Assignment II: Adopting an Open Science Workflow

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1. Motivation

1.1 Understanding Residual Income and Importance of P/B Ratios

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- Residual income is a key metric in evaluating the performance of public firms.
- It helps in assessing the value creation for shareholders beyond the cost of capital.
- Price-to-Book (P/B) ratios are widely used in financial analysis to compare a firm's market value to its book value.
- Grouping firms by P/B ratios allows for a detailed analysis of financial performance across different valuation levels.

1.2 Project Objective

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- The primary objective is to demonstrate a reproducible and collaborative research workflow by calculating and analyzing residual incomes and Price-to-Book (P/B) ratios.
- The study aims to explore the residual income of U.S. public firms grouped by P/B ratios using external Worldscope datasets for the time range 1996 to 2015.
- The project replicates the study of Penman (2013) that links current P/B ratios to future residual income.
- The analysis provides insights into the median residual income over time across different P/B groups, similar to the insights of Penman (2013).

1.3 Project Relevance

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- Understanding the distribution and trends of residual income can inform investment decisions and corporate strategies.
- It supports the broader objective of promoting transparency and reproducibility in empirical accounting research.

2. Assumptions and Notes

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The aim of Assignment I is to replicate a specific empirical table that involves calculating the residual income of US firms over a defined period and examining the relationship between residual income and the Price-to-Book (P/B) ratio. The replication process involves data preparation, cleaning, and normalization, followed by the application of statistical methods to compute and interpret financial metrics.

For Assignment I, I used the Python programming language to carry out the empirical analysis. Visual Studio Code was used as the Integrated Development Environment (IDE) for writing, debugging, and optimizing the Python code.

2.1 Assumptions

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- **Constant Cost of Equity:** Assumed at 8% ($r_e = 8\%$), a reasonable average estimate for the period 1996-2015 in the US (Goedhart, Koller, and Williams (2002); Damodaran (2024)).
- **Data Source:** Worldscope panel data includes Book Value of Equity (BVE), Market Value of Equity (MVE), and net income at fiscal year-end .
- **Year 0 Data:** Year-end data from the previous year used as the starting values for the following year.
- **Deflation Basis:** Residual income deflated by BVE at the end of the year before Year 0 for comparability.
- **P/B Values Range:** Restricted to 0-7 to exclude outliers, focusing on firms with stable valuations.

3. Data - Replication Steps

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Step 1: Data Loading and Merging

Step 2: Filter Data for US Firms and Relevant Years

Step 3: Identify Year 0 to Year 6 for Each Firm

Step 4: Calculate P/B Ratio for Each Firm in Year 0

- Use the following formula to calculate the P/B ratio:

$$P/B_t = \frac{\textit{Market value of equity}_t}{\textit{Book value of equity}_t}$$

Step 5: Form P/B Groups

Step 6: Calculate Residual Income

- The Worldscope panel data provides BVE, MVE, and net income values at the end of each fiscal year, confirmed by the *2020 Annual Report* (2021) of ISIN AN8068571086 (Schlumberger Limited 2021, 20).
- Calculate the non-deflated residual income for each firm/year using the following formula:

$$\text{Residual income}_t = \text{Net income}_t - r_e \times \text{Book value of equity}_{t-1}$$

- Calculate the deflated residual income for each firm/year using the following general formula:

$$\text{Deflated residual income}_t = \frac{\text{Residual income}_t}{\text{Book value of equity}_{\text{Year 0 start}}}$$

Step 7: Output the Replicated Table

Median Residual Income by P/B Group and Relative Year:

