

# Resolving Estimation Ambiguity

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# Roadmap

Summary

Data

Results

Discussion

# How do financial analysts deal with CAPM estimation ambiguity?

- CAPM is widely used by practitioners to guide cost of capital assessment.
- However, theory allows for multiple plausible estimation choices:
  - Market return proxy
  - Risk-free rate proxy
  - Frequency and estimation window for Beta and Equity Risk Premium estimation

## How do financial analysts deal with CAPM estimation ambiguity?

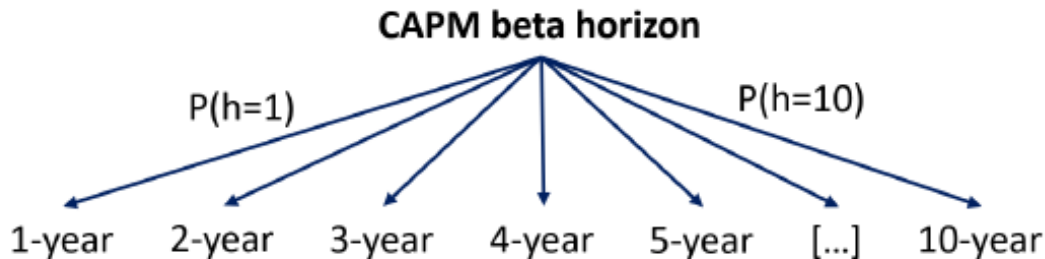
$$\mathbf{WACC}_{i,t} = \mathbf{W}_{i,t}^E * (\mathbf{rf}_t + \beta_{i,t} * \mathbf{ERP}_t) + \mathbf{W}_{i,t}^D * (1 - \tau_{i,t}) * \mathbf{r}_{i,t}^D$$
$$\mathbf{r}_{i,t} - \mathbf{rf}_t = \alpha + \beta * (\mathbf{r}_t^M - \mathbf{rf}_t)$$

Where:

- $\mathbf{WACC}_{i,t}$  is firm  $i$  weighted average cost of capital at time  $t$
- $\mathbf{W}_{i,t}^E$  and  $\mathbf{W}_{i,t}^D$  are the weights of equity and debt in the firm's capital structure
- $\mathbf{ERP}_t$  is the equity risk premium
- $\mathbf{rf}_t$  is the risk-free rate
- $\mathbf{r}_t^M$  and  $\mathbf{r}_{i,t}$  are the expected returns of, respectively, the market portfolio and the firm's stock
- $\mathbf{r}_{i,t}^D$  is the cost of debt and  $\tau$  its marginal tax rate

## How do financial analysts deal with CAPM estimation ambiguity?

**Figure 2: CAPM Beta Horizon Selection** This figure highlights the ambiguity that analysts face when selecting the horizon of the estimation window in the CAPM formula. Analysts know that the true beta of the firm can be estimated with one, or a combination of several of the horizons, however, they do not know the weights to apply (e.g.,  $P(h=1)$ ,  $P(h=2)$ , and so on).



## Paper documents findings from thousands of equity reports

- Authors look at **45,992** reports issued between **2000** and **2023** with disclosure on WACC calculation
- They extract and compare inputs used for cost of capital calculation

# Main Findings

1. There is large dispersion in WACC estimates
2. Differences in estimated parameters - Beta and ERP - are main contributors to WACC divergence
3. Disagreement over choice of risk-free proxy is relevant outside the U.S.
4. Beta estimation strategy is highly persistent at the analyst level
5. Observable individual analyst characteristics do not explain well differences in beta estimation strategy
6. WACC disagreement positively predicts trading volume

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## Selection of Equity Reports

- Initial batch of **155,479** equity reports with mentions to terms "DCF", "discounted cash flow", and "weighted average cost of capital", or "WACC"
- Kept only reports published in the first quarter from **2000** to **2023**
- Kept only the first report for a given analyst-firm-year
- Kept firm-year pair only if covered by at least **2** analysts
- Cost of Capital inputs extracted from reports using a combination of AI and manual inspection

