How the Bank of England Influenced British Interest Rates in the Classical Gold Standard Era

Christopher Hanes,
State University of New York at Binghamton
chanes@binghamton.edu

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Abstract: I use current models of monetary-policy implementation to examine the mechanism through which the Bank of England influenced British interest rates in the classical gold-standard era from the 1870s to 1914. The traditional view of this mechanism is that the Bank operated mainly through changes in Bank Rate, a posted rate at which the Bank rediscounted bills of exchange. I argue that the crux of the Bank's influence on money markets was actually the overnight (call money) rate in the London financial market, which was proximately determined by reserve supply and expected future overnight rates. Bank Rate may have affected the term premium in bill rates, that is the spread between bill rates and expected future call money rates.

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There have been many studies of Bank of England operations in the classical gold-standard era, which began at the end of the 1870s as most major countries joined Britain in linking their currencies to gold at fixed parities (Meissner 2005), and ended in 1914 at the outbreak of the First World War. Modern economists have paid thorough attention to topics such as the Bank's actions in financial crises and its role in business cycles in Britain and abroad (e.g. Goodhart 1972; Dutton 1984; Pippenger 1984; Eichengreen 1992: 42-54; Davutyan and Parke 1995; Jeanne 1995; Flandreau and Ugolini 2013; Anson et. al. 2017). Less studied is the Bank's system of "monetary policy implementation," that is the tools and techniques by which it influenced market interest rates in calmer times. Modern descriptions of the system (e.g. Dutton 1984, Ugolini 2016) echo old economics literature (e.g. Sayers 1936; Hawtrey 1938) and observations of pre-1914 contemporaries (e.g. Withers, 1910). They focus on the market for bills of exchange. They describe the Bank as standing ready to rediscount or lend on such bills at its posted "Bank Rate," mainly to “discount houses,” which were independent bill dealers ordinarily financed by short-term, arm’s-length loans from commercial banks. On most days Bank Rate was well above market rates, hence “ineffective,” with no bearing on market rates. But when market rates rose high enough Bank Rate became “effective,” serving as a ceiling on market rates, and Bank lending to discount houses indirectly supplied liquidity to the entire financial system. The Bank could *make* Bank Rate effective by draining funds from commercial banks through open-market operations and other means. Then banks, scrambling for funds, withdrew loans from discount houses; market rates rose to the Bank Rate ceiling; and discount houses came “into the Bank" for funding.

Judging from this description, the Bank’s pre-1914 implementation system was essentially different from systems used by today’s central banks (described by Bank for International Settlements, Markets Committee, 2019), which influence interest rates mainly by controlling the overnight rate and manipulating the public's expectations of its future path. To control the overnight rate most modern central banks pay (or charge) a rate of interest on banks' reserve accounts, and provide overnight credit to banks at a higher interest rate (often call the “discount rate”). In the “floor system,” the target overnight rate and the reserve-account interest rate are equal and the central bank drives the market

rate down to this floor by providing a sufficiently large supply of reserves. In the “corridor system,” the target overnight rate is halfway between the two administered rates, and the central bank holds the market rate at the target by supplying just the right quantity of reserves through open-market operations. At times central banks have supplemented control of overnight rates with "unconventional" operations such as “quantitative easing.” These are meant to affect longer-term rates perhaps by influencing the term premiums that hold longer-term rates above expected future overnight rates, perhaps by signalling the central bank’s commitment to a particular future path for overnight rates, (Bowman, Erceg and Leahy 2010: Bernanke 2016).

The apparent difference between modern systems and that of pre-1914 Britain might make it hard for today’s policymakers to draw lessons from it. That is too bad, for the antique mechanism had two features that would be useful today. First, the Bank’s lending facility for discount houses appears to have been quite unaffected by “stigma,” that is the fear that borrowing from the central bank will be taken as a signal that the borrower is in financial distress (Capie 2002, Gorton and Ordonez 2014, Jobst and Ugolini 2016). That is notable because such stigma has often hampered the ability of modern central banks to maintain a ceiling on market rates or supply liquidity in a financial crisis (Bernanke 2009:3; Madigan 2009; Haltom, 2011; Winters 2012:60; Armantier, Ghysels, Sarkar and Shrader 2015). Second, today’s policymakers are considering the adoption of new tools to give better control over medium- and long-term interest rates (“yield curve control”), including standing offers to buy short-to-medium term bonds at posted prices (Brainard 2019). The Bank’s standing offer to discount bills at Bank Rate would seem to have been a tool of this type.

In this paper I re-examine the policy implentation mechanism of the Bank of England in the pre-1914 era. I make use of classic literature such as Palgrave (1903), Clapham (1944), Goodhart (1972), and Sayers (1976). I also take advantage of historical Bank balance sheet data recently released by the Bank, data on London money market conditions newly collected from *the Economist* , and documents in bank archives.

I find that the Bank's mechanism was, in fact, surprisingly similar to those used by modern central banks. British bill rates were equal to expected future rates on collateralized overnight loans in the London money market ("call money" or "day-to-day" loans, similar to today's overnight repos), plus term premiums. The overnight rate was determined by supply and demand for reserve balances held by London banks at the Bank of England ("bankers' balances"). Reserve demand was a function of the spread between the overnight rate and overnight rates expected to prevail in the near future, as in modern systems characterized by "open mouth operations" (Guthrie and Wright 2000; Hanes 2019). In the long run, the workings of the international gold standard adjusted reserve supply to a value that held London money-market rates at an equilibrium spread against corresponding rates in other gold standard countries. But in the short run reserve supply was affected by various shocks that affected the London overnight rate exactly as reserve supply shocks have been observed to affect overnight rates in modern systems (e.g. Hamilton 1997; Carpenter and Demiralp 2006). Thus, the crux of the Bank's influence on British interest rates was not bill rates but rather the overnight rate.

Bank Rate was not, in fact, the rate at which the Bank rediscounted bills. But it did play important roles in the system. It was one (not the only) determinant of the cost of Bank credit to discount houses. Thus Bank Rate influenced the overnight rate indirectly, by affecting a marginal supply of reserves that came through Bank lending to discount houses. Bank Rate also appears to have affected the term premium in bill rates, perhaps through the channels envisioned by today's proponents of central-bank operations on longer-term rates. The traditional view is right about one thing: Bank lending to discount houses was not hampered by stigma. It is not clear why, so this question remains an an important one for future research.

In the first section of the paper I review current models of overnight-rate determination and term premiums, highlighting features relevant for pre-1914 London. In the second section I present evidence that bill rates were equal to expected future overnight rates plus a variable term premium, and that the term premium was affected by Bank Rate. In the third section I examine the process of reserve supply, reserve demand and the determination of the overnight rate in the short run and the long run.

Appendix 3 describes sources of data not described in the text.

1) Current models of monetary policy implementation

In this section, I review the model of reserve demand and overnight-rate determination that is generally used to analyse today's systems of overnight-rate control, and a model of term premiums (following Vayanos and Vila 2009) that has been used in much recent literature on "unconventional" operations to influence term premiums. I explain how each model describes modern systems. Then I point out features of the models relevant for understanding the Bank of England's pre-1914 system.

1.1) Determination of the overnight rate

Today's standard model of overnight-rate determination (e.g. Whitesell 2006, Ennis and Keister 2008) is an extension of Poole's (1968) "inventory-theoretic" model of reserve demand. In the model, a bank borrows and lends at a market overnight rate. It uses a central-bank reserve account to settle interbank payments. It is subject to a cost if the balance in the account falls below a required level (perhaps zero). It is uncertain about the exact balance that will be in the account at a point in time (perhaps because it cannot forecast exactly how long it will take some types of payments to clear), so up to a point leaving a larger balance in the account reduces the probability of a costly shortfall in the account.

In today's systems the central bank pays (or charges) interest on reserve account balances, and freely offers overnight credit to cover reserve-account shortfalls at a relatively high "penalty" rate. The market overnight rate cannot fall below the reserve-account interest rate (no bank would accept a lower interest rate to lend money overnight) or rise above the penalty rate (no bank would pay more to borrow overnight).[1] When the market rate is between the ceiling and the floor, the profit-maximizing reserve balance trades off the cost of holding another dollar (the spread between the market rate and the reserve-account interest rate) against the benefit (reducing the probability at the bank will have to

[1]The floor can be "soft" - the market rate can fall a bit below the reserve interest rate - if there are institutions other than banks that hold reserve accounts but are not paid interest on them, as the Fed discovered after 2008 (Craig and Millington 2017).

borrow from the central bank to cover an overdraft), creating a negative relationship between the market rate and reserve demand. The market rate ends up at a point between the ceiling and the floor, or pushed down to the floor, depending on the supply of "nonborrowed reserves," that is the quantity of reserve balances *not* lent through the central bank's overnight credit facility.

To hold the market rate at a target, central banks follow a couple of different methods. Prior to 2008, most central banks set the floor and ceiling to form a corridor around the target overnight rate and adjusted reserve supply with open-market operations to hold the market rate at the right point within the corridor. Since 2008 many central banks, including the Fed, hold the market rate have set the interest rate paid on reserve balances equal to the target and supplied enough nonborrowed reserves to keep the market rate on that floor. Appendix 1 presents a model illustrating these methods.

Some central banks require banks to maintain minimum balances - "reserve requirements" - in their reserve accounts on average over multi-day "maintenance periods." It is well-understood that in these systems, however the market rate may be determined in the later days of a maintenance period, on earlier days reserve demand is negatively related to the spread between the day's market overnight rate and overnight rates expected to prevail later in the maintenance period, because a bank meets the requirement at lowest cost by holding more (less) reserves on days within the period when the overnight rate is relatively low (high). Thus, the market overnight rate resulting from any given nonborrowed reserve supply on an earlier day in the period rises and falls with the expected value of overnight rates for later days in the period (Hamilton, 1996; Furfine, 2000; Demiralp and Jorda, 2002).

In the absence of multi-day reserve requirements, reserve demand may still be negatively related to the spread between the day's market overnight rate and overnight rates expected to prevail in the near future, if the cost of credit to cover reserve-account shortfalls is in some way linked to current *longer-term* rates. This was the case in early-1990s New Zealand. There the central bank set the rate charged for overnight credit, and the rate paid on reserve balances, equal to fixed margins around the current market rate for bills. As bills rates reflected expected future overnight rates, changes in expected future overnight rates affected current reserve demand and market overnight rates resulting

from a given reserve supply. Guthrie and Wright (2000) analyzed this system using a version of the standard model (and referred to the resulting automatic effect on market rates of signalled changes in the central bank's target rate as "open-mouth operations").

Finally, reserve demand is affected by expected future overnight rates if the central bank *rations* credit to cover reserve-account shortfalls in a way that is meant to limit the *frequency* of a bank's borrowing, so that a bank which has borrowed too frequently in the recent past may not be allowed to borrow again for a spell (Goodfriend 1983, Dutkowsky 1993, Hanes 2019). That means the cost of a reserve shortfall includes the loss of the option to borrow in the near future. A bank that loses the option will have to hold extra reserves in the future because, without the ability to borrow, it cannot run the risk of a reserve shortfall. The opportunity cost of those extra reserves will be the future overnight rate. Thus, an increase in the level of overnight rates expected to prevail in the near future increases banks' *current* demand for reserves. Appendix 1 gives an example.

1.2) Determination of term premiums

Since 2008 many central banks have engaged in operations such as "quantitative easing" (QE) meant to affect longer-term rates at least partly by influencing term premiums. The effectiveness of such operations is still controversial as a matter of economic theory.[2] In QE a central bank acquires long-term bonds in exchange for newly-created reserve balances or short-term bonds from the central bank's portfolio. Proponents argue this depresses term premiums because term premiums compensate investors for "interest-rate" or "duration risk," that is the risk of a future drop in bond prices due to an unforeseeable increase in yields. As a QE operation decreases the average duration of bonds in investors' portfolios, it reduces the total amount of duration risk in those portfolios and "With less duration risk to hold in the aggregate, the market should require a lower premium to hold that risk" (Gagnon, Raskin, Remache and Sack 2011:7; see also D'Amico et. al. 2012, Joyce et. al. 2012).

[2]There is no such ability in models with perfect financial markets and a representative household (Eggertsson and Woodford, 2003).

