# Methodological Musings on Firm Performance

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# Strategy and Firm Performance

"Performance improvement is at the heart of strategic management" (Venkatraman and Ramanujam, 1986).

"Understanding persistent heterogeneity in firm performance is, perhaps, the central objective in the field of strategy" (Gans and Ryall, 2017).

"Explaining organizational performance is at the heart of the strategy literature" (Wibbens and Siggelkow, 2020).

# Motivation for this research

$$\frac{Net\ income}{Total\ assets} = \beta_1 \frac{R\&D\ Expenditures}{Total\ Sales} + \beta_2 Total\ assets\ (logged) + \ldots..$$

ROA

R&D Intensity

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**Many performance measures are ratios, and ratios are problematic in statistical models.**

# Ratios in OLS Models

$$\frac{Net\ income}{Total\ assets} = \beta_1 \frac{R\&D\ Expenditures}{Total\ Sales} + \beta_2 Total\ assets\ (logged) + \ldots..$$

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# Problems with Ratios

- “Empirical researchers love ratios—statisticians loathe them” (Jasienski and Bazzaz, 1999: 321).

- “A ratio is seductively simple. There is just one problem: the analysis of a ratio is complex” (Curran-Everett, 2013: p. 213).

# Pearson (1896) Noted Problems with Ratios

$$r\left(\frac{y}{z_1},\frac{x}{z_2}\right)=\frac{r_{xy}V_yV_x-r_{yz_2}V_yV_{z_2}-r_{xz_1}V_xV_{z_1}+r_{z_1z_2}V_{z_1}V_{z_2}}{\sqrt{V_y^2+V_{z_1}^2-2r_{yz_1}V_yV_{z_1}}\sqrt{V_x^2+V_{z_2}^2-2r_{xz_2}V_xV_{z_2}}}$$

$$Coefficient\ of\ Variation(V)=\frac{Standard\ Deviation}{Mean}$$

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# CVs in Strategy Research

**Table 1.** Coefficients of Variation and Examples of Several Popular Variables Used in Ratios.

| | Raw Data | | | | Winsorized at 1% | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | S&P 500 | MidCap | SmallCap | S&P 1500 | S&P 500 | MidCap | SmallCap | S&P 1500 | Database |
| Assets | 4.9 | 1.4 | 1.8 | 3.2 | 2.2 | 1.3 | 1.3 | 2.7 | Compustat |
| CEO's option pay | 3.2 | 1.9 | 2.0 | 2.6 | 1.4 | 1.6 | 1.8 | 1.8 | Execucomp |
| CEO's total compensation | 1.0 | 0.6 | 1.6 | 0.7 | 0.6 | 0.6 | 0.6 | 0.8 | Execucomp |
| Employees | 3.4 | 1.7 | 4.5 | 2.4 | 1.5 | 1.6 | 1.8 | 2.1 | Compustat |
| Long-term debt | 3.5 | 1.3 | 1.7 | 2.2 | 2.0 | 1.0 | 1.4 | 2.2 | Compustat |
| Net income | 4.4 | 4.1 | 7.6 | 2.6 | 2.0 | 3.2 | 5.5 | 3.0 | Compustat |
| Number of directors | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | ISS |
| Number of females on the board of directors | 1.2 | 1.4 | 1.7 | 0.8 | 0.8 | 1.3 | 1.6 | 1.1 | ISS |

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# Why Do We Use Ratios?

- “Everyone else uses a ratio”
- “The ratio may provide a better model”
- “Ratios are simpler”
- “The ratio is the natural quantity of interest”

“Sounds like what one hears from a teenager to justify particularly noxious behavior.”

Kronmal (1993, p. 391)

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# Simulations

- Generated 1,000 observations of independent, control, and dependent variables. Correlations between IVs set to .125, and correlations between IVs and DV set to .15.

- Manipulated the CVs by keeping the variances constant but altering the mean of the denominator.

