The Mystery of the “Greenback Era”
Interest Rates: What Does the New York Money Market Have to Tell?

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Puzzle: Price Level Data

Period of high inflation
Puzzle: Interest Rate Data

Period of high inflation
Puzzle: Outline

- 1862–1865, inflation: 18–19 %, nominal int. rate: 6 %
- 1866–1873, deflation: 4 %, nominal int. rate: 7.5–8%

  Pattern of the nominal rates is very surprising

- 1860–1865: heavy borrowing, fed. debt ↑ 34 times
- Massive short-term borrowing was frequent

  Paradox of stable rates in 1862–1865

Puzzle noticed by: Mitchell (1903)
Focus and Disambiguation

- I consider assets:
  - with maturity of 3 months
  - that provide “fixed” income, but are not risk-free
  - with nominal payoffs

- I do not consider:
  - equity market
  - long-term rates/yields (government bonds, railroad bonds)
  - gold yields
Plan of Talk

- Historical background
- Previous explanations of the puzzle
- Why arbitrage?
- Data
- Methodology
- Results
History: Brief Overview I

- December 1861: panic in NY, great suspension
- Fall 1862: Treasury in trouble, large short-term borrowing
- February 1863: National Banking Act
- 1864:
  - Spring: bond-trade ceases
  - Spring/summer: gold market crisis
  - June/July: Treasury on verge of default
  - Summer/fall: massive short-term borrowing
History: Brief Overview II

- 1869: “gold corner” and money market problems

- National banking and money market “agricultural cycle”:
  - concentration of reserves in NYC
  - railroad stock speculation and bank liquidity problems
  - crises of fall 1872 and spring 1873
  - financial disaster of September 1873
Previous Explanations

- Mitchell (1903):
  - price rise was unexpected
  - weak bargaining power of money-lenders
  - demand effect: cash business more important than credit

- Friedman and Schwartz (1963):
  supply effect: inflow of loanable funds from abroad

- Others: Roll (1972), Calomiris (1988):
  expectations played an important role
Unexploited Arbitrage: Is It Possible?

- An arbitrage opportunity is an investment strategy that:
  - has zero cost
  - will never result in a loss
  - has strictly positive expected benefit

- Market inefficiency?
  Clark (1984) finds persistent violations of gold points in late 19th century. He claims that the financial system was inefficient.

- “Patriotic” trading?
Data and Notation

- Source of data: NBER, borrowed from Macaulay (1938)
- Call loans: \( i_{t,t'}^{1} \) (net rate)
  - required collateral, callable by lender
  - made to brokers to finance speculative operations
- Commercial paper: \( i_{t,t'}^{2} \) (net rate)
  - no collateral, 90 day maturity
  - made to merchants and manufacturers
- Bankable paper: \( i_{t,t'}^{3} \) (net rate), Martin (1898)
- Gold price: \( g_t \)
- Railroad stock index: \( S_t \)
- Banker’s bill index (London): \( i_{t,t'}^{£} \) (net rate, 3-months)
Methodology: Martingale Measure and SDF

- Insatiable investor:
  - prefers more wealth to less
  - may be risk-loving, risk-averse, or risk-neutral (no restriction)

- 1st fundamental theorem: example

There exists positive SDF \((M_{t,t'})\) that prices all assets:

\[
E_0 [M_{t,t'} \cdot x_{t,t'}] = 1, \text{ for every } t
\]

- Notation: 
  \[
x_{t,t'} = \left(1 + i_{t,t'}^1, 1 + i_{t,t'}^2, 1 + i_{t,t'}^3, \frac{g_{t'}}{g_t} (1 + i_{t,t'}^F) \right)'
  \]
Methodology: Hansen–Jagannathan SDF

- SDF as an affine function of shocks:

\[ M_{t,t'} = E_0 M_{t,t'} + (x_{t,t'} - E_0 x_{t,t'})' b \]

- Representation:

\[
M_{t,t'} = E_0 M_{t,t'} + [1 - E_0 x_{t,t'} E_0 M_{t,t'}]^{-1} (x_{t,t'} - E_0 x_{t,t'})
\]

\[ \Sigma \] is covariance matrix of gross returns

\[ E_0 M_{t,t'} \] is the inverse of gross risk-free return (if traded)
Methodology: Test and Estimation

- In theory: \[ E_0 \left[ M_{t,t'} \frac{S_{t'}}{S_t} - 1 \right] = 0 \]

  Check if \[ \frac{1}{T} \sum_t \left[ \hat{M}_{t,t'} \frac{S_{t'}}{S_t} - 1 \right] \] is statistically zero

- Estimate: \[ \sum \] and \[ E_0 x_{t,t'} \]
  - Method 1: full sample
  - Method 2: all data up to period \( t \)

- \( E_0 M_{t,t'} \) cannot be estimated, but can be bounded:
  Try a range for the risk-free rate: 3–6 percent
# Results: Months of Violations

