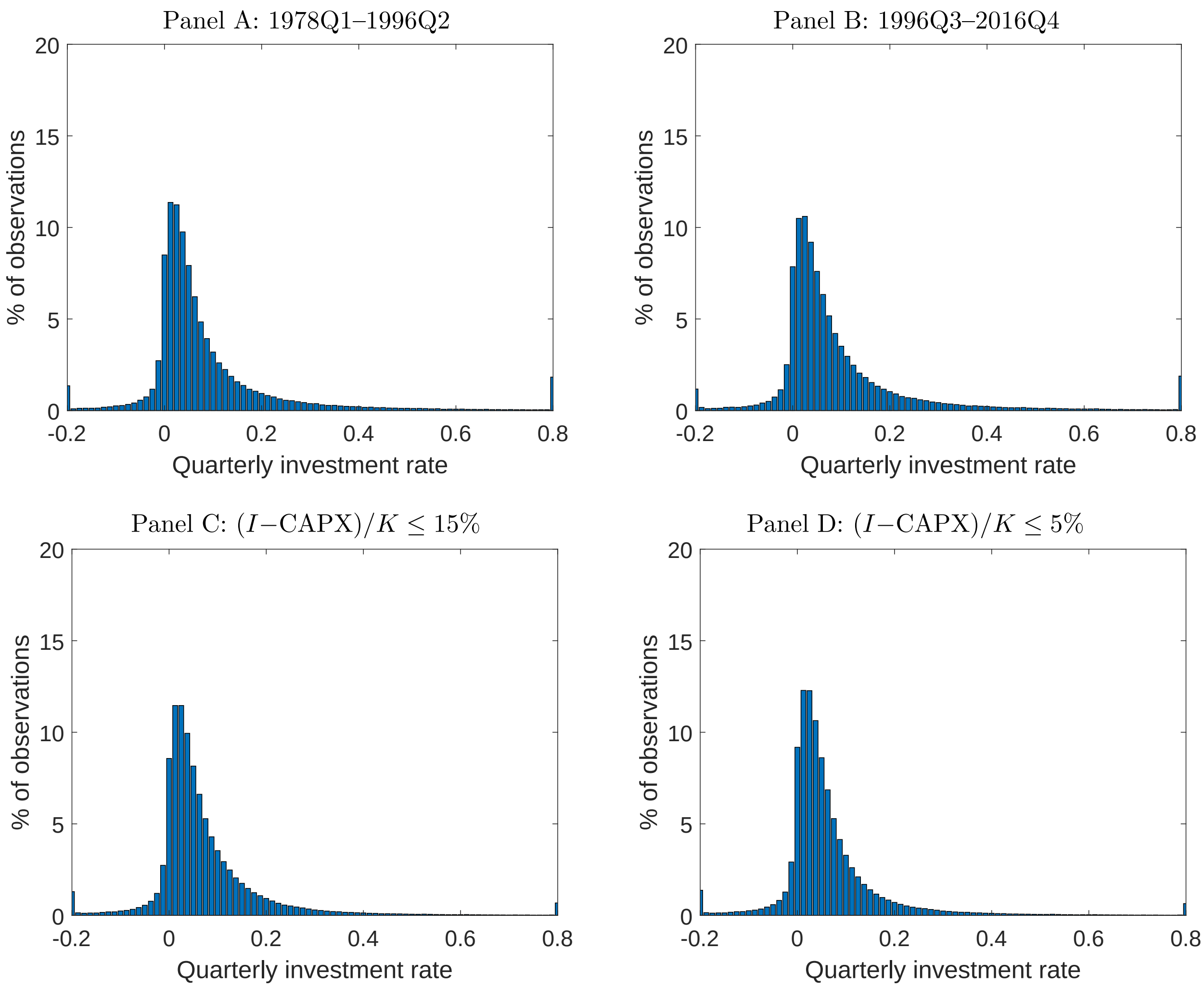
Table A4 : A Meta-study of the Asymmetry Mechanism

This table lists 28 theoretical publications in asset pricing since 1999 with costly reversibility in their models.

