How the Bank of England Influenced British Interest Rates in the Classical Gold Standard Era (1880s-1914)

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What was Bank's "policy implementation system" : how did its "tools" influence interest rates? (potentially)

Traditional view, still around today (U.S. National Monetary Commission 1914, Dutton 1984, Ugolini 2016)

- market interest rate: accepted bills, about three months' maturity
- Bank of England freely rediscounts bills at "Bank Rate"
- Bank Rate is ceiling for market rate, otherwise "ineffective" (doesn't affect market rate)
- Below ceiling, market bill rate affected by supply of loanable funds to bill market
- Loanable funds supply affected by international investment flows (hence by foreign bill rates)
  & Bank of England actions that divert loanable funds from bill market
  (reverse repos, outright sales, soliciting loans from private lenders)
- Bank of England counterparties for rediscounts: "discount houses" not banks,
  hence no stigma problem

But this view is hard to relate to current models of modern implementation systems

Pre-1914 Bank of England (introduction)

Current models of modern implementation systems (corridor, floor..)

1) Market overnight rate (e.g. fed funds, overnight repo)

i determined by interaction between R^S & R^D

$$R^D(\overset{-}{i},\ \overset{+}{\bar{i}},\ \overset{+}{\underline{i}},\ \overset{+}{Z})$$ from uncertainty about payments timing, shortfall after settlement (Poole 1968)

2) Longer-term rates, including bill rates

determined by expected future overnight rates and term premium

$$i_t^B = \frac{1}{m}[i^e_t + i^e_{t+1} + ...] + x_t \leftarrow \textit{term premium}$$

Term premium x_t perhaps determined by interaction between preferred-habitat investors & risk-averse arbitrageurs (Vayanos & Vila 2009)

I argue modern models apply to pre-1914 Bank of England system

Determination of overnight rate (call money):

$$i = 0.98\ i^{B} - 0.11\ i^{Bank\ Rate} - 1.91\ ln(R^{S}) + 0.83\ ln(Deposits) + ...$$

p-values 0.00 0.35 0.00 0.05

Determination of bill-rate term premium:

$$i^{B}{}_{t} - \frac{1}{3}\left(\tilde{i}_{t} + \tilde{i}_{t+1} + \tilde{i}_{t+2}\right) = 0.35\ i^{Bank\ Rate} + ...$$

p-value 0.00

What I'll do today

1) Overview of London money markets
   - a) Discount houses
   - b) Big London banks
   - c) Bank of England

2) Term premiums
   - a) Current models
   - b) Apply to pre-1914 London
   - c) Hypotheses
   - d) Regression results

3) Overnight rate
   - a) Current models
   - b) Apply to pre-1914 London *mysteries!*
   - c) Hypotheses
   - d) Regression results

1) Overview of London Money Market: Discount houses

Independent dealers in accepted bills

- also hold (but do not deal in) long-term liquid assets (Treasury debt, privately-issued bonds,...)
- most are privately-held firms
- funded by capital & short-term loans

  "Call money" : overnight loans collateralized by bills

- From 1878, can borrow from Bank of England

  Starting 1878, can get "advances" from Bank of England on collateral (bills, securities)
  at Bank Rate or Bank Rate *plus* 1/2% or 1% (changes over time)