<table>
<thead>
<tr>
<th>Method 1: full sample</th>
<th>Method 2: data up to $t$</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>October, 1864</td>
<td>March–May, 1864</td>
<td>Gold market crisis</td>
</tr>
<tr>
<td></td>
<td>October, 1864</td>
<td></td>
</tr>
<tr>
<td>October, 1869</td>
<td>October, 1869</td>
<td>Gold “corner”</td>
</tr>
<tr>
<td>October, 1872</td>
<td>October, 1872</td>
<td>Financial market crisis</td>
</tr>
<tr>
<td>November, 1872</td>
<td>November, 1872</td>
<td></td>
</tr>
<tr>
<td>October, 1873</td>
<td>October, 1873</td>
<td>Financial market crash</td>
</tr>
<tr>
<td>November, 1873</td>
<td>November, 1873</td>
<td></td>
</tr>
</tbody>
</table>
Results: Pricing Hypothesis

- Is railroad stock price index adequately priced?
- Null: $E_0 \left[ \frac{M_{t,t'} S_{t'}}{S_t} - 1 \right] = 0$
- Test statistic: asy. normal; s.e.: Newey–West (2 lags)

<table>
<thead>
<tr>
<th>Method</th>
<th>Net $r^f$, percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Method 1</td>
<td>-0.046</td>
</tr>
<tr>
<td>Sign. level</td>
<td>0.96</td>
</tr>
<tr>
<td>Method 2</td>
<td>-0.960</td>
</tr>
<tr>
<td>Sign. level</td>
<td>0.34</td>
</tr>
</tbody>
</table>
Conclusion

- Pattern of interest rates is puzzling

- Literature: expectations or capital inflow played a role

- This paper finds: arbitrage occurred unsystematically

- Investor expectations should be the focus of future research
Questions?
Methodology: SDF Example

- 1st Fundamental Theorem:
  
  suppose $g_t > 0$

  a financial market admits no arbitrage if and only if there exists
  an equivalent martingale probability measure, under which:
  all discounted price processes are **martingales**

- For call loans:
  
  $\frac{1}{g_t} = \tilde{E}_t \left[ \frac{1 + i_{t,t'}}{g_{t'}} \right]$ 

- Radon–Nikodym:
  
  $\tilde{E}_t \left[ \frac{1 + i_{t,t'}}{g_{t'}} \right] = E_t \left[ \zeta_{t'} \frac{1 + i_{t,t'}}{g_{t'}} \right]$

- SDF prices assets:
  
  $1 = E_t \left[ \frac{g_t \tilde{\zeta}_{t'}}{g_{t'}} (1 + i_{t,t'}) \right] \equiv E_t \left[ M_{t,t'} (1 + i_{t,t'}) \right]$
Extras: Gold Premium

![Graph showing the price of Gold Premium over time.](image-url)
Extras: Monthly Inflation and Interest
## Extras: More on Interest Rates: Means

<table>
<thead>
<tr>
<th>Asset</th>
<th>1861–1866</th>
<th>1867–1873*</th>
<th>1874–1878</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call loans</td>
<td>5.86</td>
<td>7.65</td>
<td>3.60</td>
</tr>
<tr>
<td>Comm. paper</td>
<td>6.53</td>
<td>8.13</td>
<td>5.31</td>
</tr>
<tr>
<td>Boston paper</td>
<td>6.03</td>
<td>7.05</td>
<td>4.84</td>
</tr>
</tbody>
</table>

**Notes:** Means of quotations in a given period.

*September, 1873 is excluded.
# Extras: Summary Statistics

## Table 1: Data Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Warren–Pearson Index</th>
<th>Greenbacks per Gold $100</th>
<th>Call Loan Rate</th>
<th>Comm. Paper Rate</th>
<th>Boston Paper Rate</th>
<th>London Bills Rate</th>
<th>Stock Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>126.77</td>
<td>127.47</td>
<td>6.15</td>
<td>6.85</td>
<td>6.43</td>
<td>3.62</td>
<td>30.82</td>
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<tr>
<td>st. dev.</td>
<td>32.04</td>
<td>27.42</td>
<td>4.63</td>
<td>2.31</td>
<td>2.57</td>
<td>1.84</td>
<td>9.39</td>
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<tr>
<td>max</td>
<td>225.00</td>
<td>280.50</td>
<td>61.23</td>
<td>24.00</td>
<td>30.00</td>
<td>9.75</td>
<td>45.20</td>
</tr>
<tr>
<td>min</td>
<td>83.00</td>
<td>100.00</td>
<td>1.70</td>
<td>3.60</td>
<td>3.00</td>
<td>0.91</td>
<td>12.83</td>
</tr>
<tr>
<td>median</td>
<td>124.00</td>
<td>115.44</td>
<td>5.50</td>
<td>6.49</td>
<td>6.00</td>
<td>3.10</td>
<td>32.68</td>
</tr>
</tbody>
</table>