On this argument, a similar effect should occur if the central bank makes a standing offer to buy short-to-medium term bonds at prices set above usual market prices. As investors know that future prices of the bonds cannot fall below the posted offers *in the future*, the offer must reduce the degree of interest-rate risk associated with the particular bonds the central bank offers to buy as well as aggregate duration risk in investors' portfolios. Thus it would reduce term premiums at all times (Bowman, Erceg and Leahy 2010).

Much current literature about central bank operations and term premiums (e.g. Krishnamurthy and Vissing-Jorgensen, 2011; Gagnon et. al. 2011; D'Amico et. al. 2012) refers to a model developed by Vayanos and Vila (2009) to formalize the "preferred habitat" theory of Modigliani and Sutch (1966). In this model, the general level of term premiums increases with the degree of unpredictable day-to-day variance in the value of arbitrageurs' bond portfolio. The term premium at a specific maturity depends on the covariance between prices of bonds at that specific maturity and the value of arbitrageurs' whole portfolio. Based on this model, it is argued (e.g. D'Amico et. al. 2012:425-26; Joyce et. al. 2012:F279) that QE operations reduce term premiums by reducing day-today variance in the value of the public's bond portfolio, and/or covariance between the value of the portfolio and the value of bonds at a particular maturity.

A case relevant for pre-1914 London is one where the central bank posts a buying price for specific maturities of bonds *or* offers to lend on those bonds as collateral for a longer-than-overnight term. Either offer places a floor on the possible future price of an eligible bond, which can reduce the bond's term premium as it reduces covariance between the price of the asset and the value of the portfolio. It may reduce term premiums in general to the degree that it reduces variance in the value of the entire portfolio. Appendix 2 presents a model illustrating this.

2) The overnight rate, bill rates, Bank Rate and term premiums in pre-1914 London.

In this section I argue that, in pre-1914 Britain, bill rates were equal to expected future overnight rates plus term premiums. I explore the possibility that term premiums were affected by Bank Rate. To begin I present a *dramatis personae* of key players in the market - banks, discount

houses and the Bank of England - and describe the functions of overnight loans and bills. I propose hypotheses based on the historical facts and the model presented above. Then I examine data. Results suggest that term premiums in bill rates were indeed affected by Bank Rate.

2.1) The London money market

Bills of exchange

A bill of exchange was a short-term zero-coupon bond, subject to the condition that any seller subsequent to the original issuer guaranteed payment of the face value in the event of default by the issuer. In the pre-1914 era sterling bills of exchange were issued by borrowers to finance purchases of long-term securities, inventories and imports.[3] A bill could be traded in the open market once it had been "accepted" (bought) by a London bank or other financial institution. The perceived default risk of an accepted bill depended mainly on characteristics of the acceptor, not the issuer. "Bank" or "prime" bills, those that had been accepted by "banks and leading firms" (U.S. National Monetary Commission 1910: 108; see also Spalding 1930), were ordinarily believed to be practically free of default risk and "always discountable at best rates" (Spalding 1930: 136).

Discount houses

A discount house was an independent dealer in accepted bills, buying and selling on its own account.[4] Discount houses were "specialists in bills; they know better than anyone else the standing and means of the parties on the bills, and they watch closely how much paper of the different firms and houses is currently on the Market" (Scott 1921: 264). They "keep a considerable floating supply of bills always, with a view to disposing of them to bankers" (Withers 1910: 62), but they also held many bills to maturity, profiting from the usual spread between bill rates and rates discount houses paid for

[3] "Trade bills" were drawn to finance the sale or shipment of goods and theoretically collateralized by those goods. "Finance bills" were drawn to finance purchases of financial assets, which could serve as collateral." Accommodation bills" were associated with no particular collateral or transaction (U.S. Monetary Commssion 1910: 109). Original maturities ranged from three months to a year.

[4] There were other firms that served merely as brokers in bills, arranging sales between buyers and sellers without guaranteeing repayment (Spalding 1930: 137), but discount houses dominated the market. Confusingly, contemporaries often referred to discount houses as bill "brokers."

funding.[5] They also held, but did not deal in, other liquid assets including short- and long-term government and corporate bonds (U.S. Monetary Commission 1910: 107; King 1936:206; Sayers 1968: 48-51).

Discount houses were funded by loans at maturities ranging from overnight to two weeks (Sayers 1968: 36). Some of these loans came from nonbank businesses and out-of-town banks in the form of unsecured "deposits" at call or one or two weeks' notice. Rates paid on deposits were usually set by discount houses unilaterally, at a fixed spread below the Bank of England's Bank Rate (Sayers 1968: 52; U.S. National Monetary Commission 1910: 106). But most came from banks at call (Goodhart 1972: 122), at negoatiated rates, effective overnight as rates on rolled-over loans could be renegotiated (Straker 1920:111).[6] These loans was referred to as "call money," "day-to-day money" or "floating money." They were collateralized by prime bills or liquid bonds with haircuts to guard the lender against declines in collateral value (Spalding 1930: 132), They were arms-length transactions; banks felt free to recall without notice. At any time a discount house borrowed from many banks and a bank lent to many discount houses (Goodhart 1972:120).[7]

A surprise withdrawal of call money or deposits late in the day posed a problem for a discount house. A typical firm kept an account in a London bank to clear payments but held only a small balance (King 1936:183; Palgrave 1903:52; *Banker's Magazine* 1883: 568). A discount house could usually get a last-minute market-rate loan from its clearing bank (a type of credit called "privilege money") but only as long as it did not draw on such credit "habitually" (Sayers, 1968: 54-55).

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[5] Sayers (1968: 37) reports about Gillett's, a typical discount house, that "'A large portion' of the shorter-dated bills were normally retained by Gilletts to maturity, being used meanwhile as securities for money borrowed from banks." Hawtrey (? : 37) states that the bills bought by discount houses were "either sold to banks by the discount houses or held by the discount houses themselves."

[6] Securities used as collateral for call money loans were called "floaters," "from the fact that they float from bank to bank, as one bank calls and another lends" (Straker 1920:112).

[7] " Every morning the brokers call on the banks with which they do business, and ascertain whether the latter wish to lend any more money, or if any of the money already borrowed is required to be repaid; at the same time usually arranging the rate to be paid for money. They also ascertain if the banks wish to buy any bills...In the case of money being lent to a briker, he simply sends in security to cover the advance, and draws a cheque on the bankers for the agreed amlunt. In the case of money being 'called in' by a banks, the broker sends in his checque on some other banker for the sum called, and takes away a corresponding amount of security" (Straker, 1921: 111). There were more than 20 discount houses in 1910 (National Monetary Commission 1910: 104).

Frequently, a discount house covered a late-day shortage of funds by borrowing on collateral from the Bank of England. The Bank's standard haircut on such loans was five percent (Sayers 1968:58).

The operations of a discount house were constrained by its capital. Capital had to cover haircuts on call money loans as well as loans from the Bank of England. According to Sayers (1968:58-59), for a discount house (the "firm"):

> The necessity of always being in a position to provide a margin sufficient to cover any conceivable borrowing at the Bank was thus an important limiting factor in deciding the firm's commitments...A bigger portfolio would..have meant a risk of bigger borrowing at the Bank; this could only have been faced if they had a larger capital in the business...The Bank's rule about the margin of security thus operated seriously, as was intended, as a check on the extension of commitment in the bill market beyond all regard for the capital resources.

.More capital was not easy to come by, as almost all discount houses were private firms (National Monetary Commission 1910: 104).

Banks

By the end of the 1870s banks active in London money markets were mainly "joint stock" banks. These were publicly-held corporations with many branches and a head office in London or a large provincial city (e.g. Manchester, Birmingham), funded by capital and deposits - they had almost no managed liabilities. London joint-stock banks set deposit interest rates collusively. Cartel members agreed to pay no interest on checking ("current") accounts. Rates on time deposits were set by a commitee of cartel members, usually set equal to the Bank of England's Bank Rate minus a fixed differential. As one would expect, these rates appear to have been below market-clearing levels.[8]

On the asset side banks held till money, vault cash and deposits at the Bank of England called "banker's balances." They held bonds, and bills bought on the open market from discount houses.

[8]"Every time the bank rate is changed the bankers meet and fix the deposit rate...usually 1 1/2 percent under the bank rate" (U.S. National Monetary Commission 1910:45).Banks outside London did not link their deposit rates to Bank Rate (Withers 1910: 102). Occasionally cartel members tried to get away with paying higher rates to attract deposits. Cartel committee minutes from 1905 note that "The Committee have heard with regret that attempts have been made by a bank, which is a member of the committee, to obtain accounts from another bank..by offering 2 1/2 percent interest on deposits payable at call [above the cartel-set rate] and deposit rates on ..current account balances" (London Metropolitan Archives, Catalogue number MS32006-2, Committee of London Clearing Bankers Minutes, January 5th 1905).

They made various kinds of long-term relationship loans to customers at interest rates that were often tied explicitly to Bank Rate.[9] They made short-term, arm's-length loans to discount houses as described above, and also to securities dealers.

Call-money loans to discount houses were perfectly liquid. The exchanges of funds and collateral for a call-money loan were completed within the day the loan was arranged; the funds from a loan recalled in the morning would be in a bank's reserve account in the day's final clearing. settlement.[10] No other interest-paying asset was liquid in the same sense. It could take days to liquidate a security because the London Exchange settled transactions on an odd semi-monthly schedule.[11] For the same reason most bank loans to securities dealers were at a maturity around two weeks. Bills were potentially liquid assets but banks did not treat them as such. "In practice,..banks rarely, if ever, re-sell the bills they have bought under discount. There is no particular reason why a bank should refrain; but, as the matter stands, it seems to be considered *infra dignitatem* for a banker, once he has acquired a bill from the discount market, to offer it again for sale" (Spalding, 1930, p. 138; see also Sayers 1936: 21; King 1936:92ff; Capie and Webber 1985:313).[12]

The Bank of England

The Bank of England took deposits, referred to as "drawing accounts," from banks, the British government, local and foreign governments, other central banks, and "private customers" - nonbank firms and individuals. The Bank did not pay interest on deposits but otherwise provided depositors with most of the services of ordinary British banks: checking; "rediscounting" (purchasing) marketable

[9]See Goodhart (1971: 143-165). Loans to customers took the form of overdrafts; loans against collateral such as securities or real estate, called "advances,"; and ordinary business loans. Confusingly, the last usually had the legal structure of bills (Straker 1921: 100; Goodhart 1971: 144) and were referred to as such. They could not, however, be liquidated on the open market like the acceptances dealt in by discount houses.

[10]"When a banker is lending, he either gives the broker [discount house] his cheque drawn on the Bank of England or lets the broker draw a check on him..if a loan is called in, the broker hands the lending banker his cheque on his own banker, and receives back his security" (Spalding 1930: 133). Checks were cleared by the end of the same day, as I explain below.

[11]Funds and securities were actually exchanged only twice a month, on "settling days" (U.S. National Monetary Commission 1910: 44, 73, 119; Withers 1910: 104; Straker 1920: 53; Whitaker 1920: 214).

[12]I speculate that this was because a bill accepted by a bank were carried as a liability on the bank's balance sheet (U.S. National Monetary Commission 1910: 72), but a bill bought and sold by a bank was not, even though the bank (like a discount house) was an additional gurantor of payment on a sold bill. Thus, selling bills would create an invisible, unfunded and hard-to-estimate libility for a bank. I speculate that it therefore became good banking practice *not* to resell bills.

bills depositors wished to liquidate; and short-term loans - “advances” - on collateral of bills or marketable securities. A private customer was required to maintain an average balance large enough to cover the cost of services provided.[13] Private customers were not allowed to overdraw their accounts but the Bank was “always ready to discount satisfactory bills for its customers and to make advances on certain classes of securities" to cover an overdraft (Francis 1888: 191-92). It is not clear whether the Bank applied similar rules to accounts held by banks. I will return to this point below.

Apart from drawing accounts the Bank offered another type of account, a "discount account," which required only a token balance. A holder of a discount account could rediscount bills at the Bank and procure advances on collateral but only at the Bank’s discretion, and did not receive any other services. Discount houses were allowed to hold discount accounts, but not deposit accounts.