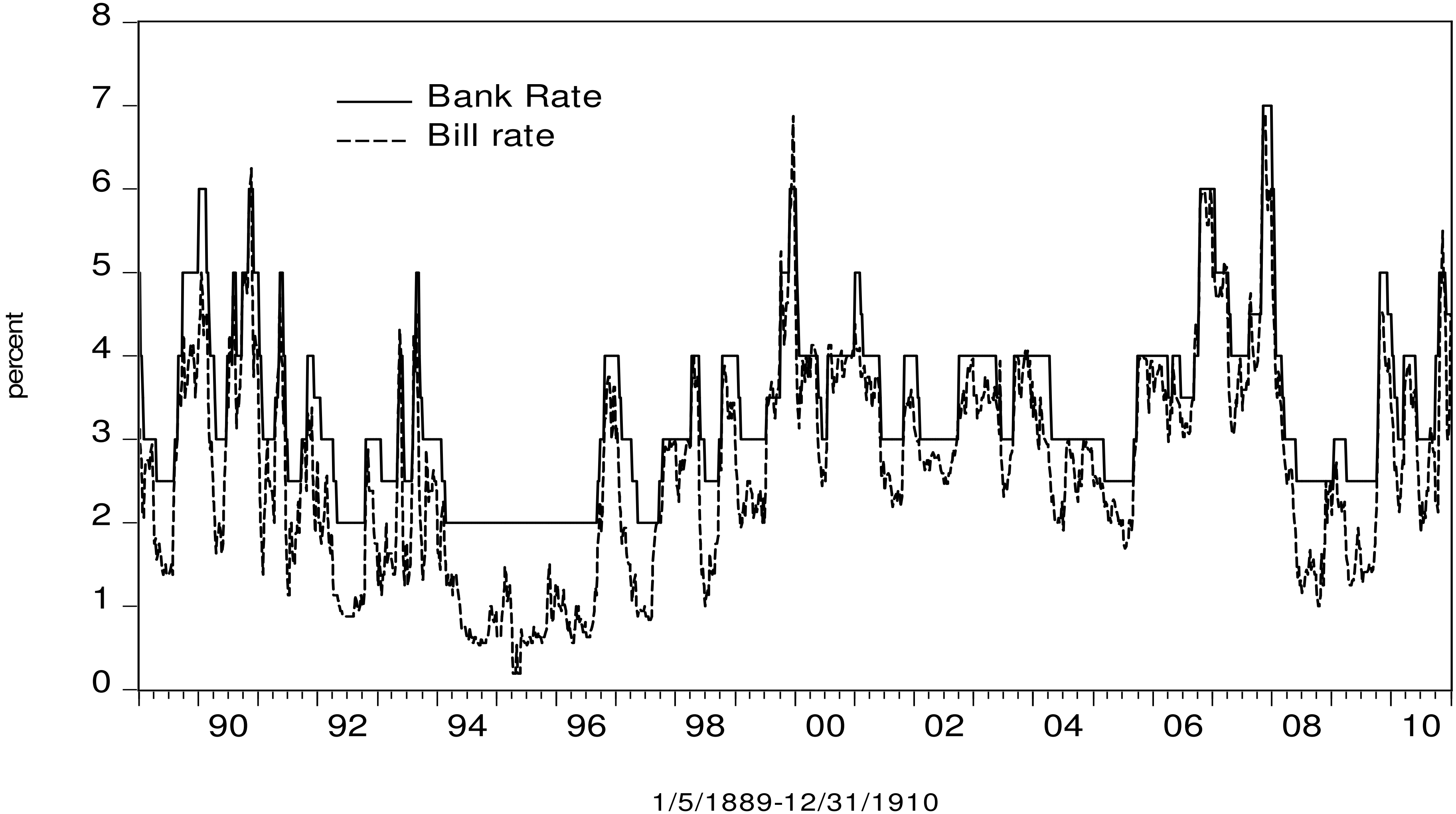
  Starting 1890, can rediscount at Bank of England at Bank Rate,
  Maturity of bills Bank will take changes over time

  Discount houses often take advances rather than rediscount

  No apparent stigma: will rediscount or advance whenever profitable (market rates high)