# Examples of OLS models we examined

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 z$$

$$\frac{y}{z} = \beta_1 x_1 + \beta_2 x_2 + \beta_3 z$$

$$\frac{y}{z} = \beta_1 \frac{x_1}{z} + \beta_2 x_2 + \beta_3 z$$

# When the DV is a Ratio and CV Changes

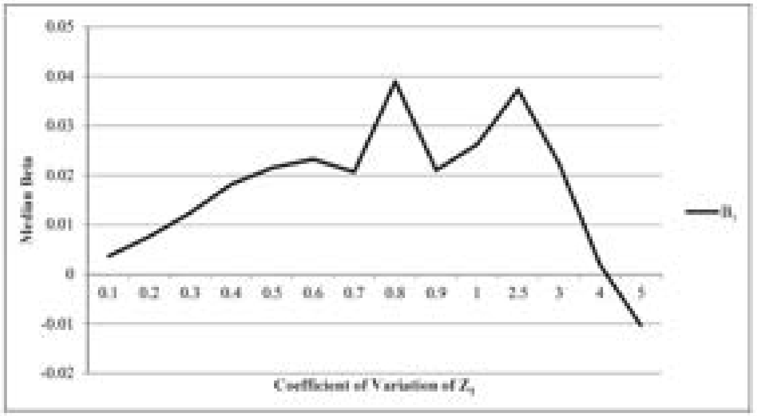


**Figure 2.** Median Beta When the Dependent Variable Is a Ratio (Study 2).

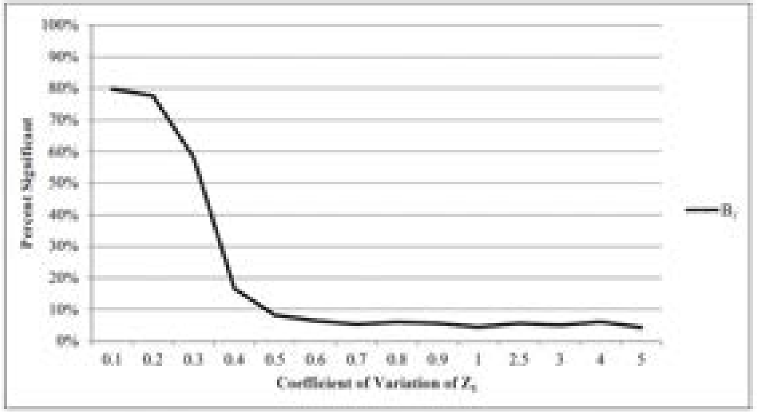


**Figure 3.** Percentage Significant When the Dependent Variable Is a Ratio (Study 2).

| | Raw Data | | | |
|---|---|---|---|---|
| Variable | S&P 500 | MidCap | SmallCap | S&P 1500 |
| Assets | 4.9 | 1.4 | 1.8 | 3.2 |

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# Ratios: A Summary

- Ratios are great for benchmarking purposes.

- Ratios in statistical models, regardless of whether they are used as DVs, IVs, or controls, produce inconsistent results (both Bs and SEs).

- In contrast, using a denominator as a control variable instead produced consistent results.

- Our study only examined denominators. Numerators make these issues even more complex.

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**Academics are addicted to ROA.**
**Executives are not.**

# ROA: An Academic Favorite

- In one of the earliest strategic management publications, Lenz (1980, p. 214) suggested that ROA “is a relatively comprehensive measure that is widely used as a performance objective by industry executives.”

- Since that time, ROA has become the most popular ratio to operationalize firm performance (Bromiley & Harris, 2014; Wibbens & Siggelkow, 2020).