"Bank Rate,” set by the Bank's policy committee (the "Court"), was officially the Bank's minimum rate of rediscount for high-quality bills. Prior to 1878 this was true, more or less. The Bank rediscounted prime bills for its depositors at Bank Rate. For discount houses, it rediscounted bills and made advances only at times of crisis or at particular times of the year when interest rates were seasonally high.

In 1878, howevere, the Bank announced that its head office in London would thenceforth rediscount bills at *market* rates for customers holding deposit accounts.[14] From that point forward, private customers and London offices of foreign and colonial banks often came to the Bank to discount bills and take advances at market rates.[15] London banks did *not*, except at times of crisis. At least, that

[13] : "There is no stipulated sum insisted upon..; but the head of the office will always explain to any person, on his opening an account, what kind of balance would be deemed remunerative" (Francis 1888: 180). The Bank would cancel an account that did not pay its costs, or start charging the customer annually for services (Bank of England archive catalog number C40/77, file labeled "Unsatisfactory Accounts," undated form letter).

[14] The policy was extended to Bank branches outside London at the end of 1887.

[15] It is not clear exactly what "market rate" meant initially. The resolution adopted by Bank policymakers in 1878 stated only that "in times when from any cause a marked difference exists between the published minimum Rate of the Bank of England and the Rate of interest charged by other Banks to their customers, the Governor in consultation with the Committee of Daily Waiting, shall have the power to charge reduced rate. And, other similar circumstances, the Governor will fix the Rate for Advances on Securities" (Bank of England Court of Directors, Minutes for meeting Tuesday February 14th 1878, p. 210). By 1895 it specifically meant "the Market rate current for bills of the class offered" (Bank of England Court of Directors, Minutes for Meeting September 5th 1895, p.137).

was what the banks said, and what was generally believed (U.S. National Monetary Commission 1910: 21). Apparently, this was because of stigma:

> in London if it were known that a bank, even of the highest standing, habitually re-discounted with the Bank of England, it would at once be held to be 'in extremis.' In times of panic and peril such things, of course, have to be done, but in the ordinary way of business no London banker ever dreams of such a thing (Palgrave 1903: 52).

What about discount houses? In 1878, when the Bank announced it would discount for private customers at market rates, it also announced that it now stood willing to make advances - *only* advances, not rediscounts - to discount houses at any time, on collateral of bills or securities. Initially, the term of an advance to a discount house had to be between one and two weeks. The rate charged was Bank Rate (Palgrave 1903:51; Spalding 1930:91). At this time, therefore, "Bank Rate was not a rediscount rate at all...It was the rate at which the bill market could obtain advances for a week or a fortnight" (Sayers 1936: 4).

Soon after 1878, the Bank raised the rate charged for advances to discount houses above Bank Rate. From the 1880s through 1903 the Bank frequently set the rate for advances to discount houses at Bank Rate *plus* 1/2% or 1% or even 1 1/2%.[16] Sometimes the Bank reverted to its old policy of lending to discount houses only when money markets were strained.[17] From 1903 through 1914 the advances rate was usually equal to Bank Rate *plus* 1/2%, but not always (Sayers 1976:55). From time to time the Bank changed its standards for collateral and the term for an advance (though the term usually remained somewhere between one and two weeks).[18]

Starting in July 1890 the Bank allowed discount houses to rediscount bills at Bank Rate (Palgrave 1903:51), as well as take advances. At first discount houses could present only very short

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[16] *The Economist*, January 2, 1892, 50 (2523), p. 1, reported the last differential.

[17] In May 1883 the Committee resolved to grant advances to "Bill Brokers, Discount Companies and Money Dealers" only "at such periods as, by the incidents arising from the mothod of collecting the Revenue, public moneys are diverted from the Money Market into the custody of the Bank on Treasury Account, or to loans made under special and urgent circumstances" (Bank of England Court of Directors, Minutes, May 31st 1883, p. 35).

[18] According to Sayers (1968: 57-58) "there was at first much variation between seven, ten, and fourteen days, with terms of less than seven days sometimes occurring. In the 1900s, however, seven days became usual, and in the last years before 1914 it was almost the rule, though ten days' Advances did occur."

bills, with fifteen days or less remaining to maturity, for rediscount. Starting in 1895 discount houses were regularly allowed to present bills of up to 63 days, and sometimes, temporarily, even longer maturities (Sayers 1976: 35-36). The Bank did not always keep the rediscount rate for discount houses equal to Bank Rate. Sometimes it charged discount houses more than that (Sayers 1976: 55). But generally it kept the rediscount rate below the advances rate. Thus one might expect advances to have disappeared. But that was not the case. Discount houses continued to borrow more through advances than rediscounts. Perhaps this was because the Bank would take some types of bills as collateral for advances that it would not accept for rediscount (Sayers 1936: 22; 1968:55).

Throughout the era from 1878 to 1914, Bank Rate was one component of the cost of Bank credit to discount houses, but not the only one. There was also the spread between Bank Rate and the advances rate or rediscount rate applied to discount houses; the term of an advance and required quality of collateral; the types and maturities of bill the Bank would rediscount; and the relative important of rediscounts versus advances. All of these varied over time. Unfortunately, Bank Rate is the only component that is observable today. The Bank did not usually announce changes in the others. Often market participants could only infer them from the response of Bank staff when discount houses tried to borrow. I have found no comprehensive records of advances rates or collateral standards in Bank archives.

One thing is clear, however: there was *no stigma* associated with any type of discount house borrowing from the Bank. Discount houses were always willing to take funds from the Bank when it was the cheapest way to obtain funds. Over 1890-1914 one house went into the Bank for funds fifteen times a year, on average (Sayers 1968:56). It is not obvious why stigma existed for banks but not discount houses. According to contemporaries, discount houses borrowed so frequently from the Bank because they held no cash reserves.[19] But presumably discount houses would have held more cash if a stigma had raised the effective cost of borrowing from the Bank.

[19] According to a writer in the Banker's Magazine (June 1883, p. 568), "The bill broker frequently keeps no reserve of ready cash at all...If he is suddenly called on to repay a large sum to a bank which may have lent it to him at call, he may not

In any case, since discount houses *did* feel free to borrow from the Bank, it is plausible that the cost of Bank credit to discount houses placed a ceiling on market short-term rates. Certainly, contemporaries believed this to be the case. But because Bank Rate *per se* was just one component of that cost, there was no simple relation between this ceiling and Bank Rate. Contemporaries knew that rates for call money and prime bills could exceed Bank Rate.[20]

Despite the limited role of Bank Rate in the Bank's operations, Bank Rate retained enormous importance in the minds of financial-market participants. Bank policymakers rarely gave speeches. They did not release minutes of their meetings or press releases explaining their actions. In the absence of other information, the public appears to have taken changes in Bank Rate as the best indicator of the stance of Bank policy and Bank policymakers' view of economic conditions. In 1921, a banker observed that "A rise in Bank Rate is the danger signal, the red light warning the business community of rocks ahead..A fall in Bank Rate is the green light indicating that the coast is clear and that the ship of commerce may proceed on her way with caution" (Spalding 1930: 100).

In fact, Bank Rate *was* a special tool in the kit of Bank policymakers. They adjusted Bank Rate only when they had decided to effect a relatively large and persistent change in London money-market interest rates.

The primary objective of Bank policymakers was to maintain their ability to exchange Bank notes (and, indirectly, deposits at the Bank) for gold at the fixed rate.[21] The public exchanged Bank notes for gold when the foreign-exchange value of British currency depreciated far enough, relative to the "parity" value defined by the relative gold prices of currencies, that it became profitable for private agents to bring notes to the Bank, get gold, take it to the foreign central bank and exchange it for foreign currency. Unlike some foreign central banks, the Bank did not hold large gold reserves relative to its liabilities. Thus it could not allow gold withdrawals to continue for long. To stop a gold drain

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immediately find another bank or another broker willing to lend to him; and as we have just explained, the bill broker, since he keeps no reserve of ready cash in hand, must borrow in order to be able to pay. Under these circumstances the natural resource of the bill broker..is to ask for an advance from the Bank of England ."

[20]See for example *the Economist*, April 28, 1883, 41 (2070), p. 495.

[21] Deposits at the Bank were not exchanged for gold directly, but they could always be exchanged for Bank notes.

Bank policymakers had to engineer an increase in London bill rates. The balance of foreign investment was extremely sensitive to the spread between London bill rates and expected returns to holding comparable foreign-currency assets.[22] Thus, an increase in London bill rates would cause the pound to appreciate by tipping the balance of international investment toward Britain.[23]

Bank policymakers' implicit model of money markets seems to have been one of supply and demand for short-term lending. They believed that gold sales by the Bank tended to raise London bill rates automatically because they reduced loan supply. But to raise bill rates faster and bring a quicker end to the drain, Bank policymakers would attempt to divert supply of loans away from the bill market by selling securities, engaging in reverse repos and soliciting loans from London banks and discount houses (Sayers 1958:49, 1976: 37-41).[24] Sooner or later they would have to raise the ceiling on money-market rates created by the cost of Bank credit to discount houses. A hike in Bank Rate would do the trick. But Bank policymakers were keenly aware that Bank Rate was automatically linked to many banks' lending rates. Though Bank policymakers had no notion of macroeconomic stabilization in the modern sense, they wanted to keep the cost of credit to British business low and stable, subject to their primary goal of maintaining gold convertibility (Sayers 1976:8; 1936:117-127). Therefore they often left Bank Rate alone and instead raised other components of the cost of credit.[25] Increases in Bank Rate came later, and in large steps, usually of exactly one percent (Sayers 1936:50; 1958:61-62).

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[22] Many investors reallocated funds between London bills and foreign bills, depending on relative expected returns. Some issued sterling bills in London to finance purchases of foreign-currency assets (Margraff 1912: 34-42).

[23] A change in the spread between London and foreign bill rates was not necessarily inconsistent with perfect capital mobility (UIP), because international investors believed that exchange rates must eventually revert back toward parity. At times when the pound was depreciated against a foreign currency relative to pairty, investors expected future appreciation. Thus, it could be the case that when British interest rates were relatively low expected returns to foreign versus British bills, accounting for expected future changes in exchange rates, remained equal (Bordo and McDonald 2005).

[24] The Bank's reverse repos were called called “budlas” (Spalding 1930: 101) or “borrowing on consols,” because it was mainly consols that the Bank repoed out.

[25] “This latter working on Market Rate in a sense independently of Bank Rate was based on the accepted fact that while Bank Rate ruled the majority of home banking charges, Market Rate was the rate which influenced foreign exchanges. If, therefore, the Bank, in its tenderness toward the internal situation, wished to act on the foreign exchanges without forcing higher rates on home trade, it could use the devices..to force Market Rate up beyond its normal ‘effective’ relationship with Bank Rate” (Sayers 1936:49-50).

In the opposite situation, when the pound was appreciated relative to parity value and private agents were bringing gold into the Bank to get Bank notes, Bank policymakers were usually eager to let London bill rates fall. Though they did not try to add to the supply of loans to the bill market by, e.g., buying securities, they were quicker to cut Bank Rate than to raise it: cuts usually came in increments of one-half percent (Sayers 1936:50; 1958:61-62).

Importantly, there is no evidence that Bank policymakers sought to stabilize short-term fluctuations in money-market rates. They did not use any of their tools to counteract observed fluctuations in rates or factors that, in their view, could cause them such as Treasury borrowing operations.

2.2) Hypotheses

Clearly there was arbitrage between the call money rate and bill rates in pre-1914 London. Banks must have responded to changes in bill rates relative to the expected return to rolling over call money loans for the maturity of a bill. Discount houses, borrowing at call to finance holdings of bills and other liquid assets, must have responded to changes in the spread between the day's call money rate and the expected return to holding bills overnight. It is plausible that discount houses were risk-averse like arbitrageurs in the Vayanos-Vila model: to avoid loss of capital, a discount house needed to avoid variance in the value of its asset portfolios. Thus I hypothesize that the daily market rate for a prime or "bank" bill with negligible default risk was equal to market participants' expected value of the average call money rate over the life of the bill *plus* a variable term premium; and that the term premium was affected by the perceived day-to-day variance in the value of a portfolio of liquid assets, and the covariance of bill prices with prices of other liquid assets.