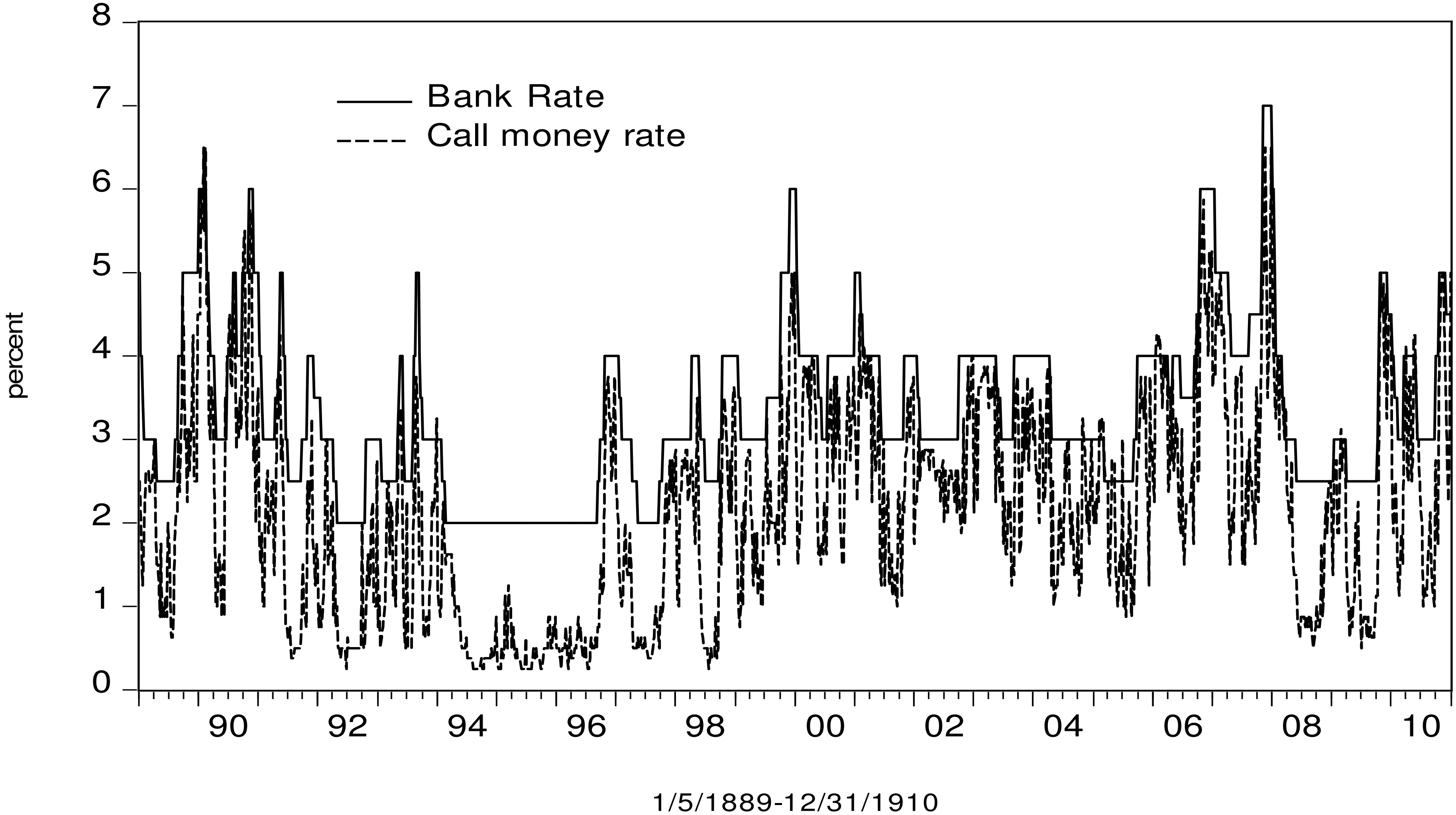
Bank Rate along with other terms of Bank lending to discount houses put a ceiling on market rates, but it's complicated: three-month bill rate sometimes exceeds Bank Rate

Figure 2 Bank Rate and prime three-month bill rate, January 1889-December 1910
Weekly, Fridays



sometimes even call money rate exceeds Bank Rate!

Figure 3 Bank Rate and call money rate, January 1889-December 1910
Weekly, Fridays



Big London banks ("joint-stock banks")

- hold reserve accounts ("bankers' balances") at Bank of England
- Clearing House, pay off net debit or receive credit through reserve accounts
  (other cities' clearing houses work the same way)
- funded by capital & deposits (no managed liabilities)
- cartel sets deposit rates, indexed to Bank Rate
- assets:
  - call money loans to discount houses
  - two-week loans to securities brokers
  - securities
  - illiquid short-term loans to customers
  - bills   but *never* sell bills, always hold to maturity
- don't (openly) borrow from Bank except in crises - stigma!