Authors	Year	Journal	Form
Berk, Green, and Naik	1999	JF	Irreversible investment
Hall	2001	AER	Asymmetric adjustment costs
Kogan	2001	JFE	Irreversible investment
Gomes, Kogan, and Zhang	2003	JPE	Irreversible investment
Kogan	2004	JFE	Irreversible investment
Carlson, Fisher, and Giammarino	2004	JF	Resale lower than purchase price
Zhang	2005	JF	Asymmetric adjustment costs
Cooper	2006	JF	Irreversible investment
Carlson, Fisher, and Giammarino	2006	JF	Irreversible investment
Kogan, Livdan, and Yaron	2009	JF	Irreversible investment
Livdan, Sapriza, and Zhang	2009	JF	Asymmetric adjustment costs
Carlson, Fisher, and Giammarino	2010	RFS	Irreversible investment
Gomes and Schmid	2010	JF	Irreversible investment
Tuzel	2010	RFS	Asymmetric adjustment costs
Belo and Lin	2012	RFS	Asymmetric adjustment costs
Ozdagli	2012	RFS	Resale lower than purchase price
Lin and Zhang	2013	JME	Asymmetric adjustment costs
Obreja	2013	RFS	Asymmetric adjustment costs
Belo,Lin, and Bazdresch	2014	JPE	Asymmetric adjustment costs
Kuehn and Schmid	2014	JF	Irreversible investment
Hackbarth and Johnson	2015	ReStud	Resale lower than purchase price
Belo, Li, Lin, and Zhao	2017	RFS	Asymmetric adjustment costs
Li	2017	MS	Asymmetric adjustment costs
Gu, Hackbarth, and Johnson	2018	RFS	Resale lower than purchase price
Bai, Hou, Kung, Li, and Zhang	2019	JFE	Asymmetric adjustment costs
Belo, Lin, and Yang	2019	RFS	Asymmetric adjustment costs
Gomes and Schmid	2021	JF	Partial irreversibility
Herskovic, Kind, and Kung	2023	JFE	Asymmetric adjustment costs

Figure A1 : Robustness, the Quarterly Gross Investment Rate Distribution in Compustat, Scaled by Net PPE, 1978Q1–2016Q4

This figure shows ten robustness tests: (i) the first half sample, 1978Q1–1996Q2; (ii) the second half sample, 1996Q3–2016Q4; (iii) $(I - \text{CAPX})/K \leq 15\%$, which excludes firm-quarters with the difference between gross investment and capital expenditure (CAPX) higher than 15% of capital (CAPX is item CAPXQ minus item SPPEQ calculated from year-to-date figures [missing SPPEQ set to zero]); (iv) $(I - \text{CAPX})/K \leq 5\%$, which excludes firm-quarters with the difference between gross investment and CAPX higher than 5% of capital; (v) Age>3, which excludes the first 12 quarters for a given firm; (vi) Age>5, which excludes the first 60 quarters for a given firm; (vii) small ME, the small market equity sample; (viii) big ME, the big market equity sample; (ix) Small K, the small capital sample; and (x) Big K, the big capital sample. For last four tests, we use the NYSE breakpoints and split all fiscal quarters ending in a calendar quarter into two groups based on the begin-of-quarter market equity or capital. In all experiments, we continue to winsorize each quarter at the 1%–99% level in the full sample to ensure comparability across subsamples.



