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

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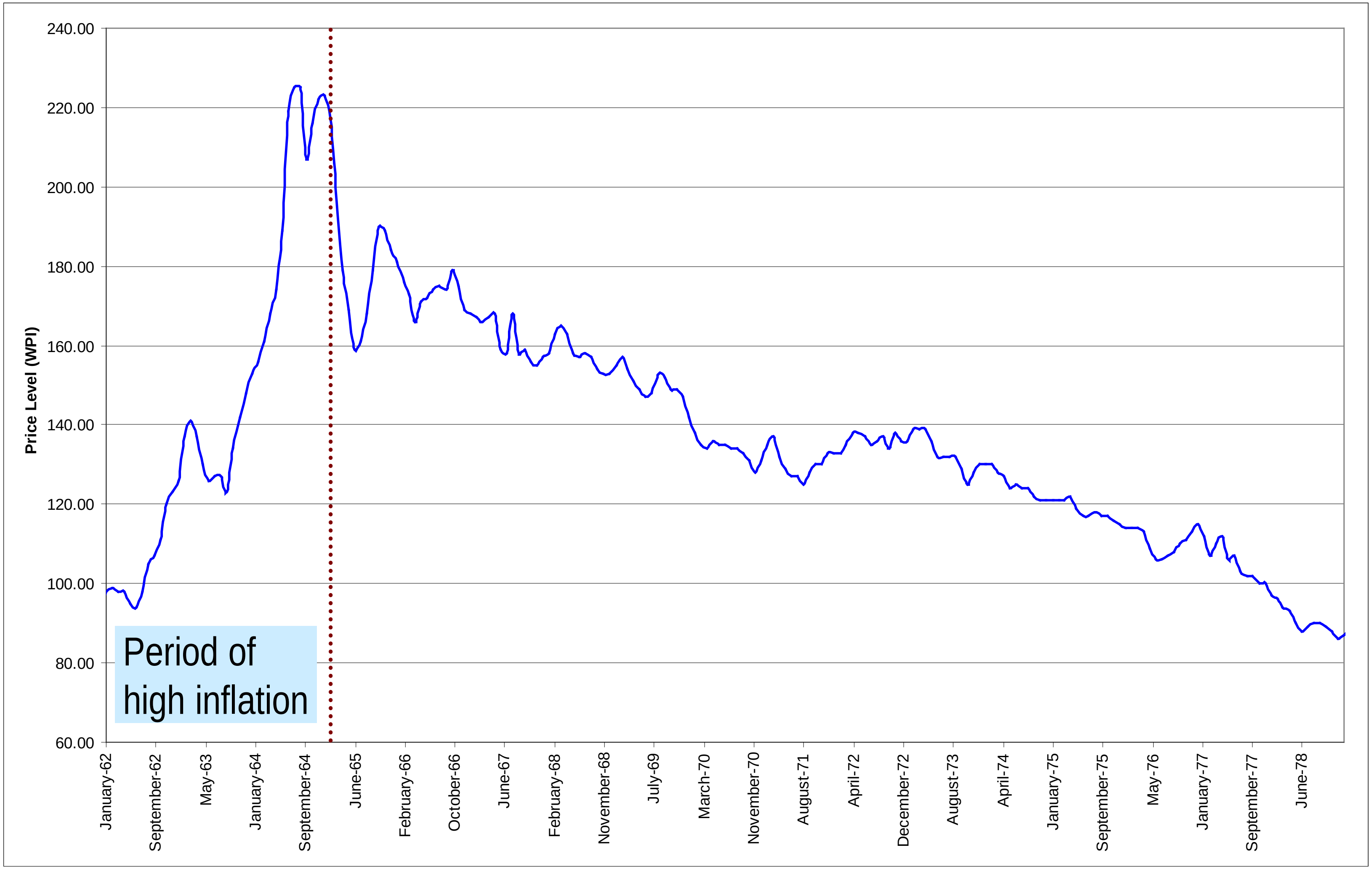
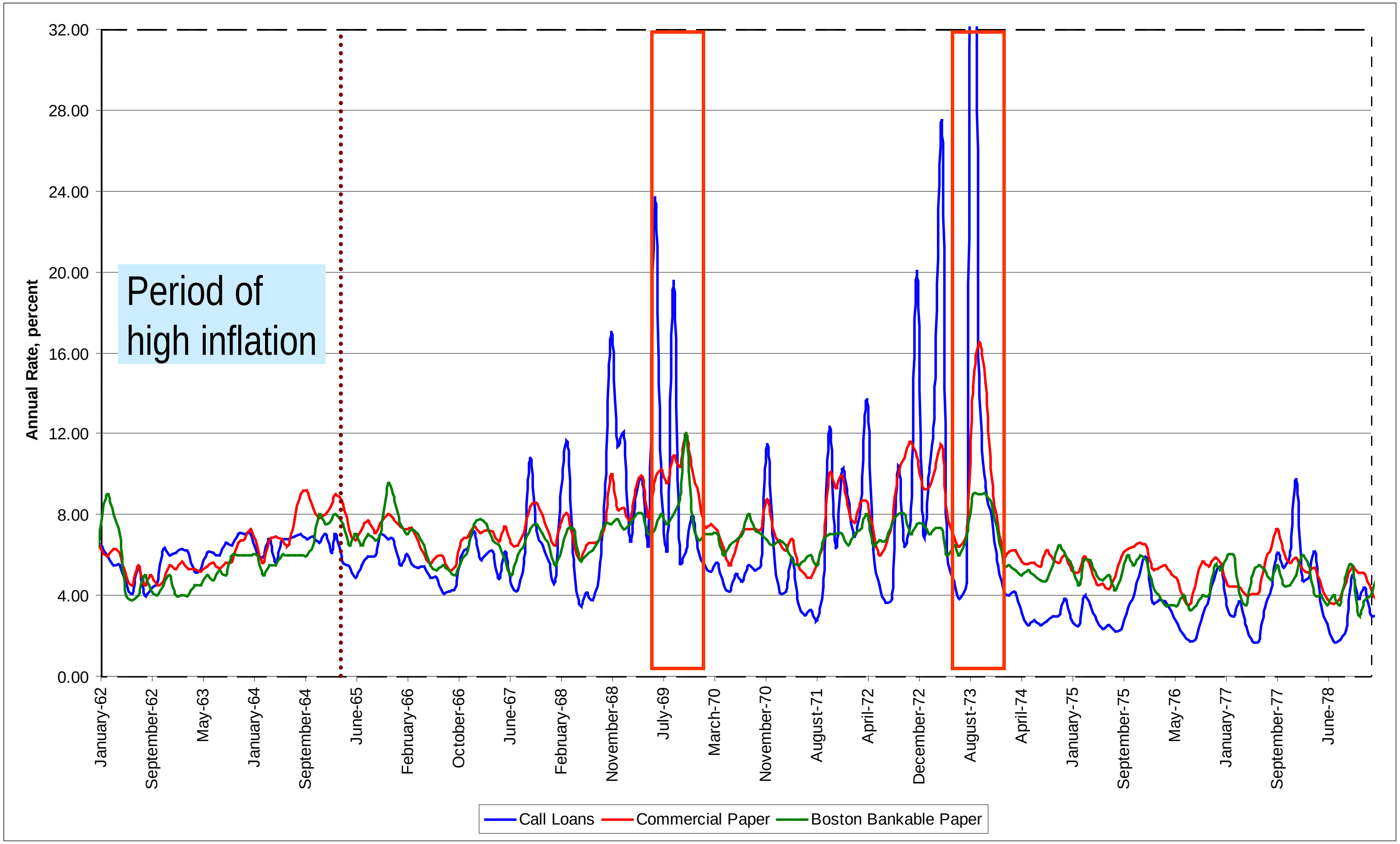
Puzzle: Price Level Data