Bank of England

- takes deposits from banks, governments (British, local, foreign), "private customers"
- goals: maintain gold standard; make profit for shareholders; keep interest rates low & stable

When paying out gold due to balance of payments deficit,

- does not sterilize, allows market rates to rise
- hurries up the process by diverting loanable funds from market (reverse repos etc.)
- raises ceiling on market rates
  does not necessarily mean raise Bank Rate: other lending terms to play with

When gold coming in (balance of payments surplus) tending to lower London rates,

- does *not* sterilize or hurry up the process (does not repo, etc.)
- lowers Bank Rate (to lower London banks' deposit rates, cost of credit to business),
- but does *not* maintain a stable spread between Bank Rate and market rates (Figures 2,3)

2) Term premiums

a) Current models (Vayanos & Vila 2009; Greenwood & Vayanos 2014; Hamilton & Wu 2012)

Assets: overnight loans, liquid bonds

Investors: preferred-habitat investors hold bonds at just one maturity

arbitrageurs borrow overnight, buy or issue bonds at all maturities

to maximize $E_t \Delta W_{j,t+1} - \frac{a_j}{2} Var(\Delta W_{j,t+1})$

Note: this approximates a cost of losing capital

Outcome: term premiums generally increase with

day-to-day variance in value of arbitrageurs' bond portfolio

term premium on specific asset increases with

covariance between value of portfolio & value of that asset (think CAPM)

2) Term premiums

b) Apply to pre-1914 London

Discount houses arbitrage between overnight rate (call money) and bills,

were risk-averse (had to preserve capital)

Banks did not play this role: did not treat bills as liquid assets

Bank Rate and other terms of Bank lending to discount houses limited day-to-day variance

in value of bills to discount houses

Example: advances at rate $i^{BR} + s^{A}$ ←*advances rate spread over Bank Rate*

for term of d_A days

$$v_{kt+1} \approx Ln(FaceValue) - d_A (i^{BR} + s^{A})_{t+1} - E_{t+1}\left[\sum_{\tau=d_A}^{d_k} \left(i + r + r_k\right)_{t+\tau}\right]$$

hence easier terms of Bank lending to discount houses should reduce term premiums on relatively short-term assets held by discount houses

2) Term premiums

c) Hypothesis

Term premiums in bill rates were positively related to observable Bank Rate

(and other, unobservable factors affecting cost of credit from Bank)

How to test this: regress ex post bill term premium on Bank Rate

$$i_t^B = \frac{1}{3}\left(\tilde{i}_t + \tilde{i}_{t+1} + \tilde{i}_{t+2}\right)^e + x_t^B \leftarrow \textit{term premium}$$

$$\frac{1}{3}\left(\tilde{i}_t + \tilde{i}_{t+1} + \tilde{i}_{t+2}\right) = \left(\tilde{i}_t + \tilde{i}_{t+1} + \tilde{i}_{t+2}\right)^e + \epsilon_t^B \leftarrow \textit{error in expectation}$$

Ex post term premium→ $$i^B{}_t - \frac{1}{3}\left(\tilde{i}_t + \tilde{i}_{t+1} + \tilde{i}_{t+2}\right) = x_t - \epsilon_t^B$$

In time-series data, ϵ_t should be uncorrelated with variables known to market participants at time *t*

if expectations rational, no peso problem

2) Term premiums

d) Regressions

Table 1 Bank Rate and Realized Bill-Call Money Spread December 1881-December 1913

Coefficient
[Robust (White) SE]
p-value

Coeff. on	Entire period (1)	(2)	Excluding. crises[1] (3)	(4)	Exc. crises & $(i^{BR}-i^{B})\leq 0.5\%$ (5)	(6)
i^{BR}	0.353	0.323	0.366	0.332	0.281	0.198
	[0.037]	[0.076]	[0.041]	[0.080]	[0.054]	[0.121]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.10*
$\tilde{i}_{t-1}$		0.037		0.042		0.092
		[0.065]		[0.065]		[0.098]
		0.57		*0.51*		*0.35*
N. obs.	385	384	367	366	217	216
R^2	0.30	0.31	0.30	0.31	0.28	0.29