Bank Rate could have affected such a term premium in two ways. First, to the degree that financial market participants took a hike in Bank Rate to be a "danger signal," a higher Bank Rate could be associated with greater uncertainty about future bill prices. Second, Bank Rate was one component of the cost of Bank credit to discount houses, which placed a floor under prices of assets

eligible for advances and/or rediscounting. As illustrated in Appendix 2, such a floor would tend to reduce the maturity-specific term premium for eligible assets and perhaps term premiums in general.

2.2) Data and tests

Regular observations of the London market call money rate are available beginning in December 1881, when the *Economist* added the Friday call money rate to the quotes in its weekly report on conditions in the London money market. For bills, the *Economist* reported rates for a wide variety of types and maturities at one time or another, but it consistently gave quotes for three-month bank bills (bills accepted by large banks). By all accounts this was the most liquid maturity.[26] Thus, I compare call money rates with three-month bank bill rates.

Presumably there is measurement error in both rates. I have not found descriptions of where the *Economist* got its quotes but they appear to have been based on informal observations of market conditions. Like rates on individual transactions, rates were quoted in increments of 1/8 percent. Daily averages of actual transaction rates would not be in 1/8 increments. On many days just one value was given; on others a range of up to 1/2 percent, presumably meant to indicate the range at which business was done over that day. When a range was given I use the average of the two values, but a true average of transaction rates may have been different.

Figure 1 plots the weekly Friday call money rate, Bank Rate, and the spread between the call money rate and Bank Rate from December 1881 through March 1914. Figure 2 replaces the call money rate with the bill rate. The figures confirm that Bank Rate *per se* was not a ceiling on market rates. Both the bill rate and the call money rate exceeded Bank Rate on several days (negative spreads). The figures also show that the Bank did not attempt to maintain a consistent spread between Bank Rate and market rates. Sometimes Bank policymakers left Bank Rate far above market rates for many months (as in the mid-1890s, late 1908 and 1909).

[26] "Three months' bills are most in demand on the London market...as a rule, bills at about that usance are not difficult to place" (Spalding 1930: 137). This may have been because banks did not usually buy bills of more than three months' maturity (U.S. National Monetary Commission 1910: 71, 109). Recall banks always held bonds to maturity.

I compare Friday bill rates with the average call money rate realized over the weeks from that Friday through the bill's maturity, thirteen weeks into the future. Let i_d^B denote the Friday bill rate and $\overline{i}_{d+j}^O$ denote the average overnight rate from that day to the bill's maturity. On my hypothesis,

$$i_d^B = E_d[\overline{i}_{d+j}^O] + \tau_d \tag{1.1}$$

where τ_d is the variable term premium. The realized average overnight rate equals the expected value plus the error in that expected value revealed *ex post:*

$$\overline{i}_{d+j}^O = E_d[\overline{i}_{d+j}^O] + \epsilon_{d+j} \tag{1.2}$$

To the degree that market participants' expectations were rational on the conventional definition, the expectational error ϵ_{d+j} should be uncorrelated with the term premium τ_d . Thus, the bill rate and the realized future call money rate should be the sums of a common component $E_d[\overline{i}_{d+j}^O]$ and uncorrelated specific components. I examine this hypothesis graphically, since it is hard to test formally given the possibility of correlated measurement errors in the observations of the rates. Also, under my hypothesis it is possible that the degree of uncertainty about future bill prices, hence the bill-tate term premium, was correlated with the general level of interest rates. As noted above, Bank policymakers raised London rates when the Bank was losing gold.

Figure 3 is a scatterplot with the bill rate i_d^B on the horizontal axis and the realized average call money rate $\overline{i}_{d+j}^O$ on the vertical axis. I end the sample in March 1914, three months before London financial markets became unusually turbulent in response to the assassination of Franz Ferdinand at the end of June. (The First World War broke out in August.) The figure is consistent with a hypothesis that bill rates were equal to expected future call money rates plus a variable term premium. If the term premium were constant and there were no measurement error in the bill rate, the figure would show points scattered above and below a line with a one-to-one slope and a horizontal intercept equal to the term premium. Vertical deviations of average call money rates from the line would reflect errors in

expected values and measurement error in overnight rates. Variable term premiums and measurement error in bill rates would scatters bill rates to the right and left of the line. The bulk of the observations are consistent with this pattern. Some observations, in the upper-right area of the figure, represent weeks when bill rates were unusually high *and* unusually high relative to future overnight rates. That is consistent with a hypothesis that term premiums were especially high in those weeks. Many of these weeks, indicated by special symbols, were around three events that contemporaries described as creating unusual turbulence in London money markets. One was the Barings crisis in 1890.[27] Another was the Boer War "Black Week" in December 1899.[28] The third was the Panic of 1907 in New York.[29]

To examine the possible relationship between Bank Rate and the term premium, I examine the behavior of the "ex post" term premium, that is the bill rate minus the realized average future call money rate:

$$i_d^B - \bar{i}_{d+j}^O = \tau_d - \epsilon_{d+j} \tag{1.3}$$

To the degree that market participants' expectations were rational, on the conventional definition, the expectational error ϵ_{d+j} should be uncorrelated with Bank Rate, so any apparent correlation between the expost term premium and Bank Rate should reflect a correlation between Bank Rate and the term premium.

Figure 4 is a scatterplot of Friday's Bank Rate against the ex post term premium. I use monthly average values of the variables to reduce the effect of transitory measurement errors. Figure 5 confines the sample to "normal" months, excluding weeks around the three crisis or near-crisis periods. In both

[27]At the beginning of November 1890 it became known that Barings Bank was potentially insolvent due to large holdings of bad South American bonds. The Bank organized and partially funded a takeover of Barings' operations by other banks for orderly liquidation. Clapham (1944: 335) judged that "everything was so quick, so decisive, and so highly centralized that there was no true panic, on the Stock Exchange or anywhere else, no run on banks or internal drain of gold." But there was an extraordinary increase in rediscounting at the Bank in November 1890, when bills with Barings' acceptance began to "pour in" (Clapham 1944:331). Barings crisis weeks (dates of Saturdays ending a week) marked are 11/1/90-12/27/90.
[28]This was a week in which there were several British army defeats in the South African War. Boer War crisis weeks marked are 12/2/1899-1/6/1900.
[29] In August 1907, in response to the approaching Panic of 1907 in New York, London banks "took fright and dropped their taking of new bills," driving up bill rates and driving discount houses to borrow from the Bank even though there had been "no export of gold, no seasonal disturbance of the Bank's balance sheet and, in the first stages, no restrictive action by the Bank" (Sayers 1976:57). Panic of 1907 weeks are 8/10/1907-12/28/1907.

Figures, it is clear that the ex post term premium tended to be higher when Bank Rate was higher. Figures 6 and 7 split the sample at July 1890, when the Bank began to allow discount houses to rediscount bills at Bank Rate as well as take advances against bill collateral. The relationship appears to have been tighter after July 1890.

The pattern apparent in Figures 5-7 might reflect a correlation between term premiums and the general level of interest rates, not necessarily Bank Rate itself. To check this I regressed the ex-post term premium on Bank Rate and two time series on long-term interest rates. One is the consol yield from Klovland (1994), monthly (last week in the month). The other is an average of yields on British railroad bonds (apparently from Harley 1976) available from the Bank of England, available only quarterly (second week in first month).[30] These appear to be the only British interest rate series, other than bill rates, at a higher-than-annual frequency from this era. I use monthly average Bank Rate along with the monthly average ex post term premiums in Figures 5-7, and monthly interpolations for the railroad bond yield. On my hypothesis the residual term for a month must be correlated with residuals for the previous two months', because of overlapping expectational errors in realizations of three-month average overnight rates. To allow for that I specify standard errors as MA(3).

Table 1 shows results with crisis months excluded from the samples (results were similar including crisis months). They are ambiguous for the 1881-June 1890 sample, but for July 1890-1914 it is clear that the ex post term premium was most closely related to Bank Rate and specifically to the *spread* between Bank Rate and long-term rates.

3) Reserve supply, reserve demand and determination of the overnight rate

So far I have examined determination of bill rates given expected future overnight rates. Now I turn to determination of the overnight (call money) rate. First I describe the settlement of interbank payments in London, the requirements the Bank imposed on banks' reserve accounts (bankers' balances) and the cost to a bank of running a shortfall in its account. I argue that the situation fits very

[30] On the Bank of England website https://www.bankofengland.co.uk/statistics/research-datasets, "A Millenium of Macroeconomic Data for the U.K."

well the standard model of reserve demand and overnight-rate determination described above and illustrated in Appendix 1. Though important points remain unclear, it appears that a London bank was subject either to limits on the frequency of borrowing to cover reserve-account overdrafts, or to informal reserve requirements, or both. I hypothesize that reserve demand was negatively related to the spread between the current overnight rate and expected near-future overnight rates. Next I describe the process of reserve supply. I hypothesize that in the long run reserve supply was endogenously determined by international gold flows so as to hold London money-market rates at an equilibrium spread against corresponding rates in other gold standard countries, but in the short run reserve supply was subject to exogenous shocks. Finally I describe available data and test my hypotheses.

3.1) Reserve demand

Clearing and settlement

In the standard model a bank uses its reserve account to settle payments, subject to uncertainty about the balance that will be in the account at the end of a period. That was certainly the case in pre-1914 Britain.

Bankers' clearing houses in London and several other cities and towns cleared local payments daily and presented a member bank with a net debit or credit in the afternoon of every business day. In most cases banks settled the balance with a transfer from (to) its reserve account in the closest Bank of England branch. The London clearing house dwarfed the others in volume as it handled payments associated with London's financial markets, as well as intercity payments.[31] Its member banks were called "clearing banks."[32] The clearing house was located "within five minutes walk" of the head offices of all clearing banks and the Bank of England (Matthews 1921: 25). All types of payment

[31]Intercity payments were made through London, using correspondent accounts in London banks (Francis 1888: 210; Seyd 1872: 52,63). Manchester, Liverpool and Birmingham were the most important clearing houses outside London. Practices of provincial clearing houses are described by Matthews (1921:139-166) and Barnett (1882). The Bradford Banker's clearing house carried out final settlement in London funds, that is accounts in London correspondent banks, not a local Bank of England branch (HSBC archives, catalog number UK0236-0016, document "Bradford Bankers' Clearing House Rules and Regulations 1898," p. 6). In some towns branches of London-headquartered banks had a local clearinghouse for purely local payments (HSBC archives, catalog number UK0217-0015, "Minutes of Association of Leicester Clearing Banks 1916-1940," describes such a clearinghouse established in 1892 in Leicester).

[32] Around 1900 there were about 25 of them (Clare 1902: 29). Most - at the end of the period, all - were joint-stock banks.

orders (checks, drafts, and due bills of exchange issued by customers of a bank) were sent to the clearing house over the course of a day, carried by messengers on foot (Matthews 1921: 26). At about 4 pm (Seyd 1878:64; Francis 1888:182; Matthews 1921: 43) the clearing house closed its doors.[33] "When the doors are closed there is no means of obtaining payments for the cheques shut out until the next day. On Stock Exchange Settling Days and other occasions when the work is heavy, it is no uncommon thing near closing time to see the runners rushing down Lombard Street as if their lives depended on it" (Matthews, 1921: 27). After clearing was completed banks were given an opportunity to challenge dubious claims. Challenged claims were removed from the clearing to be resolved on the following day.[34] Finally, banks paid off net debits or took payment for net credits with their Bank of England reserve accounts.[35] Because of the daily timing of Bank operations, an advance or rediscount made to a discount house appeared as a credit to some bank's reserve account on the same day.[36]

Until the process was complete a bank's staff must have been uncertain as to what its net clearing house balance would turn out to be. A payment order might or might not make it into the

[33]In the morning banks sent in orders held from the previous day, orders that had come in from branches and claims for payment on bills in a bank's portfolio that had come due. At the clearing house orders were totalled and netted (in the "morning clearing") to be carried forward into the afternoon (Matthews 1921: 30). In the afternoon banks sent in "cheques, bills etc. that have been received..during the day, and towards the closing time there is a constant running of clerks to and from the Clearing House (Matthews, 1921: 27).The Bank of England sent in all its claims for the day just before closing time, at about 3:45 (Francis 1888:182). When the doors were closed clerks finished sorting the afternoon claims and added them to those sorted in the morning.

