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Methods in empirical asset pricing: calendar-time portfolios

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Agenda

1. Introduction
2. Implementation of calendar-time portfolios
3. Summary

Introduction (1)

Calendar-time portfolios: main idea

- Method to implement investment strategies.
- At end of formation period:
  - Assign stocks to portfolios based on a stock characteristic.
  - Buy stocks in the long portfolio.
  - Short stocks in the short portfolio.

  → self-financing investment strategy.
- Keep positions during holding period.
- At end of holding period:
  - Sell stocks in the long portfolio.
  - Buy back shares of the short portfolio.

  → Return difference of the long and short portfolio is the profit.

Introduction (2)

Calendar-time portfolios: main idea – continued

- At each point in time, the process of portfolio assignment, initiating positions, holding positions, and closing positions is repeated.
  → calendar-time approach.
- Strategy is implementable if
  - portfolio assignment based on time t information.
  - holding period start after time t.
- Example:
  - Sort stocks at the end of month t based on their return from month t-12 to t-1.
  - Hold the long (winner stocks) and short (loser stocks) portfolio in month t+1.

  → strategy implementable in real time.

Introduction (3)

Calendar-time vs. event-time analysis

- Calendar-time: procedure performed at each point in calendar time.
  - E.g., Jan 2000, Feb 2000, …, Dec 2000, Jan 2001, …, Dec 2023.
  - Time periods are weighted equally.
  - Average strategy return $= \frac{1}{T} \cdot \sum_{t=first\ YYYYMM}^{last\ YYYYMM} return_t$
  - At each point in time, you invest same amount of money.
- Event-time: time is defined relative to the event analyzed.
  - E.g., one month before M&A announcement, month of M&A announcement, five months after M&A announcement.
  - Events are weighted equally.
  - Average strategy return $= \frac{1}{N} \cdot \sum_{i=first\ event}^{last\ event} return_i$
  - At each event, you invest same amount of money.

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Implementation of calendar-time portfolios (1)

Investment strategy setup

- Define the strategy's portfolio formation frequency.
  - In empirical asset pricing research often monthly.
  - More frequent formation → more trading → more transaction costs.
- Select characteristic/trading signal:
  - Point in time variables (end of formation period), e.g., most recent market cap.
  - Variables measured over longer periods (during formation period), e.g., past six-month return.
- Select holding period:
  - Often one-month period.
  - Longer periods with potentially overlapping portfolios also possible.
    → for details on overlapping portfolios, see Jegadeesh and Titman (1993).

Implementation of calendar-time portfolios (2)

Portfolio allocation process

- Portfolios are typically formed using percentiles.
  - 5 quintile portfolios: each contains 20% of the available stocks.
  - 10 decile portfolios: each contains 10% of the available stocks.
- At the end of each formation period, determine the relevant percentiles/breakpoints of the characteristic.
- Example: determine the 20%, 40%, 60%, and 80% percentile of firms' market cap to form size-based quintile portfolios.
- Assign stocks based on the break points to the portfolios.

Implementation of calendar-time portfolios (3)

Portfolio allocation process – continued

- Example of stock assignment: quintile portfolios based on market cap at the end of December 2023.
- Figure shows:
  - Break points.
  - 2 exemplary stocks (a small one and a large one) for each size portfolio.

Portfolio	Stocks in the portfolio	
1 (low)	Blue Star Foods Corp $0.002 bn.	Milestone Scientific Inc $0.052 bn.
20th size percentile: $0.053 bn.		
2	Fluent Inc $0.054 bn.	Astria Therapeutics Inc $0.279 bn.
40th size percentile: $0.285 bn.		
3	John Wiley & Sons Inc $0.290 bn.	Guess Inc $1.238 bn.
60th size percentile: $1.245 bn.		
4	Veritex Holdings Inc $1.264 bn.	Harley Davidson Inc $5.131 bn.
80th size percentile: $5.318 bn.		
5 (high)	Macy's Inc $5.514 bn.	Apple Inc $2994.371 bn.