# Academics and ROA

**Table 9.** Strategic Management Journal Performance Measure Occurrences (% of Articles).

| | Measure as Dependent Variable | | | | | | | Measure as Independent Variable | | | | | | | Measure as Control Variable | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Articles by Year (%) | | | | | Total[1] | Rank | Articles by Year (%) | | | | | Total | Rank | Articles by Year (%) | | | | | Total | Rank |
| Measure | 2000 | 2005 | 2010 | 2015 | 2019 | (%) | | 2000 | 2005 | 2010 | 2015 | 2019 | (%) | | 2000 | 2005 | 2010 | 2015 | 2019 | (%) | |
| ROA | 31 | 44 | 29 | 38 | 33 | 35 | 1 | 0 | 43 | 50 | 56 | 33 | 41 | 1 | 33 | 60 | 43 | 92 | 68 | 68 | 1 |
| ROS/Profit margin | 19 | 19 | 16 | 16 | 4 | 15 | 2 | 0 | 0 | 0 | 11 | 0 | 3 | 5 | 17 | 0 | 9 | 6 | 8 | 7 | 5 |
| CARs/Stock market returns | 27 | 4 | 10 | 6 | 25 | 14 | 3 | 33 | 14 | 17 | 22 | 11 | 18 | 2 | 0 | 20 | 0 | 8 | 0 | 4 | 8 |
| Tobin's Q | 0 | 15 | 13 | 16 | 13 | 11 | 4 | 33 | 0 | 0 | 11 | 0 | 6 | 4 | 0 | 20 | 17 | 3 | 12 | 9 | 3 |
| Revenue | 19 | 11 | 6 | 6 | 4 | 9 | 5 | 0 | 14 | 0 | 0 | 0 | 3 | 5 | 33 | 0 | 9 | 0 | 8 | 6 | 6 |
| Revenue growth | 15 | 7 | 3 | 6 | 8 | 8 | 6 | 33 | 14 | 17 | 11 | 11 | 15 | 3 | 17 | 0 | 13 | 17 | 8 | 13 | 2 |
| ROI | 8 | 19 | 0 | 6 | 4 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 17 | 20 | 0 | 3 | 0 | 3 | 7 |
| ROE | 4 | 15 | 3 | 6 | 4 | 6 | 8 | 0 | 0 | 17 | 0 | 0 | 3 | 5 | 0 | 60 | 9 | 0 | 4 | 6 | 5 |
| Market share | 15 | 7 | 10 | 3 | 0 | 7 | 7 | 0 | 14 | 17 | 11 | 0 | 6 | 4 | 0 | 0 | 4 | 0 | 4 | 2 | 8 |
| Profit | 4 | 4 | 3 | 0 | 4 | 3 | 9 | 0 | 0 | 0 | 11 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| Market to book | 8 | 4 | 0 | 3 | 0 | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 0 | 0 | 13 | 6 | 8 | 7 | 4 |
| Cash flow | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 33 | 0 | 0 | 0 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| EPS | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| Stock price | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| Credit rating | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| Other[2] | 23 | 41 | 32 | 16 | 50 | 31 | | 33 | 29 | 0 | 33 | 56 | 32 | | 0 | 0 | 17 | 6 | 16 | 11 | |
| N | 26 | 27 | 31 | 32 | 24 | 140 | | 3 | 7 | 6 | 9 | 9 | 34 | | 6 | 5 | 23 | 36 | 25 | 95 | |

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# Do executives agree?

# Executives and Firm Performance: 10Ks

**Table 2.** Percent of the MD&A Sections Referencing Performance Measures by S&P Classification.

| Measure | S&P1500 | S&P 500 | S&P MidCap 400 | S&P SmallCap 600 | Chi-squared | *p*-value |
|---|---|---|---|---|---|---|
| Revenue | 98.79 | 98.56 | 98.55 | 99.18 | 9.49 | .01 |
| Profits | 98.45 | 98.16 | 98.64 | 98.56 | 3.39 | .18 |
| Cash flow | 98.49 | 97.85 | 98.90 | 98.75 | 16.41 | <.001 |
| Stock price | 34.12 | 36.31 | 31.82 | 33.84 | 16.11 | <.001 |
| Stock returns | 23.73 | 28.76 | 25.19 | 18.68 | 127.66 | <.001 |
| Credit rating | 33.38 | 50.58 | 33.21 | 19.48 | 949.15 | <.001 |
| Market share | 26.47 | 28.81 | 26.96 | 24.25 | 23.82 | <.001 |
| EPS | 48.29 | 59.09 | 50.16 | 38.26 | 385.13 | <.001 |
| ROS | 29.74 | 36.54 | 28.03 | 25.32 | 137.43 | <.001 |
| ROA | 13.54 | 18.43 | 14.24 | 9.09 | 164.49 | <.001 |
| ROE | 9.25 | 9.87 | 10.92 | 7.65 | 27.16 | <.001 |
| ROI | 13.35 | 17.85 | 13.19 | 9.77 | 123.34 | <.001 |
| Market to book | 0.03 | 0.05 | 0.00 | 0.04 | 1.49 | .47 |
| Tobin's Q | 0.00 | 0.00 | 0.00 | 0.00 | N/A | N/A |
| Number of words | 8486.19 | 9478.61 | 8338.85 | 7610.80 | | |
| Number of categories | 5.27 | 5.81 | 5.30 | 4.83 | | |
| N | 11,989 | 3,960 | 3,168 | 4,861 | | |

