TESTING ASSET PRICING THEORY ON 600 YEARS OF STOCK RETURNS

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Motivation

- Present-value formula is one major insight from financial economics
- Simply stated: the price of a risky asset should equal the expected future cash flows discounted at the required rate of return
- However testing this formula requires a good understanding of the statistical process underlying cash flows
- Difficult to study:
  - with short time-series (think about disaster risk à la Rietz-Barro)
  - with technological change that affects uncertainty in growth rates and risk (think about technological revolutions à la Pastor-Veronesi)
The present research

What we do:

- Study the most ancient stockholding corporation: **The Bazacle Mills of Toulouse from 1372 to 1946**
- Document its emergence, structure, and operations
- Collect and study stock prices and dividends over seven centuries

Contribution: Almost complete price and dividend data from 1532 onward

- Very long time series
- Stable corporate governance (up to 1815)
- Stable technology (up to 1888)
- Several important disasters present in the data
Why it is interesting (to us ;-)

- Document the longest-lived corporation
- Study what governance structure enables a corporation to last for centuries?
- Test the present value relation
- Measure what stocks return over centuries
- Determine whether stocks protect against inflation over very long time periods?
Partial literature review

- Long-term financial series: Golez-Koudijs, LeBris-Hautcoeur, Dimson-Marsh-Staunton, Goetzmann-Jorion, Goetzmann-Li-Rouwenhorst, Goetzmann-Renneboog-Spaenjers
- History of capitalism and corporate governance: Gelderblom-deJong-Jonker, Malmendier
- Present-value tests: Chen, vanBinsbergen-Koijen, Chen-Da-Priestley
- Empirical asset pricing: Parker-Julliard, Rietz, Barro, Bansal-Yaron, Gosh-Julliard
Sicard (1954, 2015) is up for sale
Preview of the results

Bazacle company’s stock price and present value of subsequent realized dividends using 5% discount rate - Kilograms of silver - Figure in spirit of Shiller (1981)
Agenda

1. The “Honor del Bazacle”
2. Data
3. Present-value relationship
4. Econometric methodology
5. Empirical results
The “Honor del Bazacle”
The Bazacle Mills, in Toulouse (map from Melchior Tavernier, 1631)
The “Honor del Bazacle”
The Bazacle Mills of Toulouse (Collignon map, 1642)
The “Honor del Bazacle”
The Bazacle Mills of Toulouse (Collignon map, 1642)
The “Honor del Bazacle”

Important dates

- 1071: Archive (St. Raimon hospital) mentions Bazacle Mills
- 1177: First dam, first disputes
- 1248: 12 shore mills at the Bazacle
- 1372: Merge into one company
- 1531: New corporate statutes
- 1888: Turned into hydro-electricity
- 1910: Listed on the Paris Bourse
- 1946: Nationalized in EDF (listed in 2005)
- 2015: Bazacle plant still produces electricity
The “Honor del Bazacle”
The Bazacle Mills, in Toulouse
The “Honor del Bazacle”

Corporate form

A shareholding company

- Owners (*pariers*) are not millers and own shares (*uchaux*)
- Shares are transferable without the consent of other shareholders
- Shareholders have limited liability
- 1/16 of the grain is retained and paid directly (*partisons*) to shareholders in proportion to the number of shares held
- If a shareholder cannot or does not want to contribute to mills’ expenses, his or her shares are sold via forced auctions
The “Honor del Bazacle”
Corporate governance

Corporate statutes of 1531

- A yearly general assembly (Cosselh general dels senhors paries am gran deliberacio)
  - votes on a financial contribution to Mills’ expenses (talha)
  - approves board of directors (regents) composition: 8 shareholders in charge for one year

- Board chooses:
  - 2 accounts’ auditors among shareholders
  - a contêrôlle (chief executive)
  - a treasurer
  - a syndic for legal affairs
  - 6 new members at the end of the year (staggered board)
Data

Stock prices

- Before 1450, data from notaries (P. Wolff via G. Sicard)
- After 1530, data from registers of partisons or registers of pariers:
  - Each page corresponds to a shareholder and transactions are recorded in the margins (similar to real estate registers)
- Transactions are also mentioned during the 15th century but prices are recorded only from 1530 onwards
- Late 19th century onward, regional or national press
Data

Example: A register of pariers from 1530
The parier is Jean de Bernuy (one share was bought from king Francis I)
Data

Stock prices

- Pariers could trade portions of a share and we corrected for this
- Uchaux existed up to 1888

<table>
<thead>
<tr>
<th>Year</th>
<th>1372</th>
<th>1374</th>
<th>1384</th>
<th>1535</th>
<th>1714</th>
<th>1804</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uchaux</td>
<td>80</td>
<td>88</td>
<td>96</td>
<td>100</td>
<td>128</td>
<td>136</td>
</tr>
</tbody>
</table>

- In 1889, each uchau is divided into 4 shares
- In 1910, merger with Société Toulousaine d’Electricité to create the Société Toulousaine du Bazacle
  - Each shareholder from the Bazacle receives 70 francs per share and 6 shares of the new company
- In 1929, stock spilt: 2.5 for 1
Data

Stock prices in Livres/Assignats/Francs:
Inflation and disasters (in 1595: -90%, in 1639: -69 %, 1709: -92 %, 1815: -70 %)
Data

Stock prices converted from Livres/Assignats/Francs into kilograms of silver

Disasters (in 1595: -90%, in 1639: -69 %, 1709: -92 %, 1815: -70 %)
The partisons, paid in wheat at several times during the year, were collected from the registers of partisons (about 4,000 partisons).