relative_year	P/B	0	1	2	3	4	5	6
p/b_group								
1	117.42	-0.792	-0.367	0.000	-0.397	-0.662	-1.357	-0.975
2	19.23	-0.094	-0.380	-0.179	-0.327	0.084	-0.346	-0.126
3	9.56	0.063	0.159	0.017	0.108	-0.025	-0.322	-0.202
4	6.42	0.109	0.149	0.109	0.106	0.118	-0.040	-0.100
5	4.82	0.134	0.144	0.110	0.109	0.127	0.023	0.003
6	3.81	0.105	0.114	0.064	0.052	0.050	-0.026	-0.025
7	3.15	0.099	0.115	0.077	0.092	0.103	0.032	0.013
8	2.62	0.076	0.075	0.055	0.067	0.084	0.024	0.012
9	2.26	0.074	0.080	0.068	0.072	0.103	0.030	0.031
10	1.96	0.065	0.066	0.055	0.064	0.064	0.017	0.044
11	1.71	0.046	0.048	0.048	0.054	0.053	0.032	0.022
12	1.51	0.035	0.041	0.043	0.039	0.045	0.031	0.026
13	1.31	0.022	0.028	0.033	0.029	0.028	-0.000	0.016
14	1.12	-0.003	0.002	-0.000	-0.005	0.003	-0.033	-0.016
15	0.94	-0.031	-0.021	-0.009	-0.005	-0.002	-0.018	-0.006
16	0.73	-0.052	-0.050	-0.037	-0.039	-0.027	-0.041	-0.052
17	0.17	-0.091	-0.138	-0.054	-0.042	-0.038	-0.030	-0.085
18	-1.92	-0.239	-0.141	-0.148	-0.161	-0.095	-0.059	-0.001
19	-15.57	-1.324	-0.517	-0.354	-0.476	-0.377	-0.611	-0.315
20	-190.52	-1.036	-0.421	-0.218	-0.166	0.304	0.370	-0.076

Step 8: Modification - Exclude Extreme P/B Values

Median Residual Income by P/B Group and Relative Year:

relative_year	P/B	0	1	2	3	4	5	6
p/b_group								
1	6.27	0.102	0.147	0.070	0.106	0.073	-0.142	-0.150
2	5.13	0.150	0.172	0.148	0.117	0.070	0.022	-0.011
3	4.31	0.113	0.112	0.074	0.086	0.127	-0.019	-0.043
4	3.73	0.095	0.112	0.070	0.053	0.061	-0.015	-0.001
5	3.29	0.106	0.116	0.070	0.099	0.102	-0.012	0.011
6	2.92	0.097	0.109	0.078	0.084	0.100	0.067	0.031
7	2.58	0.075	0.078	0.053	0.053	0.066	0.020	0.009
8	2.33	0.080	0.081	0.066	0.086	0.107	0.055	0.025
9	2.12	0.067	0.071	0.064	0.071	0.061	0.014	0.042
10	1.93	0.064	0.066	0.060	0.061	0.064	0.016	0.053
11	1.77	0.045	0.052	0.041	0.048	0.040	0.016	0.007
12	1.61	0.047	0.048	0.052	0.058	0.074	0.053	0.042
13	1.48	0.029	0.034	0.033	0.033	0.041	0.018	0.016
14	1.35	0.022	0.036	0.042	0.032	0.034	-0.000	0.018
15	1.22	0.019	0.005	0.009	0.012	0.019	-0.012	0.008
16	1.10	-0.007	0.002	0.004	-0.007	-0.003	-0.034	-0.024
17	0.98	-0.025	-0.015	-0.003	0.001	0.008	-0.010	-0.011
18	0.85	-0.038	-0.033	-0.023	-0.021	-0.017	-0.044	-0.016
19	0.68	-0.056	-0.050	-0.044	-0.045	-0.030	-0.035	-0.069
20	0.36	-0.107	-0.146	-0.059	-0.050	-0.053	-0.047	-0.085

4. Conclusion

4.1 Summary of Findings

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- Replicated an empirical table from Penman (2013), showcasing similar trends.
- The project structure demonstrated the effectiveness of an open science and collaborative workflow.
- This repository can be cloned or forked for further projects on residual income analysis.

4.2 Key Insights

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- From analysis of residual incomes and Price-to-Book (P/B) ratios of U.S. public firms:
  - High P/B groups initially exhibit higher residual earnings, which decline over time.
  - Low P/B groups consistently show negative residual earnings.
- Residual income analysis by P/B ratios offers valuable insights that can promote better investment and corporate strategy decisions.

References

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