Source: own computations based on monthly CRSP file.

Implementation of calendar-time portfolios (4)

Holding period portfolio return

- Compute the portfolios' returns during the holding period.
- For each calendar month and each portfolio, compute the average holding period return across all stocks in the portfolio.

2000/02		2000/03		...	2023/12	
Stocks in quintile 1	Stock return	Stocks in quintile 1	Stock return	...	Stocks in quintile 1	Stock return
A Inc	0.03	A Inc	-0.13	...	D Inc	0.03
B Inc	-0.09	C Inc	0.02	...	I Inc	0.07
E Inc	0.05	F Inc	-0.15	...	T Inc	-0.12
...	...	...	...	...	...	...
X Inc	0.17	Z Inc	0.04	...	Y Inc	-0.02
	↓		↓			↓
Average	0.04		-0.055			-0.01

Repeat procedure for quintiles 2 to 5.

Implementation of calendar-time portfolios (5)

Value-weighted vs. equally weighted portfolios

- Equally weighted portfolios:
  - Compute the simple average of the returns of all stocks in the portfolio.
  - Gives the same weight to each stock, i.e., 1/N investment strategy.
  - Requires frequent trading to rebalance portfolios.
- Value-weighted portfolios:
  - Weight stocks' returns by the market capitalization from the beginning of the formation period.
  - Gives larger firms more weight.
  - Easier to implement in the real-world.
  - Market indexes are usually value weighted.

Implementation of calendar-time portfolios (6)

Value-weighted portfolios - Example

- Compute value-weighted portfolio return of this three-stock portfolio.

Stock	MCap end of month t	Return month t+1	MCap end of month t+1
A Inc.	100	0.20	120
B Inc.	50	0.10	55
C Inc.	10	0.00	10

- Correct approach using market cap from the beginning of holding period:

$$r_{value-weighted} = \frac{100 \cdot 0.2 + 50 \cdot 0.1 + 10 \cdot 0.0}{100 + 50 + 10} = 0.1563 = 15.63\%$$

- Incorrect approach using market cap from the end of the holding period:

$$r_{value-weighted} = \frac{120 \cdot 0.2 + 55 \cdot 0.1 + 10 \cdot 0.0}{120 + 55 + 10} = 0.1595 = 15.95\%$$

Implementation of calendar-time portfolios (7)

Computing average (risk-adjusted) returns

- After calculating the monthly portfolio returns, you have time-series data.
- Next, compute time-series average of portfolio returns.

Portfolio	2000/02	2000/03	...	2023/11	2023/12
1	0.04	-0.055	...	0.045	-0.01
2	0.03	0.02	...	-0.04	0.02
...	...	...	...	...	...
5	0.01	0.02	...	0.04	-0.01

Average
0.0050
0.0075
...
0.0150

High-minus-low return	
Average	0.01
t-statistic	*2.47*

- Then, test whether high-minus-low return is significantly different from zero.
- To obtain risk-adjusted returns, regress the portfolio (excess) returns on market excess returns (and further risk factors).

$$r_{portfolio,t} - r_{f,t} = \alpha + \beta \cdot \left(r_{market,t} - r_{f,t}\right) + \varepsilon_t$$

α is the risk-adjusted return.

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Conclusion

Calendar-time portfolios

- Standard method in empirical asset pricing.
- Formation period: assign stocks to portfolios.
- Holding period: buy (sell) stocks in the long (short) portfolio.
- Procedure performed at each point in time.
- Compute portfolio return by taking two averages:
  1. For each portfolio and point in time: cross-sectional average across all stocks in the portfolio.
  2. For each portfolio: take the time-series average of the portfolio returns (i.e., of the cross-sectional averages).
- Portfolio returns can be risk-adjusted in a time-series regression using your preferred asset pricing model.

References

- Jegadeesh, N., & Titman, S. (1993). Returns to buying winners and selling losers: Implications for stock market efficiency. The Journal of Finance, 48(1), 65-91.

Thank you very much for watching!

Questions and feedback are very welcome!

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