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# Robustness Tests

- Similar results regardless of performance
- Results similar over time (2010-2019)
- Similar results across industry categories
- Similar results for proxy statements
- Similar results for earnings call transcripts

**Ratios and non-ratios are not even close to being the same.**

# Correlations

**Table 10.** Performance Measure Correlations in S&P 1500 Firms (2010 – 2020).

| Measure | N | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | 15,365 | 1.00 | | | | | | | | | | | | |
| Revenue growth | 15,056 | 0.00 | 1.00 | | | | | | | | | | | |
| Net income | 15,365 | 0.66** | 0.00 | 1.00 | | | | | | | | | | |
| Free cash flows | 11,585 | 0.47** | −0.02 | 0.74** | 1.00 | | | | | | | | | |
| Stock returns | 14,359 | −0.02* | 0.00 | 0.01 | 0.00 | 1.00 | | | | | | | | |
| Market share | 15,365 | 0.48** | 0.00 | 0.61** | 0.43** | −0.03** | 1.00 | | | | | | | |
| EPS | 15,353 | 0.13** | 0.00 | 0.25** | 0.23** | 0.05** | 0.15** | 1.00 | | | | | | |
| ROS | 15,351 | 0.01 | 0.00 | 0.01 | 0.01 | 0.03** | 0.01 | 0.01 | 1.00 | | | | | |
| ROA | 15,365 | 0.04** | 0.00 | 0.13** | 0.12** | 0.10** | 0.07** | 0.29** | 0.13** | 1.00 | | | | |
| ROE | 15,364 | 0.04** | 0.00 | 0.02* | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | 0.04** | 1.00 | | | |
| ROI | 15,365 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05** | 0.00 | 0.01 | 0.04** | 0.17** | −0.06** | 1.00 | | |
| Market to book | 15,068 | −0.01 | 0.00 | 0.02** | 0.03** | 0.03** | 0.00 | 0.02** | 0.00 | 0.01 | 0.35** | −0.01 | 1.00 | |
| Tobin's Q | 15,068 | −0.04** | −0.01 | 0.02 | 0.03** | 0.26** | −0.03** | 0.04** | −0.06** | 0.16** | 0.00 | 0.08** | 0.05** | 1.00 |

*p < .05, **p < .01

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# Rankings Of Top Performers