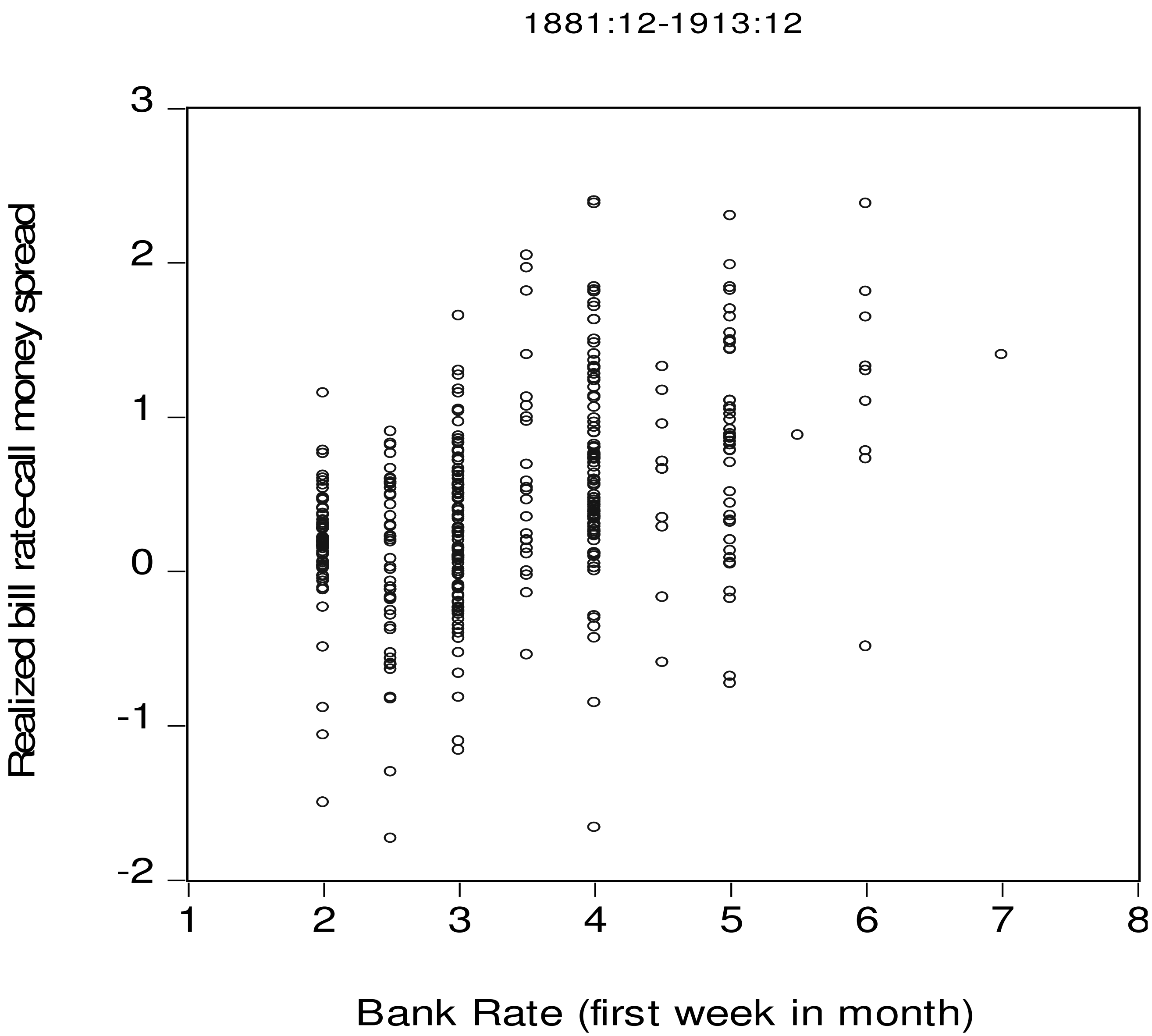
1 Excluding 1890:7-1890:12, 1907:1-1907:12