# Final Sample

- **45,992** equity reports
- **42** large equity research firms operating in **45** countries
- **4,261** firms located in **63** countries
- **4,556** analysts
- Further textual analysis on Beta estimation strategy of **1,023** reports

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# 1. Large dispersion in WACC estimates

|                                       | Mean  | Std. Dev. | 25 <sup>th</sup> Pct. | Median | 75 <sup>th</sup> Pct. | Obs.   |
|---------------------------------------|-------|-----------|-----------------------|--------|-----------------------|--------|
| <u>Firm Details</u>                   |       |           |                       |        |                       |        |
| Analyst Coverage (#)                  | 10.0  | 7.4       | 4.0                   | 8.0    | 15.0                  | 12,060 |
| Sample Coverage (years)               | 4.0   | 4.2       | 1.0                   | 2.0    | 5.0                   | 4,261  |
| <u>Equity Report Details</u>          |       |           |                       |        |                       |        |
| $WACC_{a,i,t}$                        | 0.089 | 0.019     | 0.076                 | 0.087  | 0.100                 | 45,992 |
| $rf_{a,i,t}$                          | 0.040 | 0.017     | 0.030                 | 0.040  | 0.050                 | 10,921 |
| $CAPM\ Beta_{a,i,t}$                  | 1.089 | 0.280     | 0.900                 | 1.050  | 1.200                 | 12,409 |
| $ERP_{a,i,t}$                         | 0.057 | 0.014     | 0.050                 | 0.055  | 0.064                 | 11,052 |
| $r_{a,i,t}^E$                         | 0.101 | 0.024     | 0.085                 | 0.099  | 0.114                 | 7,833  |
| $TGR_{a,i,t}$                         | 0.022 | 0.020     | 0.015                 | 0.020  | 0.030                 | 29,244 |
| <u>Pairwise Differences</u>           |       |           |                       |        |                       |        |
| $WACC_{ A-B ,i,t}$                    | 0.014 | 0.013     | 0.005                 | 0.010  | 0.019                 | 48,019 |
| $rf_{ A-B ,i,t}$                      | 0.010 | 0.011     | 0.003                 | 0.008  | 0.013                 | 3,247  |
| $CAPM\ Beta_{ A-B ,i,t}$              | 0.219 | 0.211     | 0.080                 | 0.170  | 0.300                 | 4,170  |
| $ERP_{ A-B ,i,t}$                     | 0.013 | 0.013     | 0.005                 | 0.010  | 0.016                 | 2,921  |
| $(CAPM\ Beta \times ERP)_{ A-B ,i,t}$ | 0.016 | 0.016     | 0.005                 | 0.011  | 0.022                 | 2,059  |
| $r_{ A-B ,i,t}^E$                     | 0.018 | 0.017     | 0.006                 | 0.013  | 0.024                 | 1,498  |

# 1. Large dispersion in WACC estimates

- Differences are economically significant: a one standard deviation increase in the estimated cost of equity is associated with a **22%** drop in intrinsic value for the median firm
- Mean pairwise difference in WACC estimate for a given firm is **1.4** percentage points. For the median firm, that corresponds to a **17.3%** drop in firm value.
- Nearly **50%** of the pairwise differences in estimated WACC exceed **1** percentage point.

## 2. Differences in Beta and ERP are main contributors to WACC divergence

Campbell-Shiller Decomposition: They regress differences in cost of equity  $r_{a,i,t}^E$  on differences in risk-free rates and risk compensation.

$$r_{A,i,t}^E - r_{B,i,t}^E = r_{A-B,i,t}^E = \theta_1 \mathbf{rf}_{A-B,i,t} + \theta_2 [\beta * \mathbf{ERP}]_{A-B,i,t} + u_{A,B,i,t}$$