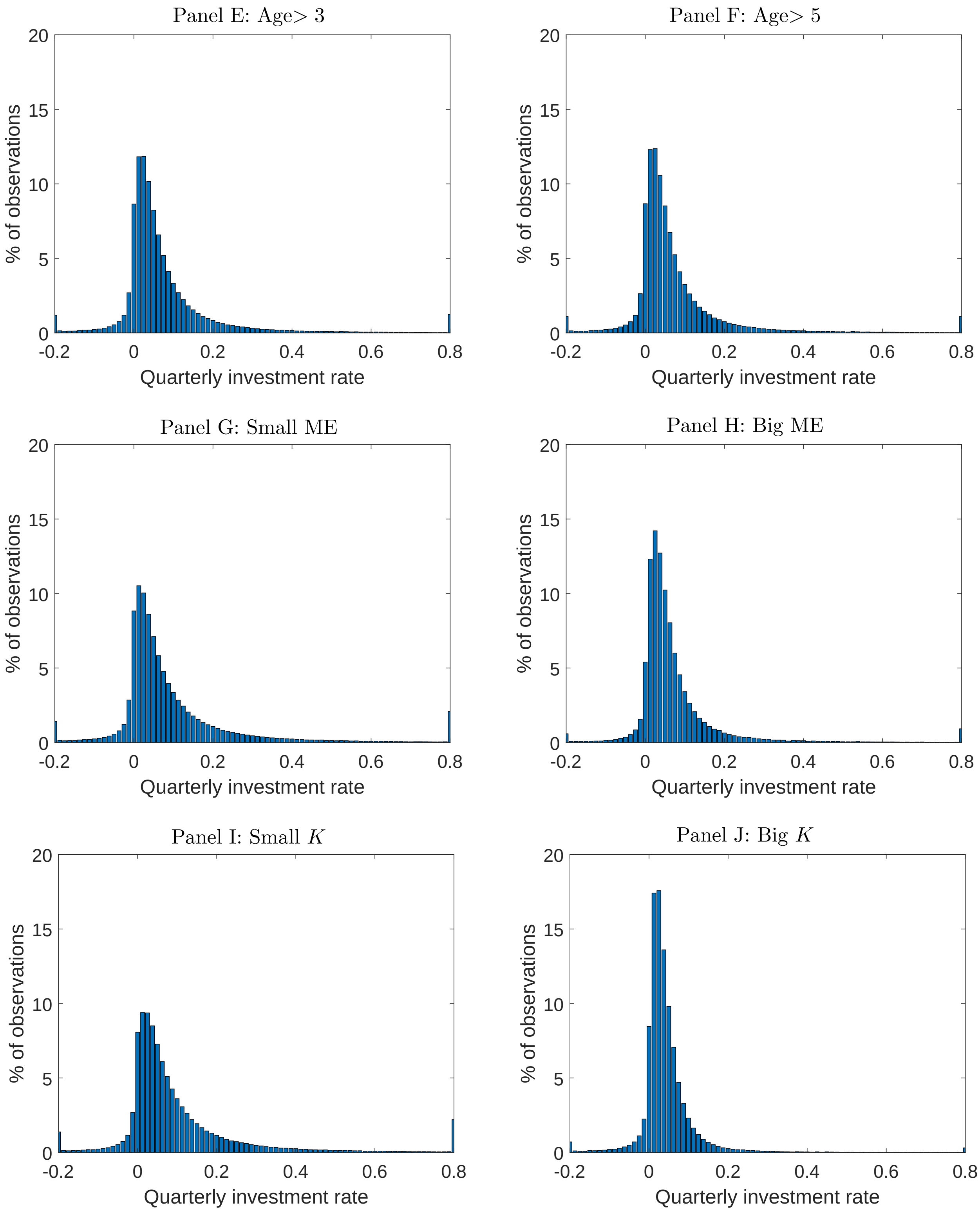
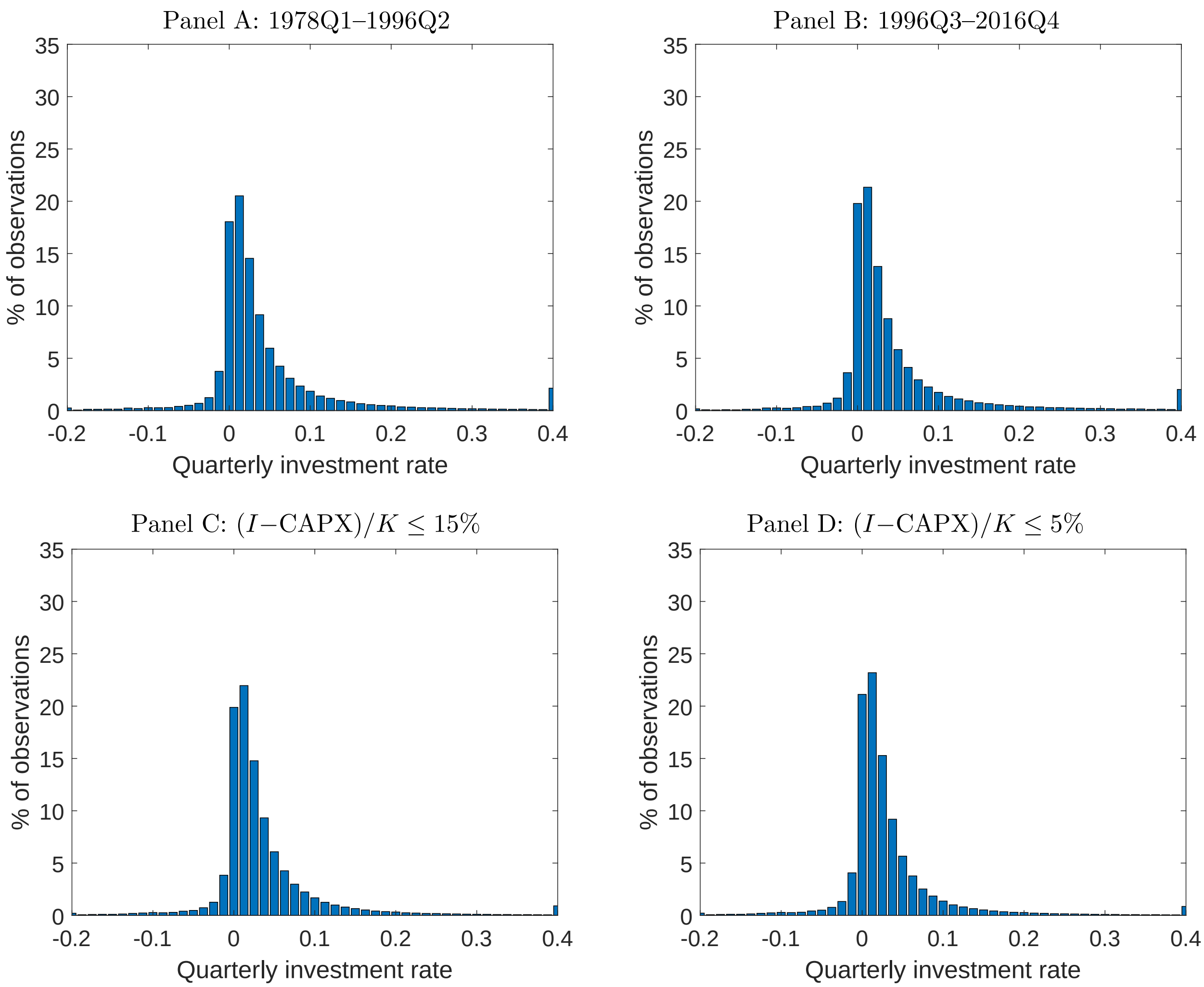