Also on RHS: quadratic time trend, seasonal dummies

2) Term premiums

d) Regressions

Figure 4 Bank Rate and Realized Bill-Call Money Spread, Monthly



3) Overnight rate

a) Current models (e.g. Whitesell 2006, Ennis & Keister 2008)

i market overnight rate

$\underline{i}$ interest on (excess) reserves

$\overline{i}$ cost to cover shortfall in reserve account (e.g. primary credit rate)

Balance that will be left in a bank's reserve account after final clearing $R^D + \delta$ ←*random variable*

Maybe a reserve requirement with multi-day maintenance period

Outcome

- *early in a maintenance period,* reserve demand depends on $(i_t - i^e)$

- *at end of maintenance period* Z is remaining portion of reserve requirement

$$i = \underline{i} + F\{Z - R^S\}(\overline{i} - \underline{i}) \quad \text{for} \quad Z - \overline{\delta} \le R^S \le Z - \underline{\delta}$$

$$i = \underline{i} \quad \text{for} \quad R^S > Z - \underline{\delta}$$

$$i = \overline{i} \quad \text{for} \quad R^S < Z - \overline{\delta}$$

In some systems, $\overline{i}$ linked to expected future overnight rates hence "open mouth operations"

- New Zealand early 1990s: $\overline{i}$ = market bill rate

- U.S. late 1980s-1990s: below-market discount rate plus "don't borrow again for a while!"
  hence $\overline{i}$ is cost of holding lots of extra reserves for a while

3) Overnight rate

b) Apply to pre-1914 London

$\underline{i} = 0$

Every day at 4:00 clearing house stops accepting payment orders, clears payments

A bank settles up with its reserve account

Various reasons a bank is uncertain about $R^D + \delta$

Before that, at 3:30 (up to 1894) or 2:30 (after),

discount houses apply to Bank of England for advances or rediscounts

by end of day funds will be in the Bank of England account of a clearing bank

hence R^S includes Bank's lending to discount houses

$\bar{i}$ = **?** Possibilities: advance at Bank Rate plus a margin

advance at market rate plus "don't borrow again for a while!"

Reserve requirement? Goodhart (1972) speculates yes, because reserve balances very big

3) Overnight rate

c) Hypotheses

Reserve demand was:

$$Ln(R_t^{\,D}) \;=\; -\; a\,i_t \;+\; b\,\hat{i}_t + \; c\,Ln(D_t) \;+\; \epsilon_t^{\,RD}$$

D Deposits

$\hat{i}$? Bank Rate plus a margin *or* expected near-future call money rates

(informal reserve requirement, "don't borrow again...")

Market call money rate was:

$$i_t \;=\; \frac{b}{a}\,\hat{i}_t \;-\; \frac{1}{a}Ln(R_t^{\,S}) + \;\frac{c}{a}Ln(D_t) \;+\; \frac{1}{a}\,\epsilon_t^{\,RD}$$

Note: D is likely to be affected by Bank Rate because cartel indexes deposit rates to Bank Rate

3) Overnight rate

c) Regressions

Use bill rate as proxy for expected near-future call money rate

What goes on LHS? Depends on nature of reserve supply

- If perfect international capital mobility, UIP held:

  interest rates exogenous

  R^S immediately adjusts through instantaneous gold flows

  so put $Ln(R^S)$ on LHS

- If imperfect international capital mobility, international arbitrage on bill rates:

  $Ln(R^S) = di^B + \epsilon^S \leftarrow$ *foreign bill rates, current account, etc.*

  so put *i* on LHS, include bill rate on RHS

3) Overnight rate

c) Regressions with *i* on LHS
Semiannual (deposit data only for June, September)

Table 2 Call-money rate and reserve quantity 1881-1913, with call money rate on LHS