[34]After clearing was completed the day's claims on a bank were carried back to the bank. A bank was given one hour to examine the claims, identify any it did not want to pay, and carry challenged claims - "returns" or "unpaids" - back to the clearing house (Matthews 1921: 32,43). "The majority of these returns comprise Bills, for some irregularity in the endorsement, or want of funds...The returns of Cheques are less numerous, and they are mostly connected with technical irregularities" (Seyd 1872: 50). Challenged claims were "deducted at once from the balances" (Seyd 1878: 51) to be resolved on the following day.

[35]The Bank of England was a member of the clearing house "on one side": it sent in claims for payment on clearing banks but paid claims on itself directly into a bank's Bank of England account (Seyd 1878:55; U.S. National Monetary Commission 1910:11). "When the balance sheet has been so far completed as to include the last unpaids..it remains only to strike the balance...If it is a pay balance, the clerk in charge fills up an order to the Bank of England to transfer from the account of his bank to the Clearing House account at the Bank of England the amount this bank is liable to pay...If on balance the bank has a claim against the Clearing House, the clerk in charge makes out a transfer for the amount of his claim from the Clearing House to the account of his bank at the bank of England" (Matthews p. 34).

[36] Until 1894 a discount house could apply for a loan or advance up to 3:30 in the afternoon; starting in 1894 the closing time was 2:30 (Sayers 1976: 37). It would receive a check drawn on the Bank. The discount house took this check to its clearing bank and the bank presented the check to the Bank of England for payment at the end of the same day, receiving an immediate credit to its own Bank of England account (Seyd 1878:55; U.S. National Monetary Commission 1910: 11; Withers 1910: 63).

clearing house by 4 o'clock. A payment-in might be challenged by the paying bank and held over to the following day.

A bank actively managed its call money lending to aim at a target balance in its reserve account (Clare 1902:44; Hawtrey 1938: 37; Spalding 1930:121-26). In 1882, the *Economist* observed:

> Towards the close of an afternoon in the City there are constant enquiries at all the principal offices either for money to "lend," or to offer money which is "over."...the amount of the bankers' balances with the Bank..have to be retained there, in great measure, to meet the "clearing charges" [that is, settle the clearing house balance], and no bank, however strong might be the wish to employ its money elsewhere, can allow those balances to run below a certain minimum.[37]

In an extensive study of London bank practices around the turn of the century, Goodhart (1972: 108) observed that "The normal practice..was for banks (the decision being taken at the highest level - the board of directors) to choose either a minimum balance or a target level for the balance to be held at the Bank. In each case this balance was described as a single figure..which was adjusted from time to time." But it is clear that these infrequently-changed minimums or targets were not meant to hold strictly every day. Daily records of individual banks' reserve balances, available for a few banks, show enormous variation across days. Sometimes balances were very low; sometimes they were relatively low for many days in a row.[38] On certain days in each year banks sought to hold extra reserves for "window dressing" of their balance sheets, as it was conventional to publish a bank's balance sheet (in aggregated categories) as of those particular days.[39] Banks also aimed to hold more on days when the

[37] "Why the Rate for Money Varies So Rapidly," February 4, 1882, p. 129.

[38] Weekly Wednesday records of Parr's bank balances found by Goodhart (1972: 543-549) show enormous variation above the board-set minimum (e.g., sometimes more than £500,000 above a minimum of £500,000). Daily balances of Lloyds bank from 1901 show variation from a low figure of £1,691,000 to £2,466,000 within a span of six weeks (Lloyds Bank archives, no catalog number, Daily Committee Minute Book, Volume 975, 28 January 1901-19 March 1901). Weekly Wednesday balances for Lloyds in the late 1880s-early show balances usually around £200,000 but often as low as £40,000 and once just £17,000 (on September 7, 1892) (Lloyds archives, catalog number HO/CA/Acc127, General Ledgers).

[39] No regulations required banks to report balance-sheet information, but throughout the 1870s-1914 era joint-stock banks published such information for one day at the end of June, and one day at the end of December. In 1891 a majority of clearing banks began to also publish statements for one day at the end of each month. One item reported was "cash reserves," the total of a bank's Bank of England deposits and currency and coin held by the bank. Banks appear to have felt a constraint to show a ratio of "cash reserves" to deposits high enough "to stand the light of publicity" (Withers 1910:27), which was higher than what they actually maintained between reports. "One aspect of this matter that is not clear is just what factors determined whether the cash reserves should be increased to the desired level..by adding to hoards [of

volume of payments was especially high such as quarter-ends and stock-exchange settlement days (Withers 1910: 14, 15; Clare, 1902: 43, 143; Matthews 1921:81). That is consistent with the standard reserve demand model, assuming that the degree of uncertainty about the net clearing house balance was higher on these days (Appendix 1).[40]

Reserve requirements and the cost to a bank of a reserve-account shortfall

In the standard model the determinants of reserve demand other than the overnight rate depend on whether a bank is subject to a reserve requirement, and the nature of the cost to a bank of running an overdraft or shortfall from the reserve requirement. If banks are subject to multi-day reserve requirements, and/or if the cost of borrowing to cover a shortfall is the loss of the option to borrow again in the near future, daily reserve demand is positively related to expected near-future overnight rates.

It is surprisingly hard to determine the situation facing a London bank in this respect. Goodhart's (1972) examination of clearing bank archives left him guessing at many points. My own examination of archives of the Bank of England as well as clearing banks (including some unavailable to Goodhart) did not clear up much. But the evidence is that banks must have have been subject to informal multi-day reserve requirements, or a high cost of reserve shortfalls due to a limit on the allowed frequency of overdrafts, or both.

According to all accounts banks held such large balances in their reserve accounts that overdrafts were very rare. Bankers' balances were "out of all proportion to the amounts required by the necessities of clearing" (Withers 1910: 283). "The balances kept by the clearing bankers with the Bank of England have increased so much ..that any necessity for some arrangement between the clearing banks and the Bank of England as to overdrafts being permissible has ceased to exist" (Holland 1910:281). Goodhart (1972: 108) judged that banks aimed to hold minimum or target balances that

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currency and coin] ot to balances at the Bank of England" (Goodhart 1972: 114), But it was well-known that banks tended to let call loans run off just before a report day to boost reserve balances (Spalding 1930:120).

[40]In modern systems banks also seek to hold more reserves for window dressing (Allen and Saunders 1992) and on days of heavy payments flow (Entz, McGowan and Sarkar 2016).

"were very greatly in excess of the balances required to maintain a continuing credit balance in the face of normal fluctuations, up and down, in the clearing process."

Large reserve balances and infrequent overdrafts could be explained by the presence of reserve requirements. There were no *regulatory* reserve requirements. But, as noted above, the Bank enforced minimum balance requirements on private customers' accounts to cover expenses. Did it apply similar requirements to bankers' balances? I have found cases in which the Bank enforced similar requirements on accounts held by banks (albeit not on accounts held by clearing banks in London).[41] Goodhart speculated that banks maintained high balances because there was an implicit threat from the Bank that a bank failing to do so would not receive lender-of-last resort help in a crisis (1972: 105, 112).[42]An informal requirement of this type might be unlike a formal requirement in that there would be no well-defined maintenance period. But there would have to be some kind of averaging across days - recall there was great day-to-day variation in an individual bank's reserve balance.

Large reserve balances could also be explained by a high cost to a bank of running a shortfall. What would happen if a bank was presented with a net debit at the clearing house which was larger than its banker's balance? In 1860, prior to the era I examine, the Bank would have automatically covered such an "overdraft" with an overnight loan to the bank, collateralized by securities the bank had previously lodged with the Bank. According to Holland (1910: 281),

> in 1860 we find the following correspondence taking place between..the chairman of the committee of clearing banks, and the Bank of England: "Referring to our recent communications on the subject of the settlement of the bankers' clearing, I beg to say, to prevent mistake, that I understand that the cashiers of the Bank of England will have the authority..in case of any banker's account appearing to have overdrawn in the clearing to overpay the same, to an extent previously agreed upon, on the deposit of any of the undermentioned securities, viz, exchequer

[41]One was an out-of-town bank for which the Bank served as clearing agent in London (Bank of England Archive, catalog number C40/72, file labeled "Metropolitan Clearing Arrangements with Sundry Banks 1907." Letter dated 14 January 1908 to Messrs Cox and Company. In the letter the Bank cashier offers the bank an arrangement where the Bank would clear its London checks at no cost as long as the bank maintained a minimum balance of £100,000. If there was shortfall below the minimum the bank would pay interest on the shortfall at Bank Rate.) The other was an account that a London bank held in the Bank's Liverpool branch. HSBC archive, London and Midland Bank, Interview Diaries of Edward Holden, Volume I January 1896-February 1899, December 5th 1898 (p. 520). The bank was apparently subject to a minimum balance in its account at the Liverpool branch of the Bank.

[42]This was not a prudential regulation but simply to increase the profits of the Bank by giving it more funds to employ in profitable investment .

> bills, India bonds or debentures, Turkish guaranteed 4 per cent stock, and commercial bills. The advance to be repaid by such bankers in the course of the next day." To this the governor replied: "You have rightly interpreted what passed at our interview yesterday, and I and my deputy will be prepared to issue our instructions to the chief cashiers to act in the sense mentioned."

In the period I examine banks continued to lodge collateral securities at the Bank to cover last-minute loans. From examples he found, Goodhart (1972: 111) concluded that "most banks had made standing arrangements with the Bank" for such loans. I found other examples, and observed that banks occasionally adjusted the amount of collateral lodged.[43] In only a very few cases, however, is it clear that banks were providing for loans to cover accidental overdrafts, specifically.[44] It is not clear how, or even if, an overdraft would appear in the Bank's books.[45]

What rate would a bank have been charged to cover an overdraft? Also unclear. In one case that I found, the rate charged appears to have been Bank Rate.[46] But, as mentioned above, the Bank

[43] From HSBC archives UKR0023, "Metropolitan and Birmingham Bank, Directors' Minute Book Number 15 1891-1894, 7 March 1893 p. 242: "The Assistant General Manager reported that £100,000 had been borrowed from the Bank of England until the 15th instant when it is intended to be repay the same by sale of Exchequer bills and City of London stock." From HSBC archves UKR0026, Metropolitan Bank of England and Wales Directors Minute Book No. 18 January 1902-August 1905, 29 Paril 1902 (p. 32): "It was resolved to add to the £200,000 of consols already held by the Bank of England on account of this bank a further £50,000..as a continuing security for any liabilities to them which may occur in connection with the bank's account."From HSBC archives, no catalog number, London and Midland Bank Board Minutes, March 1901-August 1902, 29 November 1901 (p. 193): "The Managing Director suggested that Security should be lodged with the Bank of England so that it might be drawn against by any of our large offices." Lloyds Bank archives, Minute Book, Daily Committee, Wednesday November 2 1884 (p. 4250), mentions "registered stocks and shares deposited as securitity for advances with the Bank."

[44] In minutes of the Board of the Prescott Dimsdale bank from 1891, Goodhart (1972: 109 fn 47) found explicit statements that securities were lodged at the Bank "against any accidental overdraft." In Bank of England archives, catalog number C58/3, "Temporary Advances Ledger 1886-1890," under heading "Overdrawn accounts." I found three overdrafts by Martin and Company: on October 28, 1887 (though the year for this one is not absolutely clear); December 29 1888; September 13 1889. In catalog number C40/72, file labeled "Metropolitan Clearing Arrangements with Sundry Banks 1907," document labeled "Excerpt from minutes, Board of Directors, British Linen Company, September 24, 1878," I found a document stating that the British Linen Company, a bank located in Edinburgh, had arranged for sanction of overdrafts of up to £50,000.

[45] Overdrafts appear to have been handled by Chief Cashier alone, not by the offices that handled discounts and advances. The overdraft arrangement made by the Edinburgh bank described above was made with the Chief Cashier. Bank of England archives, catalog number C40/72, file labeled "Metropolitan Clearing Arrangements with Sundry Banks 1907," document labeled "Excerpt from minutes, Board of Directors, British Linen Company, September 24, 1878." In 1894 the Economist reported that the Bank's chief cashier had been fired partly because he "in one case, allowed a considerable overdraft without any authority whatever" (May 19, 1894, "Bank of England," p. 9).