Panel E: Age> 3
Panel F: Age> 5
Panel G: Small ME
Panel H: Big ME
Panel I: Small K
Panel J: Big K
% of observations
Quarterly investment rate
0
5
10
15
20
-0.2
0
0.2
0.4
0.6
0.8

Figure A2 : Robustness, the Quarterly Gross Investment Rate Distribution in Compustat, Scaled by Gross PPE, 1978Q1–2016Q4

This figure shows ten robustness tests: (i) the first half sample, 1978Q1–1996Q2; (ii) the second half sample, 1996Q3–2016Q4; (iii) $(I-\text{CAPX})/K \leq 15\%$, which excludes firm-quarters with the difference between gross investment and capital expenditure (CAPX) higher than 15% of capital (CAPX is item CAPXQ minus item SPPEQ calculated from year-to-date figures [missing SPPEQ set to zero]); (iv) $(I-\text{CAPX})/K \leq 5\%$, which excludes firm-quarters with the difference between gross investment and CAPX higher than 5% of capital; (v) Age> 3, which excludes the first 12 quarters for a given firm; (vi) Age> 5, which excludes the first 60 quarters for a given firm; (vii) small ME, the small market equity sample; (viii) big ME, the big market equity sample; (ix) Small K, the small capital sample; and (x) Big K, the big capital sample. For last four tests, we use the NYSE breakpoints and split all fiscal quarters ending in a calendar quarter into two groups based on the begin-of-quarter market equity or capital. In all experiments, we continue to winsorize each quarter at the 1%–99% level in the full sample to ensure comparability across subsamples.