A)	Entire period			Excluding crises[1]		
	(1)	(2)	(3)	(4)	(5)	(6)
i^B	0.977	0.881		0.932	0.895	
	[0.099]	[0.038]		[0.115]	[0.040]	
	0.00	*0.00*		*0.00*	*0.00*	
i^{BR}	-0.113		0.884	-0.047		0.964
	[0.121]		[0.080]	[0.144]		[0.072]
	0.35		*0.00*	*0.74*		*0.00*
Ln(R)	-1.910	-1.875	-1.512	-1.690	-1.672	-1.219
	[0.533]	[0.530]	[0.746]	[0.517]	[0.515]	[0.701]
	0.00	*0.00*	*0.05*	*0.00*	*0.00*	*0.09*
Ln(D)	0.829	0.838	1.020	0.554	0.568	0.864
	[0.411]	[0.414]	[0.588]	[0.412]	[0.417]	[0.549]
	0.05	*0.05*	*0.09*	*0.19*	*0.18*	*0.12*
N. obs.	66	66	66	63	63	63
R^2	0.94	0.94	0.87	0.94	0.94	0.88

[1] 1890 December, 1907 June and December

Also on RHS: quadratic time trend, seasonal dummies

3) Overnight rate

c) Regressions with *i* on LHS (cont.)

Monthly data. Omitted RHS variable: deviation from trend in deposits

B)	Entire period			Excluding crises[2]		
	(1)	(2)	(3)	(4)	(5)	(6)
i^B	0.779	0.885		0.747	0.894	
	[0.054]	[0.021]		[0.054]	[0.023]	
	0.00	*0.00*		*0.00*	*0.00*	
i^{BR}	0.137		0.985	0.194		1.013
	[0.070]		[0.033]	[0.071]		[0.032]
	0.05		*0.00*	*0.01*		*0.00*
Ln(R)	-1.211	-1.227	-1.312	-1.051	-1.085	-1.053]
	[0.218]	[0.222]	[0.259]	[0.217]	[0.225]	0.249]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
"Ln(D)"	0.654	0.659	0.796	0.866	0.845	1.041
	[0.185]	[0.183]	[0.239]	[0.181]	[0.183]	[0.241]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
N. obs.	388	388	388	370	370	370
R^2	0.91	0.91	0.85	0.91	0.91	0.86

2 1890:7-1890:12, 1907:1-1907:12

Also on RHS: quadratic time trend, seasonal dummies

3) Overnight rate

c) Regressions with *Ln(Reserves)* on LHS

Semiannual

A)

	Entire period (1)	(2)	(3)	Excluding crises[1] (4)	(5)	(6)
i	-0.105	-0.103	-0.046	-0.108	-0.108	-0.045
	[0.029]	[0.029]	[0.023]	[0.033]	[0.033]	[0.027]
	0.00	*0.00*	*0.06*	*0.00*	*0.00*	*0.10*
i^B	0.121	0.095		0.128	0.101	
	[0.036]	[0.025]		[0.040]	[0.029]	
	0.00	*0.00*		*0.00*	*0.00*	
i^{BR}	-0.030		0.043	-0.034		0.044
	[0.027]		[0.020]	[0.033]		[0.027]
	0.28		*0.04*	*0.32*		*0.11*
Ln(D)	0.407	0.413	0.427	0.402	0.418	0.452
	[0.080]	[0.078]	[0.081]	[0.087]	[0.085]	[0.088]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
N. obs.	66	66	66	63	63	63
R^2	0.95	0.95	0.94	0.95	0.95	0.94

1 1890 December, 1907 June and December

Extra material: interest rates and public deposits (drain reserve supply)

Weekly data January 1889-December 1910

$\Delta i's$ Friday-Friday
$\Delta Public\ Deposits$ Wednesday-Wednesday

$$\Delta i_{t+1} = 0.053\ \Delta Public\ Deposits_t \qquad R^2 = 0.013$$

p-value 0.00

$$\Delta i^B{}_{t+1} = 0.019\ \Delta Public\ Deposits_t \qquad R^2 = 0.009$$

p-value 0.00