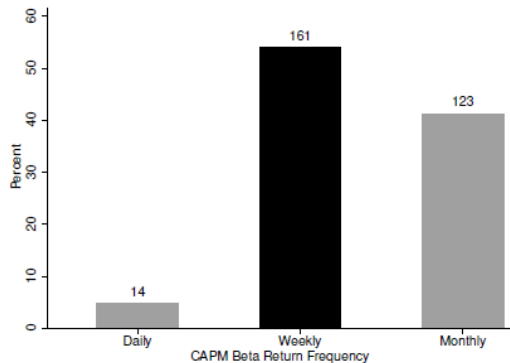
Intuition:  $\theta_1$  measures how much variation in the cost of equity is driven by the estimates of risk compensation

## 2. Differences in Beta and ERP are main contributors to WACC divergence

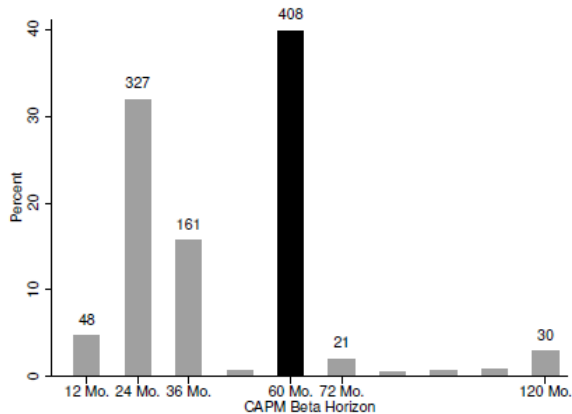
| Dep. variable =                      | $r_{A-B,i,t}$       |                     |                     |                     | $(\beta \times ERP)_{A-B,i,t}$ |                     |                     |                     |
|--------------------------------------|---------------------|---------------------|---------------------|---------------------|--------------------------------|---------------------|---------------------|---------------------|
|                                      | (1)                 | (2)                 | (3)                 | (4)                 | (5)                            | (6)                 | (7)                 | (8)                 |
| <i>Panel A: Full Sample</i>          |                     |                     |                     |                     |                                |                     |                     |                     |
| $r_{A-B,i,t}^E$                      | 0.227***<br>(0.033) | 0.227***<br>(0.032) | 0.215***<br>(0.040) | 0.214***<br>(0.040) | 0.773***<br>(0.033)            | 0.773***<br>(0.032) | 0.785***<br>(0.040) | 0.786***<br>(0.040) |
| Year FE                              |                     | ✓                   |                     | ✓                   |                                | ✓                   |                     | ✓                   |
| Firm FE                              |                     |                     | ✓                   | ✓                   |                                |                     | ✓                   | ✓                   |
| Observations                         | 1,498               | 1,497               | 1,119               | 1,117               | 1,498                          | 1,497               | 1,119               | 1,117               |
| F Statistic                          | 46.57               | 49.93               | 29.01               | 29.15               | 542.02                         | 576.98              | 386.54              | 393.63              |
| <i>Panel B: United States Sample</i> |                     |                     |                     |                     |                                |                     |                     |                     |
| $r_{A-B,i,t}^E$                      | 0.075<br>(0.053)    | 0.083<br>(0.051)    | 0.113<br>(0.078)    | 0.113<br>(0.071)    | 0.925***<br>(0.053)            | 0.917***<br>(0.051) | 0.887***<br>(0.078) | 0.887***<br>(0.071) |
| Year FE                              |                     | ✓                   |                     | ✓                   |                                | ✓                   |                     | ✓                   |
| Firm FE                              |                     |                     | ✓                   | ✓                   |                                |                     | ✓                   | ✓                   |
| Observations                         | 229                 | 228                 | 160                 | 154                 | 229                            | 228                 | 160                 | 154                 |
| F Statistic                          | 2.01                | 2.70                | 2.13                | 2.53                | 309.10                         | 329.37              | 130.73              | 156.88              |
| <i>Panel C: International Sample</i> |                     |                     |                     |                     |                                |                     |                     |                     |
| $r_{A-B,i,t}^E$                      | 0.257***<br>(0.039) | 0.256***<br>(0.037) | 0.233***<br>(0.045) | 0.225***<br>(0.045) | 0.743***<br>(0.039)            | 0.744***<br>(0.037) | 0.767***<br>(0.045) | 0.775***<br>(0.045) |
| Year FE                              |                     | ✓                   |                     | ✓                   |                                | ✓                   |                     | ✓                   |
| Firm FE                              |                     |                     | ✓                   | ✓                   |                                |                     | ✓                   | ✓                   |
| Observations                         | 1,269               | 1,268               | 959                 | 957                 | 1,269                          | 1,268               | 959                 | 957                 |
| F Statistic                          | 43.61               | 47.18               | 26.46               | 25.53               | 364.05                         | 399.78              | 287.42              | 301.57              |