[46] These were the overdrafts by Martin and Company in 1887-189 referred to in the footnote above. Numbers on the ledger that may be the associated interest rates (4 percent, 5 percent and 5 percent) were equal to the Bank Rate at the times of the overdrafts. See also footnote below.

charged market rate for discounts and advances to private customers.[47] Either market rate or Bank Rate would have been close to the call money rate. In the standard model, that would result in frequent overdrafts, if the cost of an overdraft had included only the explicit interest cost (Appendix 1). Thus, if banks were not subject to informal reserve requirements there must have been a high extra cost of borrowing due to some form of overdraft-credit rationing by the Bank, perhaps limits on the frequency of overdrafts.

Hypothesis about reserve demand

I hypothesize that the quantity of reserves demanded on day *d*, that is, the total balances banks hold in the Bank of England accounts going into the end of the day, can be described as:

$$(1.4) \quad R_d^D = -\alpha(i_d^O - E_d[\bar{i}_{d+n}^O]) + \beta M_d + \gamma Z_d + \epsilon_d^{RD}$$

where i_d^O is the day's overnight rate and $\bar{i}_{d+n}^O$ is the average overnight rate in the near future. *M* is the volume of bank deposits. *Z* is the expected volume of clearinghouse payments that day, which is positively related to banks' degree of uncertainty about the balance that will remain in their accounts after clearing. ϵ^{RD} denotes remaining variables affecting reserve demand, such as window-dressing for balance-sheet publication. If $E_d[\bar{i}_{d+n}^O]$ was about equal to the expected value of future overnight rates relevant for the rate on a bill, denoted $E_d[\bar{i}_{d+j}^O]$ above, reserve demand would be related to the spread between the overnight rate and the bill yield:

$$(1.5) \quad R_d^D = -\alpha(i_d^O - i_d^B) + \beta M_d + \gamma Z_d + \epsilon_d^{RD} + \alpha\tau_d$$

The daily market overnight rate equated this reserve demand to reserve supply.

3.2) Reserve supply

[47] In September 1895 the Bank's policy committee adopted resolutions clarifying its discounts and advances policies. The resolution specifically stated that private customers were to get credit freely ("the value of each account and the amount already under discount being taken into consideration"), and Discount houses were to get credit "not under the published Bank Rate." About banks, it stated that "Banking Companies established in England, or Colonial Banks..having Drawing Acounts with the Bank of England, shall only be admitted to Advances and Discounts with the sanction of a Governor," but did not mention the rates to be charged. (Bank of England Court of Directors, Minutes for meeting Thursday, September 5th 1895.

Reserve supply was equal to the value of the Bank's assets *less* its liabilities other than bankers' balances. In addition to gold, advances and rediscounts, Bank assets included various types of other loans and securities. Liabilities included deposits of nonbanks, Bank notes and various forms of borrowing by the Bank including reverse repos. The Bank never bought bills other than the bills it acquired in rediscounts, and never sold bills (Sayers 1936:19-20). As a matter of accounting, the increase in reserve supply across points in time was about equal to the Bank's:

purchases of gold (bullion, coins)
purchases of securities (net of runoffs)
rediscounts and advances (net of runoffs) to
- discount houses
- clearing banks
- other banks and private customers
short-term loans to the British government ("deficiency bills")
other loans

minus

sales of gold
Bank borrowing (including reverse repos)
increase in Bank notes outstanding and vault cash put into circulation
increase in deposits at Bank due to nonbanks, which included:
- British Treasury deposits
- other government deposits
- private customers

Several of these items tended to reduce (increase) reserve supply when London bill rates were low (high) relative to foreign rates. As explained above, the Bank tended to lose (gain) gold when London bill rates were lower (higher) relative to rates in foreign financial centers.[48] Moreover, when

[48]The overnight rate probably was not (directly) linked to gold purchases in the same way, as there seems to have been no international arbitrage at this maturity. At least, I have found no mention of such arbitrage in contemporary literature. Interrnational arbitrage at the overnight maturity would mean things like borrowing at call in Paris to lend in London on the same day, or reallocating funds every morning between call lending in Paris versus London in the morning. In the later part of the gold-standard era it was possible to do this, as it was possible to buy funds in a foreign financial center for delivery on the same day through "cable exchange." But the rates charged were higher than those for "sight exchange" (which was

the Bank was losing gold it attempted to divert the supply of loans away from the bill market by selling securities, engaging in reverse repos and soliciting loans from London banks and discount houses. All of these actions further reduced reserve supply (though as far as I can tell Bank policymakers did not think of them that way). Recall also that discount houses took more advances and, starting in 1890, rediscounts, when market rates were high enough relative to the cost of Bank credit. When the Bank was losing gold it sooner or later raised the cost of credit to discount houses by tightening collateral standards, raising spreads between the advances rate and Bank Rate, and perhaps raising Bank Rate. This would tend to reduce reserve supply by reducing discount-house borrowing.

Other reserve-supply factors were exogenous to conditions in money markets, at least in the short run. These include changes in Treasury deposits at the Bank and Bank loans to the Treasury. Weekly changes in these items were determined by the weekly balance of government expenditures, taxes, and debt issues. They were subject to strong seasonal factors such as the annual schedule of tax payments, but the Treasury did not adjust the timing of its activities to passing fluctuations in interest rates. Weekly changes in bank notes outstanding and vault cash were affected by crises and near crises ("more notes will be wanted if, at any time, credit is disturbed, because then bankers naturally increase their till-money" [Clare, 1902: 54]) but in normal times they were dominated by seasonal factors.

Hypotheses about reserve supply

The change in reserve supply across a span of days was:

$$\Delta R^S = \Delta D + \Delta G - \Delta TD + \Delta TL + \Delta S - \Delta N - \Delta F + \Delta B \tag{1.6}$$

where D is outstanding Bank advances and rediscounts to discount houses; G is gold held by the Bank; TD is British Treasury deposits at the Bank; TL is Bank loans to the Treasury; S is securities held and other loans made by the Bank, net of Bank borrowing; ΔN is the change in notes in circulation plus vault cash removed from the Bank; F is Bank deposits of nonbanks; B is outstanding discounts and advances to parties other than discount houses.

---

delivered in the foreign center a few days after purchase) (Whitaker 1920: 89). Perhaps the high transactions cost of cable exchange made it unprofitable to arbitrage call-money rates across cities.

Outstanding Bank credit to discount houses on day *d* was:

(1.7) $$D_d = (1-\mu_k)D_{d-k} + \omega(\bar{i}_{d-k} - \bar{i}^A_{d-k}) + \epsilon^D_d \quad where \quad 0 < \mu < 1$$

D_{d-k} is borrowing outstanding k days ago. μ_k is the average fraction of that borrowing that runs off over *k* days. $\bar{i}^A$ is the average effective cost of Bank credit to discount houses over the days in question. Because the maturity of most Bank lending to discount houses was one to two weeks, I expect that the market rates affecting discount-house borrowing were close to the overnight rate rather than the bill rate but I will examine this point below. i^A was equal to Bank Rate i^{BR} plus an unobservable variable that describes the effect of spreads between Bank Rate and the rates actually charged, collateral standards, etc.:

(1.8) $$i^A_d = i^{BR}_d + \epsilon^A_t$$

. The change in the Bank's gold stock from day *d-k* to *d* was:

(1.9) $$G_d - G_{d-k} = \sum_{g=0}^{g=h} \eta_g [i^B_{d-g} - (i^* + \tau^*)_{d-g}] + \epsilon^G_{d-g} \quad where \quad h \geq k$$

where *i** is the average foreign bill rate and τ^* is the risk premium on foreign bills. Because gold shipment could take several days (between London and New York, about a week in the 1890s) I allow for long lags and expect the effect of very recent days' rates to be small.

Recall that Bank policymakers often responded to gold drains by selling securities, taking loans and raising the cost of credit to disount houses. These actions are hard to describe formally but they means that when ΔG was negative, ΔS tended to be negative, and the Bank tended to raise (lower) i^A when ΔG was negative (positive).

The gold-flow equation (1.9) together with the reenforcing actions of the Bank would ensure that reserve supply tended to rise (fall) whenever $i^B > i^* + \tau^*$ ($i^B < i^* + \tau^*$). In the long run, therefore, reserve supply tended to the value that equated the London bill rate to $i^* + \tau^*$. The corresponding long-

run overnight rate would have been determined by i^* relative to expected future i^* (today's overnight rate is lower relative to bill rates when bills rates are expected to rise): $i_{LR}^{O} = i^{*} - \tau + \epsilon^{O-B}$, where ϵ^{O-B} is positive (negative) when i^{*} is expected to fall (rise). Thus in the long run reserve quantity tended to equal:

(1.10) $$R_{LR} = -\alpha (i_{LR}^{O} - i^{B}) + \beta M_{LR} + \gamma Z_{LR} + \epsilon_{LR}^{RD} - \alpha \tau_{LR}$$

4) Tests

4.1) Data

Weekly data corresponding to several of the variables in my model are available for the span from December 1881 through 1914. *The Economist* gives Friday bill rates in several European cities in addition to Friday's London call money rate, prime 90-day bill rate and Bank Rate. For the foreign bill rate i^* I use the average of the Paris and Berlin rates.[49] *The Economist* also gives the volume of payments settled through the London clearing house, totaled over days of the week ending Wendnesday. As one would expect, clearings are obviously high in weeks containing bi-monthly stock exchange settling days or quarter-ends. Weekly Bank of England balance-sheet data, recently made available on the Bank's website, give several items including discounts and advances and total deposits of banks in the London office of the Bank. I take the latter to indicate reserves as defined above.[50] Unfortunately many useful items, such as the types of loans the Bank used to drain funds from the market at times of gold outflow, are presented only as part of obscuring aggregates. Another troublesome feature of the Bank data is that they are as of Wednesdays (when the Bank made up its accounts), not Fridays like the interest-rate data.

[49] Averaging in rates from smaller European markets such as Brussels and Amsterdam gave similar results.
[50] I am unable to see whether the patterns I observe with respect to London banks held for banks in other cities, because series on reserve balances held in Bank branches outside London do not begin until January 1910.

Estimates of bank deposits are available for only two days a year, at the end of December and the end of June, from Capie & Webber (1985, Table III.3), who constructed them from the semiannual published reports described above.[51]

4.2) Tests: long-run reserve supply

My hypotheses imply that in the long run the supply of reserves, including the portion created by Bank lending to discount houses, adjusted to equate the London bill rate and overnight rates to values consistent with the gold-standard world interest rate. This reserve quantity should be consistent with (1.10) above. It should be negatively related to the spread between the call money rate and the bill rate, and *unrelated* to Bank Rate. To test this it is important to control for the volume of bank deposits as another determinant of reserve demand. Deposits must be sensitive to interest rates in the long run, including Bank Rate - recall that London banks paid for time deposits were explicitly linked to Bank Rate.

The available measures of deposits are at six-month intervals. It is plausible that variations in the quantity of total reserves at these intervals would be dominated by the long-run adjustments described by (1.10). I regress the log of two-month average reserve balances over December-January and June-July on the log of deposits at the end of December and the end of June and two-month average interest rates - call money, prime bills and Bank Rate. To the RHS I add a quadratic time trend to the right-hand side and a dummy variable for June.

Table 2 shows results. Estimated coefficients are consistent with my hypothesis that long-run reserve demand was negatively related to the spread between overnight rates and bill rates, unrelated to Bank Rate. When both the bill rate and the calll money rate are included on the RHS, the coefficient on

[51] I use their estimate of total deposits of joint-stock banks, which included most clearing banks.

the bill rate is positive and the coefficient on the overnight rate is negative. Coefficients on Bank Rate are not significantly different from zero.

4.3) Tests: discount-house borrowing

To test my hypothesis about discount-house borrowing I use weekly Bank balance sheet data on advances and rediscounts. Equation (1.7) implies that discount-house borrowing from the Bank outstanding on a Wednesday, in terms of interest rates on the preceding Friday, is approximately:

$$(1.11) \qquad D_{Wed} \approx (1-\mu_j) D_{Wed-1} + \omega i^{O}_{Fri-1} - \omega i^{BR}_{Fri-1} + e_{Wed} \quad where \;\; e^{D}_{Wed} = \epsilon^{D}_{Wed} - \omega \epsilon^{A}_{Fri-1}$$

where the subscript *-1* denotes the preceding week. The approximation is that I take Friday interest rates to stand in for interest rates over all days between the two Wednesdays.