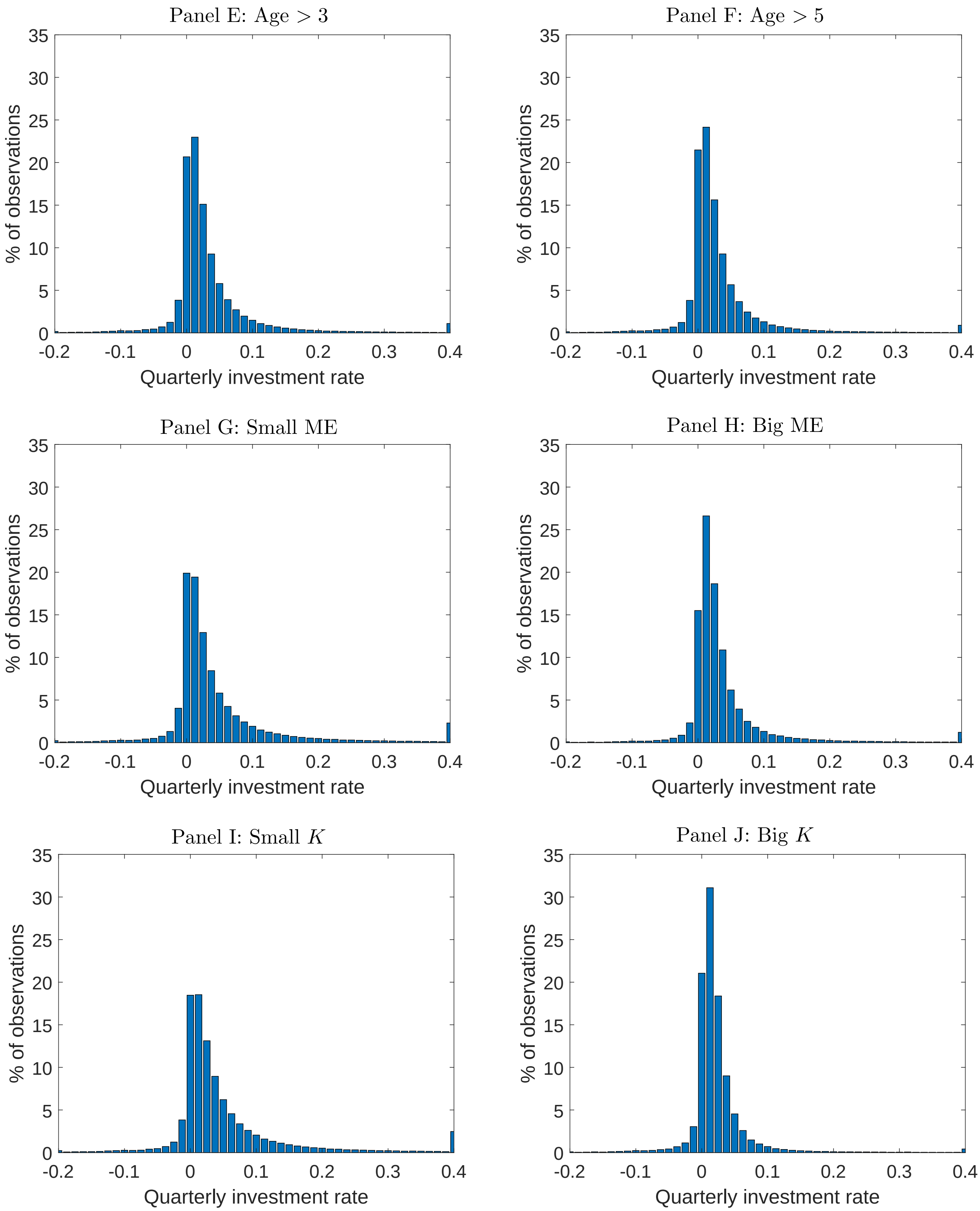
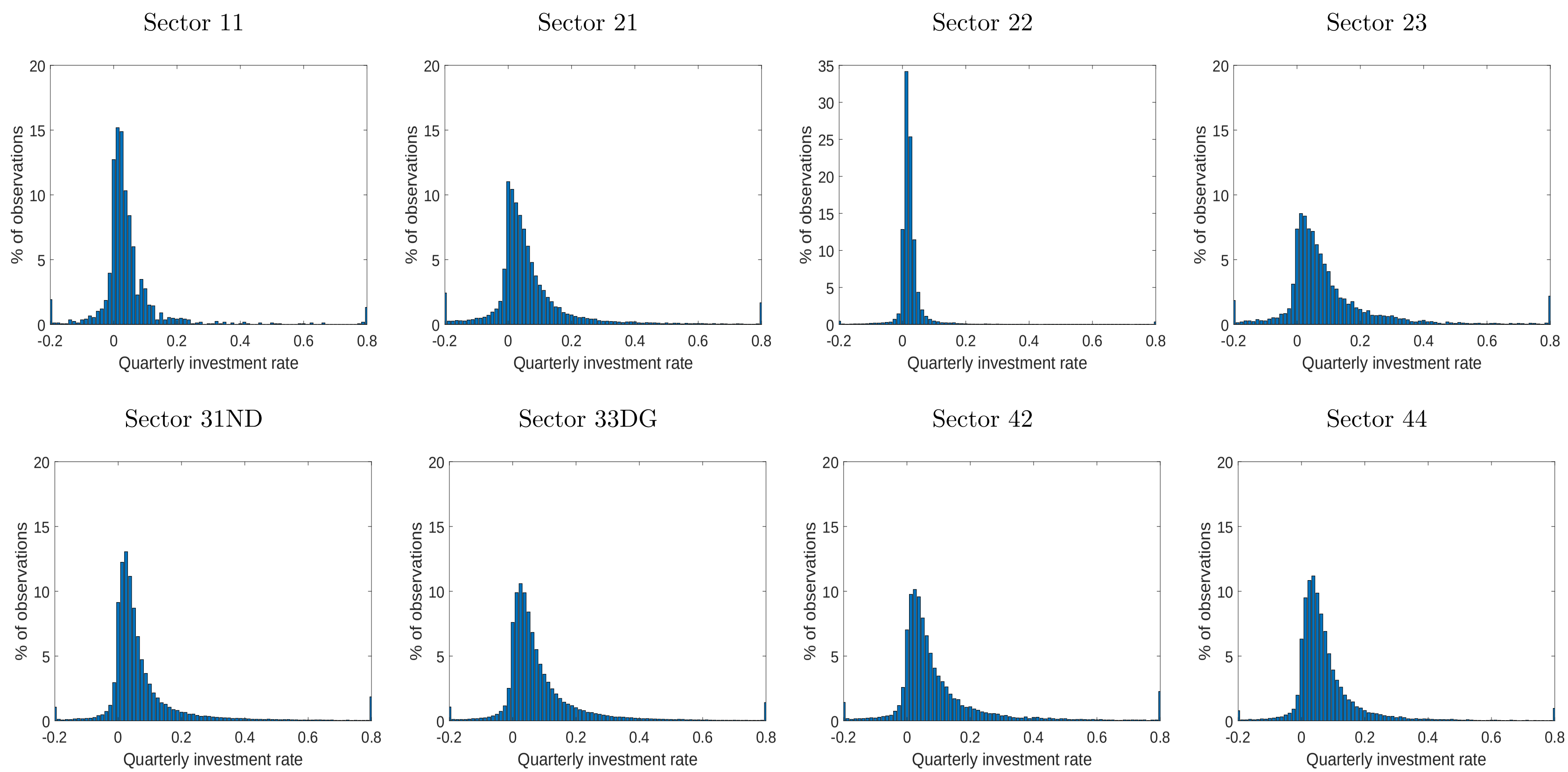