## 2. Differences in Beta and ERP are main contributors to WACC divergence

(A) CAPM Beta Estimation Return Frequency

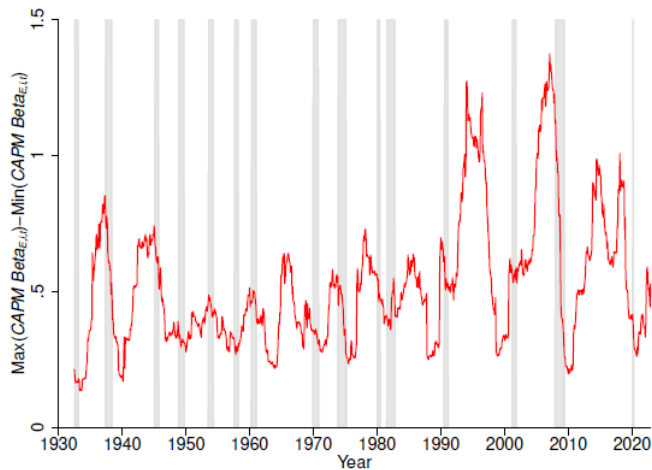


(B) CAPM Beta Estimation Horizon

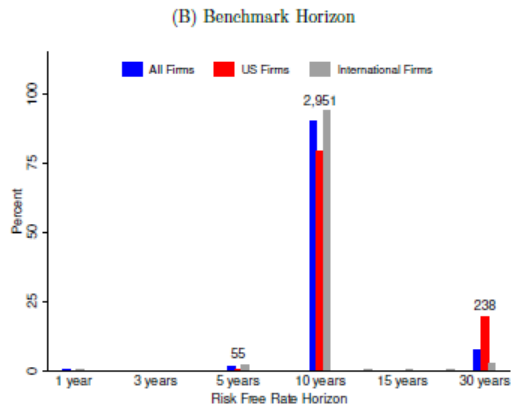
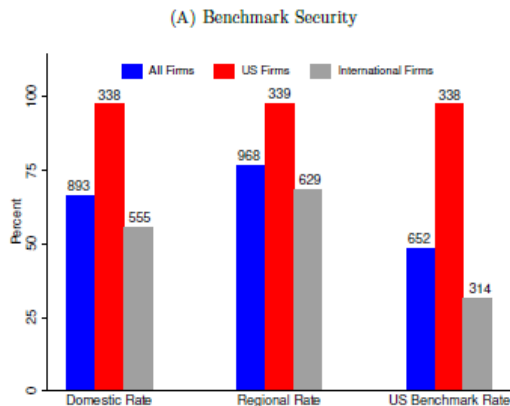