Unfortunately, rediscounts and advances to discount houses specifically are not broken out in the data.[52] What is available is outstanding rediscounts, and outstanding advances, broken out between London and a total for Bank branches in other cities - "country." One can be sure that discount-house borrowing appears only in London, but discount houses were not the only borrowers in London. I have no hypotheses with respect to other borrowers.

Table 3 shows results of regressions borrowing in these categories on the RHS, combining country advances and discounts into one figure. RHS variables are the previous Wednesday's outstanding borrowing and, from the Friday in between, the call money rate, bill rate and Bank Rate. I exclude from the samples crisis weeks as defined above. LHS variables are outstanding London advances or rediscounts, and advances *plus* rediscounts from Bank branches outside London - "country." To the degree that a category indicates credit to discount houses specifically, the model predicts that the estimated coefficient on lagged advances should be less than one, reflecting runoffs on

[52] Starting in September 1895, the Bank's policy committee (the "Court") began to receive weekly reports giving totals of discounts and advances given to discount houses (Minutes, Bank of England Court of Directors, meeting of Thursday, September 5th 1895, p. 137). However, these reports seem to have been lost. Neither I, nor the Bank's archivist can find them.

these one-to-two week loans. The coefficient on the call money rate (Bank Rate) should be positive (negative). The bill-rate coefficient should be about zero. It is hard to say more than that, because there are many possible sources of bias in estimated coefficients relative to (1.11) due to correlation between the interest rates and the unobservable variable e^D. For example, the Bank may have tended to lower other borrowing costs when it raised Bank Rate, making Bank Rate a noisy measure of borrowing cost (negative correlation between i^{BR} and ϵ^A).

The first four columns show results for London over 1881-July 1890, when discount houses were allowed to take advances but not rediscount, and for August 1890-1914, when discount houses could also rediscount but continued to borrow mostly through advances.[53] Given the possible biasses, estimated coefficients are consistent with (1.11). For London advances, columns (1) and (3), coefficients on lagged borrowing are well below one; coefficients on the call money rate (Bank Rate) are positive (negative); coefficients on the bill rate are not significantly different from zero. For London rediscounts 1881-1890, coefficients on lagged borrowing are close to one and coefficients on bill rates are positive, suggesting that the maturity of the bills the Bank would take was longer than the one-to-two week term of advances to discount houses. For 1890-1914, when some unknown portion was going to discount houses, results are similar.

The last two columns show results for country discounts *plus* advances. The policy of giving discounts and advances to private customers at market rates was not applied in country branches of the Bank of England until January 1888. Thus, I break the sample at that point.[54] For 1881-1888, when country borrowers were charged Bank Rate, the coefficient on Bank Rate is negative. For 1888-1913

[53] Bank policymakers approved the change in policy on August 24, 1890 (Bank of England Court of Directors, Minutes July 24th, 1890,p.61). I assume the new policy could have affected changes in discounts and advances to the week of August 9, 1890.

[54]The policy was extended to Bank branches in January 1888 (Bank of England Court of Directors, Minutes January 26th 1888, p. 171).

the coefficient on Bank Rate is not significantly different from zero. The other coefficients show that country borrowing was now positively correlated with the spread between the London overnight rate and the London bill rate. I have no explanation for this.

4.4) Tests: weekly changes in the call-money rate

Equations (1.6)-(1.9) imply that the call money rate on a Friday, in terms of reserve quantities on the preceding Wednesday, is approximately:

$$(1.12)\; i^{O}_{Fri} \approx -\frac{1}{\alpha+\omega}\Big[\,(R^{S}-D)_{Wed}-(1-\mu_{Wed})D_{Wed}+\omega Z_{Fri}+(\alpha-\eta_{-1})\,i^{B}_{Fri}+\omega i^{BR}_{Fri}+\eta_{-1}\,i^{*}_{Fri}+e^{i}_{O}\,\Big]$$

where

$$e^{i}_{Fri}=(T-S+N+F-B)_{Fri}-(T-S+N+F-B)_{Wed}+\beta M_{Fri}-\alpha\tau_{Fri}+\epsilon^{RD}_{Fri}+\omega\epsilon^{A}_{Fri}-\epsilon^{D}_{Fri-Wed}$$
$$-\sum_{g=3}^{g=k}\eta_{g}\,(i^{B}_{d-g}-i^{*}_{d-g})+\epsilon^{G}_{Fri-Wed}$$

In (1.12) I account for the fact that Friday's reserve supply is equal to Wednesday's in the Bank's balance sheet, plus the change since Wednesday in discount houses' outstanding advances and rediscounts and changes since Wednesday in other reserve-supply factors. All of the variables in these two equations are observable weekly except for the components of the *e*'s. One approximation is that I take Friday interest rates to stand in for interest rates over all days between Wednesday and Friday. Another is that I take clearings for the week ending Wednesday to be a proxy for Z on the Friday within that week.

Table 4 shows results of regressions corresponding to first-differences of (1.12). I add dummy variables for the weeks of each year (the ends of December and June) when banks window-dressed their balance sheets, and the following weeks. The model predicts that the coefficient on Wednesday reserves *less* credit to discount-houses ($\Delta(R^{S}-D)_{Wed}$) should be negative. The coefficient on Wednesday discount-house credit (ΔD_{Wed}) should also be negative but smaller in magnitude due to

runoffs between Wedneday and Friday. The coefficient on clearings (ΔZ) should be positive due to the effect of settlement uncertainty on reserve demand. The coefficient on the bill rate should be positive, reflecting the effect of expected future overnight rates on reserve demand. The coefficient on Bank Rate should be positive because a higher value of Bank Rate tends to reduce reserve supply by reducing discount-house borrowing from the Bank between Wednesday and Friday. I include the foreign bill rate Δi^* on the right-hand side to allow for an effect of the Thursday-Friday bill rate on gold inflow (hence reserve supply) since Wednesday (η_{-1}). But given lags in gold shipment I would expect such an effect to be negligible. Estimated coefficients may be biassed relative to coefficients in (1.9), since there may be correlations between observables and components of e_{Fri}. Fluctuations in the bill-rate term premium τ, for example, would tend to reduce the regression coefficient on the bill rate.

For column (1) the sample is 1881-1890 and I take London advances to represent discount-house borrowing *D*. For (2) the sample is 1890-1914 and I continue to take London advances to be discount-house borrowing; for (3) I use London advances *plus* rediscounts. Results are generally as predicted. For (4) and (5) I include crisis weeks in the sample. (There were no crisis weeks within 1881-1890.) Results are about the same.

4) Conclusion

The policy implementation system of the pre-1914 Bank of England was essentially similar to modern systems. The crux of the system was the open-market overnight rate, which was determined by the interaction of reserve demand and supply. The bill rate mainly reflected expected future overnight rates. Reserve demand appears to have been affected by expected future overnight rates as in 1990s New Zealand and the United States in the 1970s-90s.

Given that the fundamentals of the system were similar, there may be lessons for policymakers in the different feature of the Bank's system: its facility for lending to discount houses at longer-than-

overnight maturities. This facility was not the same as the facility that covered shortfalls in banks' reserve accounts (whatever it was). It seems to have been free from the problem of stigma, even though Bank lending to banks *was* subject to stigma and discount houses, like banks, took unsecured deposits. I can only speculate as to why. In 1866, just prior to the period I examine, the failure of Overend, Gurney, a firm known as a discount house, had touched off a massive financial panic in London (King 1936: 214-216; 242-256; Flandreau and Ugolini 2013). Perhaps it is relevant that Overend,Gurney had not been borrowing from the Bank in the run-up to this crisis (it occurred before the Bank lent regularly to discount houses). Also, Overend, Gurney was perceived to have failed only partly because of capital losses in its discount business; a bigger problem was bad investments in long-term, illiquid assets. In later years, as noted above, discount houses held only liquid assets. Perhaps it matters that discount houses were entirely independent from banks, small and capital-constrained, so that it was practically impossible for one to operate *without* frequent resort to the facility - it was hard for any other equilibrium to develop. Certainly, more research is needed to determine whether the desirable characteristics of this facility, and discount houses as an institution, could be reproduced today.

Finally, there is evidence that Bank Rate affected the term premium in bill rates. It is clear that this effect, if it existed, did not interfere with the smooth operation of the overnight lending market or the bill market, and did not require massive Bank purchases of bills. It is plausible that effect operated through the channel that today's proponents of "yield curve control" have in mind, that is manipulation of the perceived variance-covariance characteristics of future asset prices. But Bank Rate was linked to the structure of British interest rates in many peculiar ways, so other channels are possible.

Appendix 1 Model of overnight-rate determination

Modern systems

For a simple example, let $\overline{i}$ denote the rate charged for overnight credit from the central bank. $\underline{i}$ is the interest rate paid on reserves.[55] R is the balance a bank aims to have in its reserve account at the end of a day. The balance actually left in the account after final clearing is $R+\delta$, where δ is the unpredictable component of net payments. A bank has a probability distribution for δ with a minimum value $-\underline{\delta}$, a maximum $\overline{\delta}$, a c.d.f. $F\{X\}$, a p.d.f. $f\{X\}$, the inverse of the c.d.f. $G(X)$ and $H(x)=E[\delta \mid \delta < x]$. Note that $G'(X)>0, H'(x)>0$. A bank suffers a shortfall in its account if $R+\delta<Q$, where Q is equal to the portion of the reserve requirement that was not covered on earlier days of the maintenance period, or zero if there is no reserve requirement. In the event of a shortfall the bank must cover the shortfall with borrowing $B=Q-R-\delta$. Given R, prior to the realization of δ, the expected value of borrowing is:

$$E[B]=\int_{-\underline{\delta}}^{-R}(Q-R-\delta)f\{\delta\}d\delta=F\{-R\}(Q-R-H(-R)) \tag{1.13}$$

A bank chooses R to minimize the expected value of the opportunity cost of holding reserves, net of interest earned on reserves, plus the cost of any borrowing from the central bank to cover a reserve-account shortfall:

$$iR+\int_{-\underline{\delta}}^{-R+Z}\overline{i}(Q-R-\delta)f\{\delta\}-\int_{-R+Z}^{\overline{\delta}}\underline{i}(R+\delta-Q)f\{\delta\} \tag{1.14}$$

If $i=\underline{i}$ a bank holds a reserve balances big enough to completely eliminate the danger of a reserve shortfall: $R^D \geq Q+\underline{\delta}$. If the market overnight rate is between $\underline{i}$ and $\overline{i}$,

$$R^D=Q-G\left(\frac{i-\underline{i}}{\overline{i}-\underline{i}}\right) \text{ for } \underline{i}\leq i\leq\overline{i} \tag{1.15}$$

Thus, reserve demand is negatively related to the overnight rate, positively related to $\underline{i}$ and $\overline{i}$.

On the simplifying assumption that all banks are identical, setting R^D equal to nonborrowed reserve supply per bank R^S determines the market overnight rate:

[55] For overnight-rate determination and control it does not matter whether $\overline{i}$ is paid on all reserve balances, or just on a bank's "excess" reserves, that is a bank's reserve balance minus its required minimum balance.

$$
\begin{aligned}
& i = \underline{i} + F\{Q - R^S\}(\overline{i} - \underline{i}) \qquad for \quad Q - \overline{\delta} \le R^S \le Q + \underline{\delta} \\
& i = \underline{i} \qquad for \quad Q + \underline{\delta} < R^S \\
& i = \overline{i} \qquad for \quad R^S < Q - \overline{\delta}
\end{aligned}
\tag{1.16}
$$

To keep the market overnight rate at a target i^T, one thing the central bank can do is is set $\underline{i} = i^T$ and $R^S \ge Q - \underline{\delta}$. That is the floor system. Alternatively, the central bank can set $\overline{i}$ and $\underline{i}$ to form a band around the target i^T (e.g. $\overline{i} = i^T + s$, $\underline{i} = i^T - s$), and supply the quantity of nonborrowed reserves given by (1.14) with $i = i^T$. That is the corridor system.