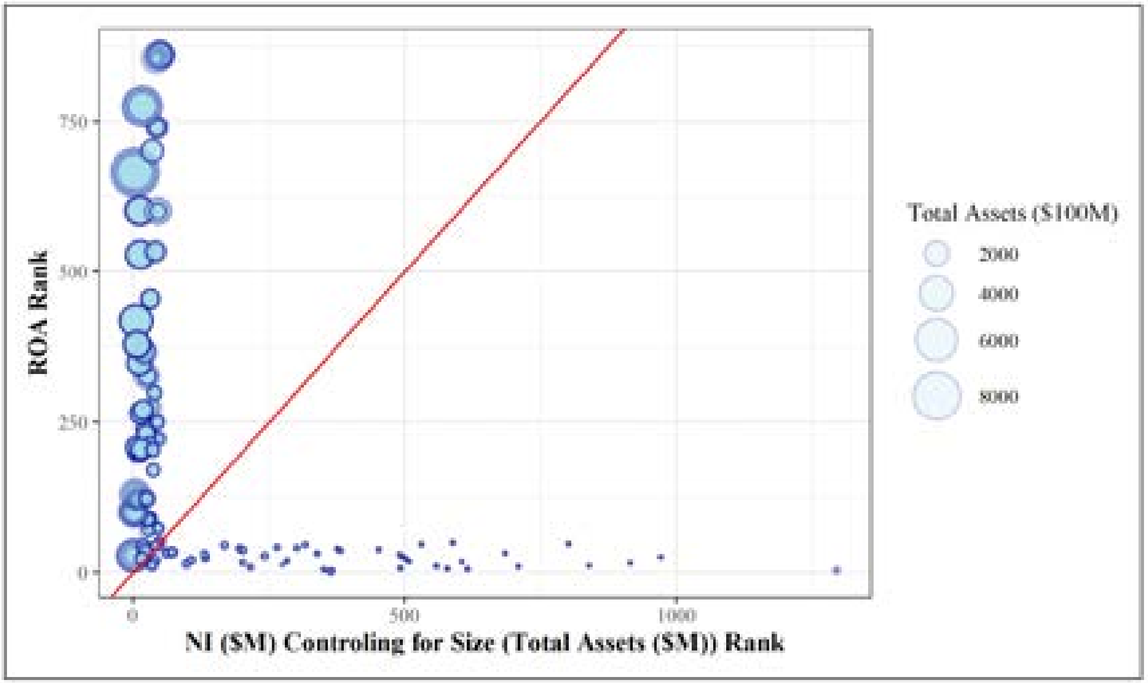


**Figure 2.** Comparing top performers in S&P 1500 by relative rank—top 50 performers.

- NI top performers: Apple, Microsoft, Berkshire Hathaway, Alphabet, and Exxon
- ROA top performers: Cboe Global Markets, Domino's, Antero Midstream, and Factset
- Only 6 companies appeared in top 50 of both lists

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# A Question to Consider

What are the implications of research that focuses on the performance effects of executive decision making when the research relies largely on measures of performance that are generally uncorrelated with the performance measures that executives ***seem to*** utilize and care about?