## 2. Differences in Beta and ERP are main contributors to WACC divergence

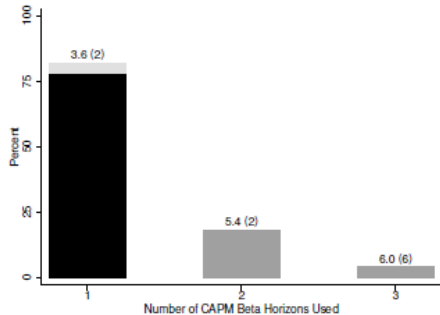


### 3. Disagreement over choice of risk-free proxy is relevant outside the U.S.

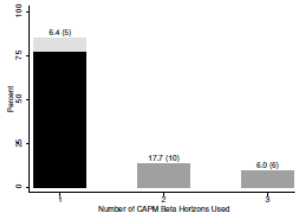


## 4. Beta estimation strategy is strongly tied to analysts (and is highly persistent)

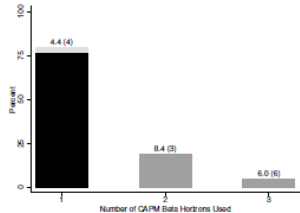
(A) All Analysts Identifying Beta Horizon.



(B) 4+ Forecasts.



(C) Forecasts Across Multiple Firms and Years

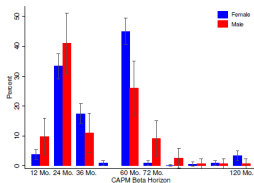


#### 4. Beta estimation strategy is strongly tied to analysts (and is highly persistent)

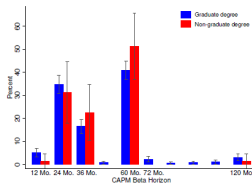
|                             | Sum of Squares<br>(% of Model) | Degrees<br>of Freedom | Adjusted<br>Partial $R^2$ |
|-----------------------------|--------------------------------|-----------------------|---------------------------|
|                             | (1)                            | (2)                   | (3)                       |
| <i>Panel A: Full Sample</i> |                                |                       |                           |
| Firm Indicators             | 78%                            | 1,947                 | 0.38                      |
| Brokerage Indicators        | 2%                             | 36                    | 0.01                      |
| Analyst Indicators          | 19%                            | 1,120                 | 0.28                      |
| Observations                |                                | 6,411                 |                           |
| $R^2$                       |                                | 0.78                  |                           |
| Adjusted $R^2$              |                                | 0.57                  |                           |

# 5. Individual analyst characteristics do not explain well differences in beta estimation strategy

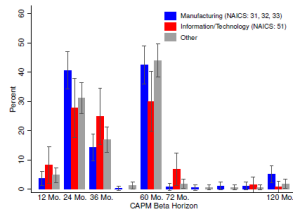
(A) Analyst Gender



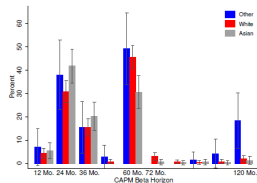
(B) Analyst Education



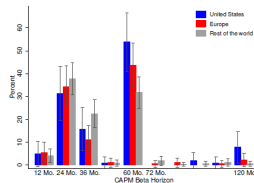
(E) Firm Industry



(C) Analyst Race



(D) Analyst Region



## 5. Individual analyst characteristics do not explain well differences in beta estimation strategy

|                            | Sum of Squares<br>(% of Model) | Degrees<br>of Freedom | Adjusted<br>Partial $R^2$ |
|----------------------------|--------------------------------|-----------------------|---------------------------|
|                            | (1)                            | (2)                   | (3)                       |
| <i>Panel A</i>             |                                |                       |                           |
| Gender Indicator           | 6%                             | 1                     | 0.01                      |
| Race Indicators            | 18%                            | 4                     | -0.02                     |
| Master's Degree Indicator  | 0%                             | 1                     | -0.01                     |
| Analyst Country Indicators | 76%                            | 8                     | 0.02                      |
| Observations               |                                | 154                   |                           |
| $R^2$                      |                                | 0.09                  |                           |
| Adjusted $R^2$             |                                | -0.00                 |                           |
| <i>Panel B</i>             |                                |                       |                           |
| Gender Indicator           | 15%                            | 1                     | 0.00                      |
| Race Indicators            | 16%                            | 3                     | -0.03                     |
| Master's Degree Indicator  | 0%                             | 1                     | -0.01                     |
| Analyst Country Indicators | 69%                            | 8                     | -0.02                     |
| Young Indicator            | 1%                             | 1                     | -0.01                     |
| Observations               |                                | 96                    |                           |
| $R^2$                      |                                | 0.09                  |                           |
| Adjusted $R^2$             |                                | -0.07                 |                           |