Puzzle: Interest Rate Data



Puzzle: Outline

- 1862–1865, inflation: 18–19 %, *nominal* int. rate: 6 %
- 1866–1873, *de*flation: 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.

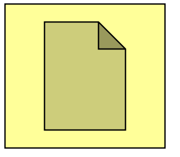
- “Patriotic” trading?

Data and Notation

- Source of data: NBER, borrowed from Macaulay (1938)
- Call loans: $i^1_{t,t'}$ (net rate)
  - required collateral, callable by lender
  - made to brokers to finance speculative operations
- Commercial paper: $i^2_{t,t'}$ (net rate)
  - no collateral, 90 day maturity
  - made to merchants and manufacturers
- Bankable paper: $i^3_{t,t'}$ (net rate), Martin (1898)
- Gold price: g_t
- Railroad stock index: S_t
- Banker's bill index (London): $i^{\pounds}_{t,t'}$ (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 ($\mathcal{M}_{t,t'}$) that prices all assets:

$$E_0\left[\mathcal{M}_{t,t'} \cdot \mathbf{x}_{t,t'}\right] = \mathbf{1}, \text{ for every } t$$

- Notation: $\mathbf{x}_{t,t'} = \left(1 + i^1_{t,t'}, 1 + i^2_{t,t'}, 1 + i^3_{t,t'}, \frac{g_{t'}}{g_t}\left(1 + i^{£}_{t,t'}\right)\right)'$

Methodology: Hansen–Jagannathan SDF

- SDF as an affine function of shocks:

$$\mathcal{M}_{t,t'} = E_0\mathcal{M}_{t,t'} + \left(\mathbf{x}_{t,t'} - E_0\mathbf{x}_{t,t'}\right)'\mathbf{b}$$

- Representation:

$$\mathcal{M}_{t,t'} = E_0\mathcal{M}_{t,t'} + \left[\mathbf{1} - E_0\mathbf{x}_{t,t'}E_0\mathcal{M}_{t,t'}\right]'\mathbf{\Sigma}^{-1}\left(\mathbf{x}_{t,t'} - E_0\mathbf{x}_{t,t'}\right)$$

$\mathbf{\Sigma}$ is covariance matrix of gross returns

$E_0\mathcal{M}_{t,t'}$ is the inverse of gross risk-free return (if traded)

Methodology: Test and Estimation

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

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

- Estimate: $\boldsymbol{\Sigma}$ and $E_0\mathbf{x}_{t,t'}$
  - Method 1: full sample
  - Method 2: all data up to period *t*

- $E_0\mathcal{M}_{t,t'}$ cannot be estimated, but can be bounded:

  Try a range for the risk-free rate: 3–6 percent

Results: Months of Violations

Method 1: full sample	*Method 2*: data up to *t*	*Comment*
October, 1864	March–May, 1864 October, 1864	Gold market crisis
October, 1869	October, 1869	Gold “corner”
October, 1872 November, 1872	October, 1872 November, 1872	Financial market crisis
October, 1873 November, 1873	October, 1873 November, 1873	Financial market crash

Results: Pricing Hypothesis

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

Method	Net r^f, percent			
	3	4	5	6
Method 1	-0.046	-0.218	-0.534	-1.230
Sign. level	*0.96*	*0.83*	*0.59*	*0.22*
Method 2	-0.960	-0.729	-0.228	0.534
Sign. level	*0.34*	*0.47*	*0.82*	*0.59*

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:

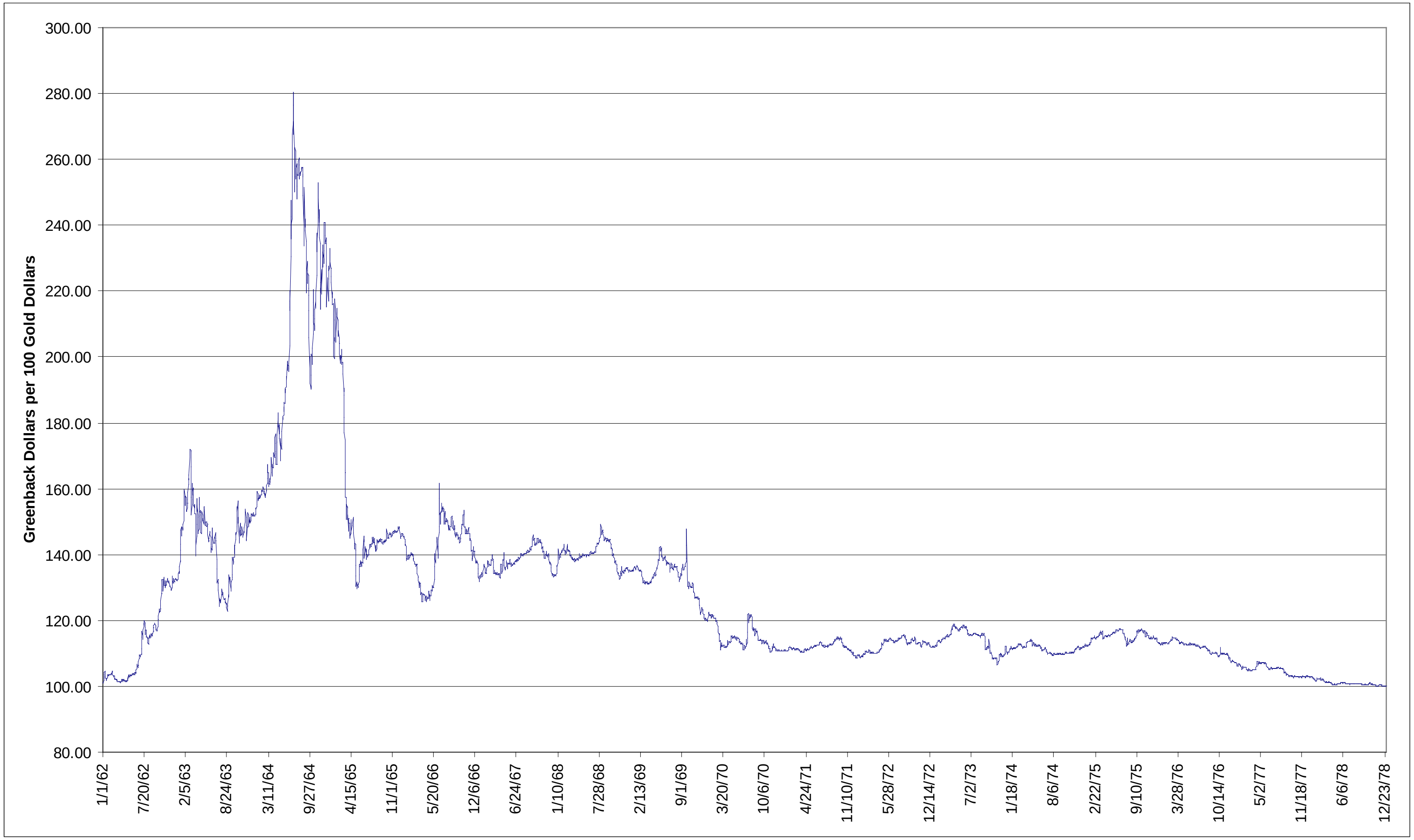
  all discounted price processes are martingales