# Performance measures are extremely non-normal.

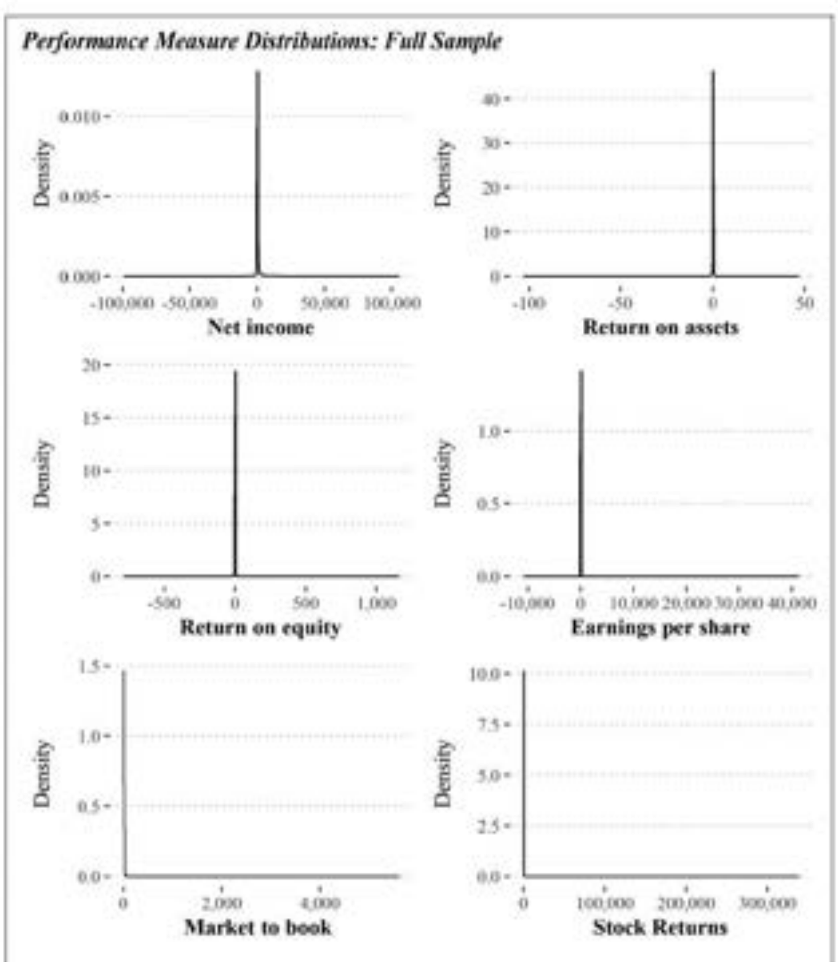
# Non-Normality: Skewness and Kurtosis

**Table 2.** Distribution Parameters of Performance Measures.

| **Net Income** *Transformation* | *N* | *Mean* | *SD* | *Skew* | *Kurtosis* | *Min* | *1st Pctl* | *50th Pctl* | *99th Pctl* | *Max* |
|---|---|---|---|---|---|---|---|---|---|---|
| None | 45,055 | 367.30 | 2284.20 | 4.94 | 489.37 | −99289.00 | −1431.70 | 53.91 | 7495.00 | 104,821.00 |
| Winsorized | 45,055 | 326.20 | 1071.20 | 4.63 | 28.14 | −1431.71 | −1431.70 | 53.91 | 7495.00 | 7495.00 |
| Log | 45,055 | 11.51 | 0.06 | −147.02 | 25,619.47 | 0.00 | 11.49 | 11.51 | 11.58 | 12.23 |
| Inverse hyperbolic sine | 45,055 | 3.26 | 4.41 | −1.12 | 3.19 | −12.20 | −7.96 | 4.68 | 9.62 | 12.25 |

| **Return on Assets** *Transformation* | *N* | *Mean* | *SD* | *Skew* | *Kurtosis* | *Min* | *1st Pctl* | *50th Pctl* | *99th Pctl* | *Max* |
|---|---|---|---|---|---|---|---|---|---|---|
| None | 45,043 | 0.01 | 0.76 | −66.85 | 9476.61 | −103.00 | −0.73 | 0.04 | 0.29 | 46.45 |
| Winsorized | 45,043 | 0.02 | 0.13 | −2.97 | 16.23 | −0.73 | −0.73 | 0.04 | 0.29 | 0.29 |
| Log | 45,043 | 4.64 | 0.02 | −186.98 | 37579.74 | 0.00 | 4.64 | 4.64 | 4.65 | 5.01 |
| Inverse hyperbolic sine | 45,043 | 0.02 | 0.18 | −5.69 | 123.43 | −5.33 | −0.68 | 0.04 | 0.29 | 4.53 |

# Bell-Shaped?

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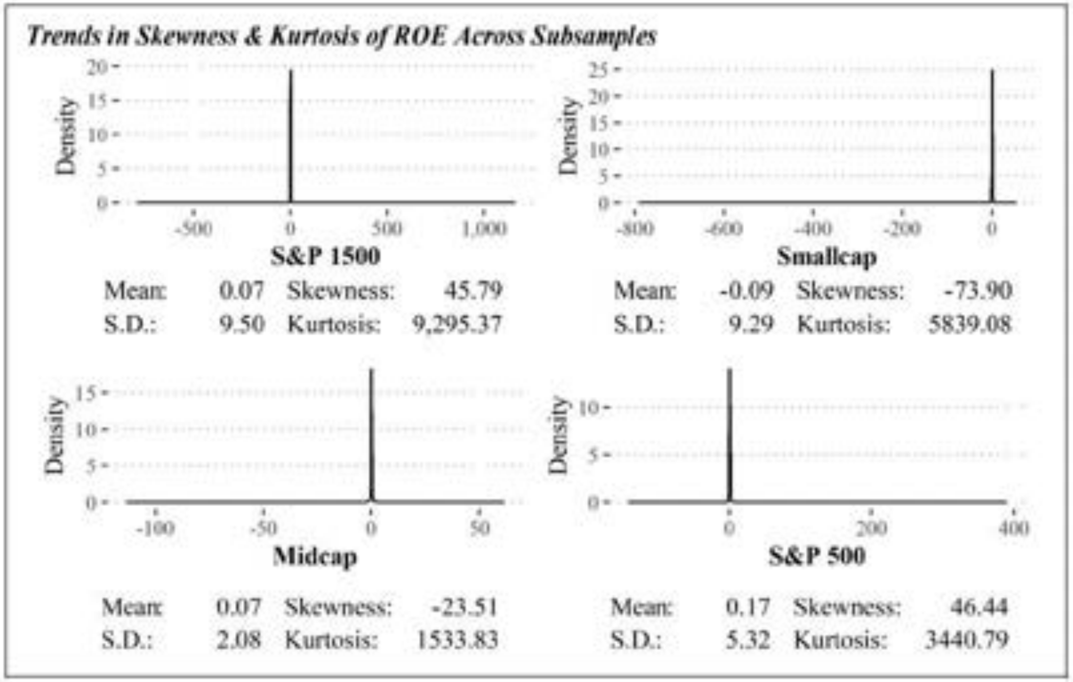
# Non-Normality Depends on Sub-Sampling

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# Commonly used techniques to resolve non-normality are not very effective.