## 6. WACC disagreement positively predicts trading volume

$$\mathbf{FVOL}_{i,t} = \theta \mathbf{MAX}_a(\mathbf{WACC}_{i,t}) - \mathbf{MIN}_a(\mathbf{WACC}_{i,t}) + \mathbf{CONTROLS} + u_{i,t}$$

Where:

-

## 6. WACC disagreement positively predicts trading volume

| Panel A                                                                                                               | FVOL <sub><i>i,t</i></sub> |                     |                     |                     |                      |                      |
|-----------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------|---------------------|---------------------|----------------------|----------------------|
|                                                                                                                       | (1)                        | (2)                 | (3)                 | (4)                 | (5)                  | (6)                  |
| Max <sub><i>a</i> ∈ A</sub> (WACC <sub><i>i,t</i></sub> ) − Min <sub><i>a</i> ∈ A</sub> (WACC <sub><i>i,t</i></sub> ) | 1.060***<br>(0.128)        | 0.230***<br>(0.047) | 0.238***<br>(0.048) | 0.154***<br>(0.045) | 0.120***<br>(0.042)  | 0.134**<br>(0.057)   |
| Max <sub><i>a</i> ∈ A</sub> (TGR <sub><i>i,t</i></sub> ) − Min <sub><i>a</i> ∈ A</sub> (TGR <sub><i>i,t</i></sub> )   |                            |                     |                     |                     |                      | 0.046<br>(0.067)     |
| FVOL <sub><i>i,t</i>−1</sub>                                                                                          |                            | 1.018***<br>(0.010) | 1.019***<br>(0.010) | 0.784***<br>(0.019) | 0.761***<br>(0.021)  | 0.742***<br>(0.030)  |
| log(Market Capitalization <sub><i>i,t</i></sub> )                                                                     |                            |                     |                     |                     | -0.009***<br>(0.002) | -0.012***<br>(0.003) |
| Cumulative Return <sub><i>i,t</i>−3,<i>t</i>−1</sub>                                                                  |                            |                     |                     |                     | -0.010*<br>(0.006)   | -0.006<br>(0.008)    |
| Cumulative Return <sub><i>i,t</i>−12,<i>t</i>−4</sub>                                                                 |                            |                     |                     |                     | 0.001<br>(0.003)     | -0.001<br>(0.004)    |
| Return Volatility <sub><i>i,t</i>−3,<i>t</i>−1</sub>                                                                  |                            |                     |                     |                     | 0.000<br>(0.000)     | 0.000<br>(0.000)     |
| Months Between Forecasts <sub><i>i,t</i>0,<i>T</i></sub>                                                              |                            |                     |                     |                     | -0.002***<br>(0.001) | -0.002**<br>(0.001)  |
| Year-Month FE                                                                                                         |                            |                     | ✓                   | ✓                   | ✓                    | ✓                    |
| Firm FE                                                                                                               |                            |                     |                     | ✓                   | ✓                    | ✓                    |
| Observations                                                                                                          | 16,186                     | 15,836              | 15,836              | 14,431              | 12,351               | 6,978                |
| F Statistic                                                                                                           | 68.89                      | 5542.75             | 5510.84             | 833.66              | 210.69               | 104.30               |
| R <sup>2</sup>                                                                                                        | 0.01                       | 0.80                | 0.80                | 0.88                | 0.88                 | 0.89                 |



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# Discussion

- How large is WACC disagreement relative to cash flow disagreement?
- Is there a cyclical component to estimated beta dispersion?
- Is there a relationship between WACC disagreement and stock volatility?
- Could authors expand set of analyst level variables to explain choice of beta estimation horizon:
  - Analyst cohort
  - First job
  - Education institution

# The End

Thank you!