Panel E: Age > 3
Panel F: Age > 5
Panel G: Small ME
Panel H: Big ME
Panel I: Small K
Panel J: Big K
% of observations
Quarterly investment rate
35
30
25
20
15
10
5
0
-0.2
-0.1
0
0.1
0.2
0.3
0.4

Figure A3 : Robustness, the Quarterly Gross Investment Rate Distribution by 19 NAICS Nonfinancial Sectors, Scaled by Net PPE, 1978Q1–2016Q4

The 19 NAICS nonfinancial sectors are: Sector 11, Agriculture, forestry, fishing, and hunting; 21, Mining; 22, Utilities; 23, Construction; 31ND, Nondurable goods; 33DG, Durable goods; 42, Wholesale trade; 44, Retail trade; 48TW, Transportation and warehousing; 51, Information; 53, Real estate and rental and leasing; 54, Professional, scientific, and technical services; 55, Management of companies and enterprises; 56, Administrative and waste management services; 61, Educational services; 62, Health care and social assistance; 71, Arts, entertainment, and recreation; 72, Accommodation and food services; 81, Other services, except government.



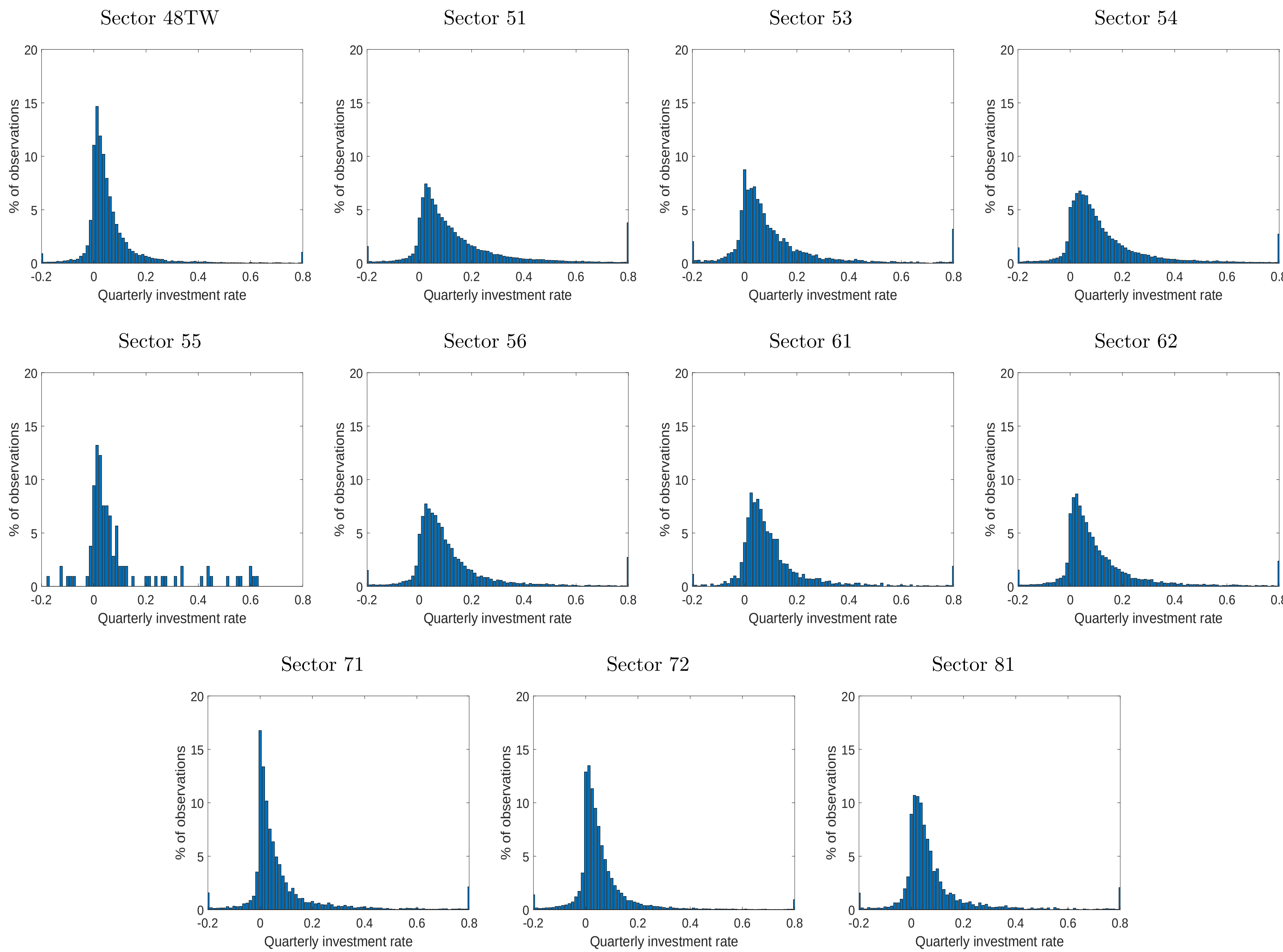
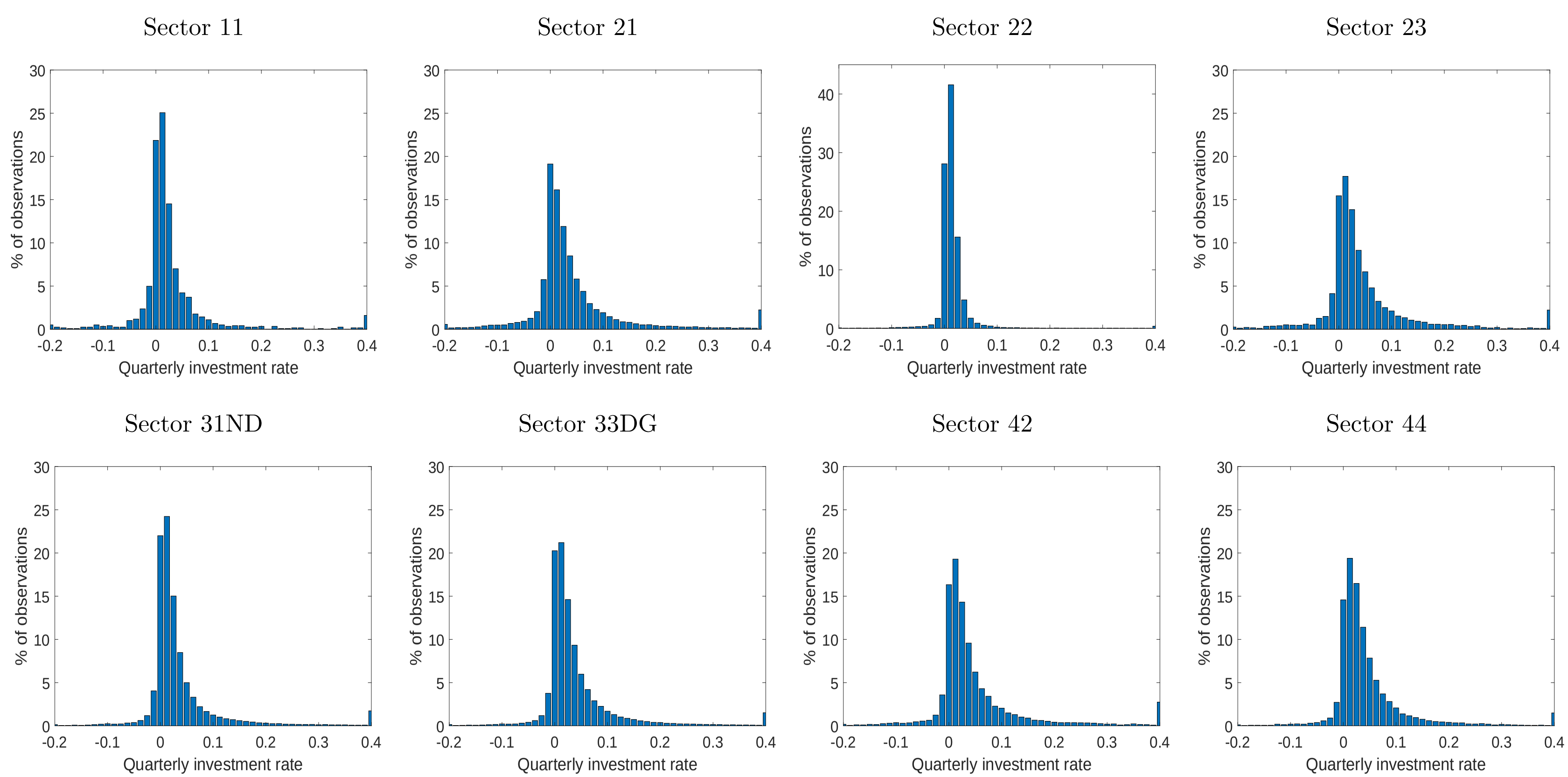
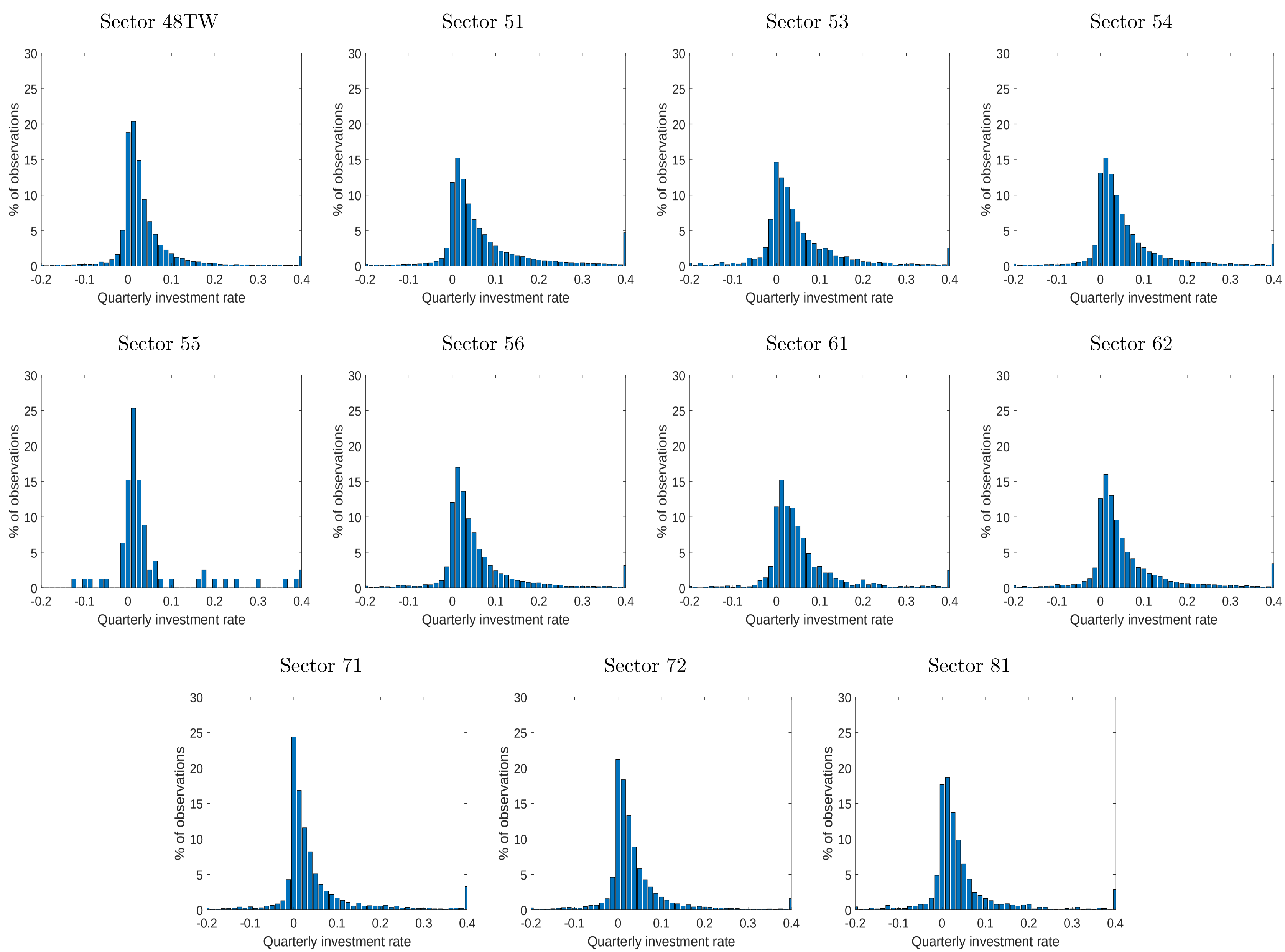

Sector 48TW
Sector 51
Sector 53
Sector 54
Sector 55
Sector 56
Sector 61
Sector 62
Sector 71
Sector 72
Sector 81
% of observations
Quarterly investment rate

Figure A4 : Robustness, the Quarterly Gross Investment Rate Distribution by 19 NAICS Nonfinancial Sectors, Scaled by Gross PPE, 1978Q1–2016Q4

The 19 NAICS nonfinancial sectors are: Sector 11, Agriculture, forestry, fishing, and hunting; 21, Mining; 22, Utilities; 23, Construction; 31ND, Nondurable goods; 33DG, Durable goods; 42, Wholesale trade; 44, Retail trade; 48TW, Transportation and warehousing; 51, Information; 53, Real estate and rental and leasing; 54, Professional, scientific, and technical services; 55, Management of companies and enterprises; 56, Administrative and waste management services; 61, Educational services; 62, Health care and social assistance; 71, Arts, entertainment, and recreation; 72, Accommodation and food services; 81, Other services, except government.




Sector 48TW
Sector 51
Sector 53
Sector 54
Sector 55
Sector 56
Sector 61
Sector 62
Sector 71
Sector 72
Sector 81
% of observations
Quarterly investment rate