# Simulations: Skewness and Kurtosis

- OLS
- Transformations
  - Winsorizing
  - Log
  - Inverse hyperbolic sine
- Robust SEs
- Bootstrapping
- Quantile regression

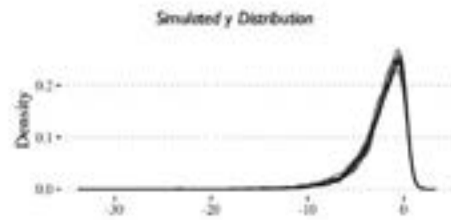
# Quantile Regression and Standard Errors

**Table 4.** (continued)

**Condition 3: Moderate Negative Skewness and Moderate Kurtosis**

| *Mean* | *SD* | *Skewness* | *Kurtosis* | *Min* | *Max* | *1st Pctl* | *99th Pctl* |
|---|---|---|---|---|---|---|---|
| −2.262 | 2.516 | −2.493 | 11.334 | −255.038 | 19.145 | −11.178 | 0.593 |

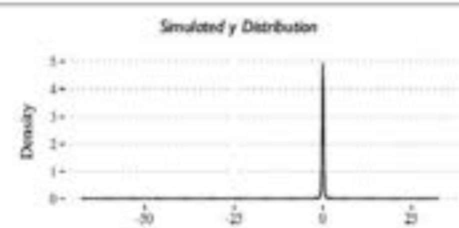
| *Model* | *B* | *SE* | *PerSig* | *DfBeta* |
|---|---|---|---|---|
| Original | 0.051 | 0.080 | 9.710% | 0.033 |
| Winsorized | 0.050 | 0.072 | 10.440% | 0.000 |
| Log | 0.002 | 0.005 | 7.290% | 0.000 |
| Inverse hyperbolic sine | 0.029 | 0.028 | 17.290% | 0.000 |
| Robust standard errors | 0.051 | 0.079 | 9.990% | – |
| Bootstrap | 0.051 | 0.078 | 10.180% | – |
| 10th percentile | 0.053 | 0.206 | 8.100% | – |
| 50th percentile | 0.051 | 0.076 | 11.020% | – |
| 90th percentile | 0.051 | 0.036 | 30.570% | – |




**Condition 4: No Skewness and High Kurtosis**

| *Mean* | *SD* | *Skewness* | *Kurtosis* | *Min* | *Max* | *1st Pctl* | *99th Pctl* |
|---|---|---|---|---|---|---|---|
| 0.000 | 0.606 | 0.044 | 153.975 | −1058.808 | 949.569 | −1.241 | 1.240 |

| *Model* | *B* | *SE* | *PerSig* | *DfBeta* |
|---|---|---|---|---|
| Original | 0.050 | 0.019 | 67.040% | 0.039 |
| Winsorized | 0.049 | 0.010 | 99.730% | 0.000 |
| Log | 0.006 | 0.003 | 52.770% | 0.000 |
| Inverse hyperbolic sine | 0.049 | 0.010 | 99.270% | 0.000 |
| Robust standard errors | 0.050 | 0.017 | 72.650% | – |
| Bootstrap | 0.050 | 0.017 | 72.620% | – |
| 10th percentile | 0.050 | 0.019 | 71.200% | – |
| 50th percentile | 0.050 | 0.003 | 100.000% | – |
| 90th percentile | 0.050 | 0.019 | 71.200% | – |




*(continued)*

# Conclusions

- Strategy research is largely addicted to ratios, which present statistical issues.
- Executives seem to rely on non-ratios.
- Firm performance measures are extremely non-normal. This extreme non-normality changes based on measures and samples.
- Ratios are more non-normal than non-ratios.
- Quantile regression can help deal with such non-normality.

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# Recommendations

- Avoid ratios and use unscaled measures.
- Increase the use of quantile regression to address non-normality.
- Warning: Beware of multicollinearity.

# Questions?

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