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

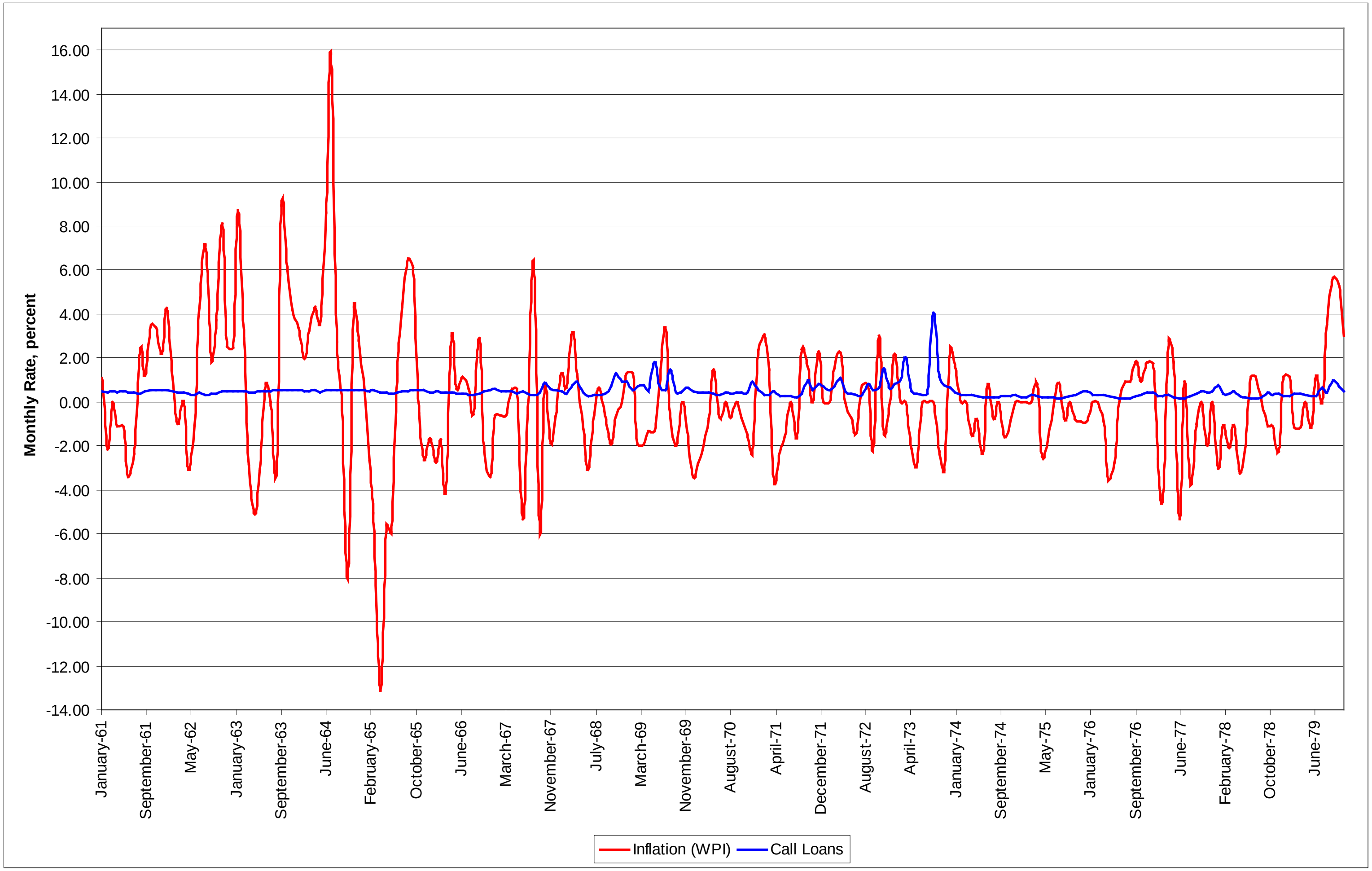
- Radon–Nikodym: $\tilde{E}_t \left[\frac{1 + i^1_{t,t'}}{g_{t'}} \right] = E_t \left[\zeta_{t'} \frac{1 + i^1_{t,t'}}{g_{t'}} \right]$

- SDF prices assets: $1 = E_t \left[\frac{g_t \zeta_{t'}}{g_{t'}} \left(1 + i^1_{t,t'}\right) \right] \equiv E_t \left[\mathcal{M}_{t,t'} \left(1 + i^1_{t,t'}\right) \right]$

Extras: Gold Premium



Extras: Monthly Inflation and Interest



Extras: More on Interest Rates: Means

Asset	1861–1866	1867–1873*	1874–1878
Call loans	5.86	7.65	3.60
Comm. paper	6.53	8.13	5.31
Boston paper	6.03	7.05	4.84

Notes: Means of quotations in a given period.

*September, 1873 is excluded.

Extras: Summary Statistics

Table 1: Data Summary Statistics

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