Financial contributions to the Mills’ annual expenses, talha, come from three sources:

- Sometimes mentioned in partisons registers
- General assembly registers
- Accounting registers (it is the first receipt for the honor)

Net Dividend = Partison – Talha

Beginning in the 18th century, there is no more talha (some partisons are sold for the benefit of the Mills)

Standard dividend after 1843
Data

Examples of dividends sources:
General assembly register from 1522 and accounting document from 1469
Data
Net Dividends in kilos of silver
Data

Prices and Net Dividends in kilos of silver
Data

Descriptive statistics

<table>
<thead>
<tr>
<th>Data in Silver</th>
<th>Dividend Yield</th>
<th>Capital Gain</th>
<th>Price Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>St. Dev.</td>
<td>Mean</td>
</tr>
<tr>
<td>1372-1946</td>
<td>5.16%</td>
<td>7.55%</td>
<td>15.48%</td>
</tr>
<tr>
<td></td>
<td>327</td>
<td>(0.00)</td>
<td>295</td>
</tr>
<tr>
<td>1372-1531</td>
<td>4.94%</td>
<td>6.11%</td>
<td>-2.70%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>(0.16)</td>
<td>11</td>
</tr>
<tr>
<td>1532-1888</td>
<td>5.14%</td>
<td>8.16%</td>
<td>18.44%</td>
</tr>
<tr>
<td></td>
<td>270</td>
<td>(0.00)</td>
<td>232</td>
</tr>
<tr>
<td>1889-1946</td>
<td>5.29%</td>
<td>3.34%</td>
<td>6.13%</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>(0.00)</td>
<td>52</td>
</tr>
</tbody>
</table>
Present-value relationship

Present-value formula

\[ P_t = \mathbb{E}_t [M_{t+1} (D_{t+1} + P_{t+1})] \]

- \( M_{t+1} \) is the stochastic discount factor at date \( t + 1 \)
- \( D_{t+1} \) is the dividend distributed at date \( t + 1 \)
- \( P_{t+1} \) is the post-dividend price at date \( t + 1 \)
- This equation derives from an investor’s first order condition when maximizing expected utility from consumption (see e.g. Cochrane, 2005)
Present-value relationship

Derivation of the pricing formula

- Dividends follow an ARMA(1,1) process:

\[ D_{t+1} = \alpha + \beta D_t + \gamma \varepsilon^D_t + \varepsilon^D_{t+1} \]

- Stochastic discount factor is time varying:

\[ M_{t+1} = \frac{1}{1+r} \left( 1 + \varepsilon^M_{t+1} \right) \]

- The risk correction \( \pi_t = -\text{Cov}_t(\varepsilon^M_{t+1}, \varepsilon^D_{t+1}) \) is auto-regressive:

\[ \hat{\pi}_t = \pi_t - \mathbb{E}(\pi_t) = \delta \hat{\pi}_{t-1} + \varepsilon^\pi_t \]

Pricing formula

\[ P_t = \frac{1+r}{1+r-\beta} \frac{\alpha}{r} - \frac{1+r+\gamma}{1+r-\beta} \frac{\mathbb{E}(\pi_t)}{r} + \frac{\beta}{1+r-\beta} D_t + \frac{\gamma}{1+r-\beta} \varepsilon^D_t - \frac{1+r+\gamma}{(1+r-\beta)(1+r-\delta)} \hat{\pi}_t \]
Empirical results
Estimating and testing the model

We estimate the dividend and pricing equations via MLE:

**GLS on dividends:**  
\[ D_{t+1} = 181 + 0.80D_t - 0.35\varepsilon_t^D + \varepsilon_{t+1}^D \]

**GLS on stock prices:**  
\[ P_t = 14,682 + 3.9D_t - 1.84\varepsilon_t^D - 0.81\hat{\pi}_t \]

We test and cannot reject two theoretical predictions using the Delta method:

**Price reactions to dividends and dividend shocks:**  
\[ \frac{\beta}{b} - \frac{\gamma}{c} = 0 \]

**Expected dividends:**  
\[ \frac{\alpha}{1-\beta} - \frac{\mathbb{E}[P_t] - a}{b} = 0 \]
Term-structure of the risk premium

Our model implies a decreasing term-structure for the risk premium

- We estimate an average risk premium at around 10%
- Normal given the high volatility of consumption and the high correlation of returns with consumption
- The one-year risk premium is estimated around 15%
- The 50-year risk premium is close to zero
Graph of the risk premium over different horizons

Figure 8: Term structure of the risk premium.

This Figure shows the term structure of the risk premium for the parameters estimated over the full 1441-1946 period.
Study Bazacle Company of Toulouse, founded in 1372 and still alive
- Rotating staggered board with flexible governance
- Present-value formula cannot be rejected
- Risk premium is much lower for long than short horizons
- The shares of the Bazacle company have been an excellent hedge against inflation