Relevant for pre-1914 London: rationing central-bank credit by borrowing frequency

To describe pre-1914 London, suppose there is no reserve requirement ($Q = 0$) and no interest paid on reserve balances ($\underline{i} = 0$). The rate charged by the central bank for overnight credit to banks is the day's market rate ($\overline{i} = i$) but the central bank *rations* overnight credit in a way that adds an implicit extra cost ϕ to the explicit interest rate charged. Then reserve demand is:

$$
R^D = -G\left(\frac{i}{i+\phi}\right) = -G\left(\frac{1}{1+\phi/i}\right) \quad for \;\; 0 \le i
\tag{1.17}
$$

Given R^D the probability that a bank will incur an overdraft is equal to the ratio of the market overnight rate to the total borrowing cost:

$$
F\{-R^D\} = i/(i+\phi)
\tag{1.18}
$$

Thus, one can infer the magnitude of the cost created by rationing from the freqneucy of bank borrowing to cover overdrafts. If banks borrow very infrequently the extra rationing cost ϕ must be high relative to the market overnight rate. Poole (1968: 783-84) shows that when overdrafts are costly in this way an increase in the degree of uncertainty about the end-of-day net payment δ - an increase in the dispersion of the bank's distribution for δ - will increase reserve demand.

Finally, suppose that the central bank rations credit by limiting the *frequency* of a bank's borrowing from the central bank: a bank that borrows on a given day may lose access to central bank overnight credit for a number of days, and it is more likely to lose access the more it borrows. Then reserve demand on a day is determined by the day's market overnight rate relative to expected future overnight rates. For a simple example let the distribution for the unpredictable payments component δ be *fixed* and the number of days a borrowing bank may lose access to credit be *one*. Thus if a bank

borrows *B* dollars in the current period *t*, this period, there is a probability πB_t that the bank will lose access to credit for the upcoming period *t+1*. (π must be scaled so that $\pi B < 1$ within the possible range of borrowing.) The penalty for running an uncovered reserve deficiency is prohibitively high, so a bank that has lost the option to borrow in a period will hold a reserve balance large **e**nough to eliminate the danger of a reserve shortfall: that is a reserve balance equal to $-\underline{\delta}$. A bank that *can* borrow in a period chooses *R* to minimize the expected present value, across present and all future periods, of the sum of the costs of borrowing and opportunity costs of holding reserves. This is equivalent to minimizing (1.13) with an extra cost per dollar of borrowing equal to:

$$\phi_t = \pi \tfrac{1}{1+i_t} E\left[i_{t+1}\ \underline{\delta} - \left(i_{t+1} R_{t+1} + (i_{t+1} + \phi_{t+1}) B_{t+1} \right) \right] \tag{1.19}$$

Using the approximation that $1/(1+i) \approx 1$,

$$\phi_t \approx \pi\ E\left[i_{t+1} \left(\underline{\delta} + H\left(G\left(\frac{1}{1+ \phi_{t+1} / i_{t+1}} \right) \right) \right) \right] \tag{1.20}$$

ϕ_t depends on the public's expected values for tomorrow's overnight rate i_{t+1} and tomorrow's extra cost ϕ_{t+1}. The latter must in turn reflect expectations of overnight rates and extra costs in the further future.

To go further I take loglinear approximations around an assumed long-run steady state. Let i_t^T denote the public's expected value for the overnight rate in a long-run future period *T* and subsequent periods. Then the expected value of the extra borrowing cost that will prevail in period *T* and subsequent periods is a multiple of i_t^T :

$$\phi_t^T \approx i_t^T Z \tag{1.21}$$

where *Z* is defined by π and the distribution for δ :

$$Z = \pi\left[\underline{\delta} + H(G(\tfrac{1}{1+Z})) \right] \tag{1.22}$$

The long-run future value of R^D is:

$$R^T \approx -G(\tfrac{1}{1+Z}) \tag{1.23}$$

Let $\tilde{x}_{t+\tau}$ denote the expected value for the deviation of the log of a variable *x* at time $(t+\tau)$ from the log of its expected long-run future value value. Given the necessary scaling of π :

(1.24) $$\tilde{\phi}_t \approx (1+a)\tilde{i}_{t+1} - a\tilde{\phi}_{t+1} \quad where\ 0 < a = \frac{H'(-R^T)}{\underline{\delta} + H(-R^T)} G'(\tfrac{1}{1+Z}) \frac{Z}{(1+Z)^2} < 1$$

Solving back from period *T*,

(1.25) $$\tilde{\phi}_t \approx (1+a)\tilde{i}_{t+1} - a(1+a)\tilde{i}_{t+2} + a^2(1+a)\tilde{i}_{t+3} - a^3(1-a)\tilde{i}_{t+4} ..... + a^{T-1}\tilde{i}_{t+T-1}$$

Finally, suppose that the public's expectations about future overnight rates correspond to beliefs that the current deviation of i_t from i_t^T has two components: an i.i.d component (no correlation from day to day) and a persistent AR(1) component so that $E_t[\tilde{i}_{t+1+\tau}] = \rho^\tau E_t[\tilde{i}_{t+1}]$. Then:

(1.26) $$\tilde{\phi}_t \approx b\ E[\tilde{i}_{t+1}] \qquad where\ b = \frac{1-a\rho}{1-(a\rho)^2}(1+a)$$

The extra cost of borrowing due to frequency rationing is determined by the expected future overnight rate. Note that *b* approaches one as deviations of *i* from i_t^T become more persistent (that is as ρ approaches one). For a bank that can borrow this period, reserve demand is negatively related to today's overnight rate, positively related to the expected value of tomorrow's overnight rate:

(1.27) $$\partial R_t^D \approx -\,c\left(\frac{1}{i_t}\partial i_t \;-\; \frac{b}{E[i_{t+1}]}\,\partial E_t[i_{t+1}]\right) \quad where\ c = \left(\frac{1}{1+Z}\right)^2 G'\big(1/(1+Z)\big)$$

Appendix 2 Model of term premiums

Following Vayanos and Vila, consider a model in which there are two types of asset: liquid zero-coupon bonds (or bills) paying off at various maturities; and overnight loans available in any quantity at an exogenously determined interest rate. The overnight rate is somewhat unpredictable so bond prices are subject to duration risk. Investors are of two types: preferred-habitat, investors, and arbitrageurs. A preferred-habitat investor demands bonds at just one maturity. His demand for bonds at that maturity depends only on exogenous factors and that asset's own interest rate or yield. An arbitrageur may hold assets at any maturity and is risk-averse with "mean-variance" preferences (as in Sharpe's [1964] Capital Asset Pricing Model). In the absence of arbitrageurs, bond demands of preferred-habitat investors would create a term structure of bond yields unrelated to expected future overnight rates. As arbitrageurs borrow overnight to buy bonds, they pull bond yields toward expected future overnight rates. But because arbitrageurs are risk-averse, in equilibrium there must be term premiums to compensate them for taking on duration risk.

Following Hamilton and Wu (2014), set the model in discrete time. A period is a day. An arbitrageur, indexed by *j*, maximizes:

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

where W_j is the arbitrageur's wealth. Following Greenwood and Vayanos (2014), allow for a negative relationship between wealth and the risk-aversion parameter a_j. To simplify notation let $a_j = a / W_j$ specifically. The resulting objective function implies that an arbitrageur wants to avoid variance in the value of his assets net of liabilities, that is his capital, in ratio to the current value of his capital.

Given (1.25) and common beliefs, all arbitrageurs hold the same portfolio of risky bonds. r_t is the spread between the expected return to holding this portfolio overnight (from *t* to *t+1)* and the overnight rate i_t (expressed on a daily basis). r_{kt} is the spread between the expected overnight return to holding a particular bond *k* and r_t. Normalizing the final payoff of a zero-coupon bond to one, its log price is approximately:

(1.29) $$p_{kt} \approx E_t \left[\sum_{\tau=0}^{d_k} \left(i + r + r_k \right)_{t+\tau} \right]$$

where d_k is the bond's duration in days. Its yield to maturity is:

(1.30) $$i_{kt} \approx \frac{1}{d_k / \zeta} E_t \sum_{\tau=0}^{d_k} i_{t+\tau} + \tau_{kt}$$

where ζ is the number of market days in a year. The first term on the right-hand side of (1.27) is the expected value of the average overnight rate over the lifetime of the bond. τ_k is the term premium. It has two components:

(1.31) $$\tau_{kt} \approx \frac{1}{d_k / \zeta} E_t \sum_{\tau=0}^{d_k} \left(r + r_k \right)_{t+\tau}$$

r is a component common to bonds of all maturitities. r_k is specific to bonds of maturity *k*.

The common component *r* is the spread between the overnight rate and the expected return to the bond portfolio. It is determined by the interaction of arbitrageurs' demand with demand of preferred-habitat investors and bond supply. An increase in arbitrageurs' demand for bonds at a given value of *r* tends to raise bond prices, lowering *r*. The total value of bonds arbitrageurs desire to hold is (from maximization of (1.25)):

(1.32) $$V_t = W_t \frac{1}{\eta_t a} \frac{r_t}{(1+i+r)_t^2} \quad where \quad \eta_t \approx \sigma_{t+1}^2$$

where W is total arbitrageurs' wealth and σ_{t+1}^2 is the perceived variance of the log of tomorrow's value of the portfolio. (η_t is, exactly, the variance of tomorrow's portfolio value divided by the square of its expected value.) (1.29) shows that a decrease in the perceived variance of log portfolio value tends to increase arbitrageurs' demand for bonds. Hence it tends to decrease *r,* the common component in term premiums.

The maturity-specific component r_k is determined by the relationship between day-to-day variations in the value of the bond, and variations in the value of the whole bond portfolio:

(1.33) $$r_{kt} = (\beta_{kt} - 1) r_t \quad where \quad \beta_{kt} \approx \frac{\sigma_{kp,t+1}}{\sigma^2_{t+1}}$$

where $\sigma_{kp,t+1}$ is the perceived covariance of the log portfolio value with the log value of bond *k*. (β_{kt} is, exactly, the covariance of the realized overnight return to holding bond *k* with the portfolio return. The approximation holds for realistically small values of *i* and *r.*) Thus, a decrease in covariance of a specific maturity's value with that of the entire bond portfolio reduces the term premium at that maturity.

Based on this model, it is argued (e.g. D'Amico et. al. 2012:425-26; Joyce et. al. 2012:F279) that QE operations affect term premiums in bond yields by affecting short-run variance in the value of the public's bond portfolio, and/or covariance between the value of the portfolio and the value of bonds at a particular maturity. Posted minimum prices for bonds at specified maturities could operate in the same way.

Relevant for pre-1914 London: advances on bond collateral

A case relevant for pre-1914 London is where the central bank makes a standing offer to lend on specific types of bonds as collateral, at a maturity longer than overnight. Like posted prices for bonds, this should tend to reduce term premiums. To see this let i^{BR} denote the rate charged for such loans and d_A be the term of the loans. Then tomorrow's price of an eligible bond (with a face value again normalized to one) cannot fall below:

(6) $$\underline{p}_{kt+1} \approx -d_A i^{BR}{}_{t+1} - E_{t+1}\left[\sum_{\tau=d_A}^{d_k} \left(i + r + r_k\right)_{t+\tau}\right]$$

The existence of this constraint on tomorrow's bond price can reduce term premiums in two ways. First, it should reduce the maturity-specific term premium for an eligible asset as it reduces covariance between tomorrow's value of the eligible bond and the value of the portfolio. Second, if enough assets in the portfolio are eligible, the central bank's lending offer may reduce variance in the value of the portfolio and hence the common component in term premiums.

Appendix 3 Data

Market discount rates for prime three-month bills from the *Economist*, taken from the Neal and Wiedenmier (2005) database. I average bid and ask rates. I made corrections to some erroneous values in the database.

Call money rates from the *Economist*, values from 1890 to 1913 kindly provided by Stefano Ugolini, other values collected by me.

Clearing house volume. From *The Economist*, total clearing for weeks ending Wednesday.

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Figure 1 Bank Rate and three-month prime bill money rate, December 1881-March 1914, weekly (Friday)

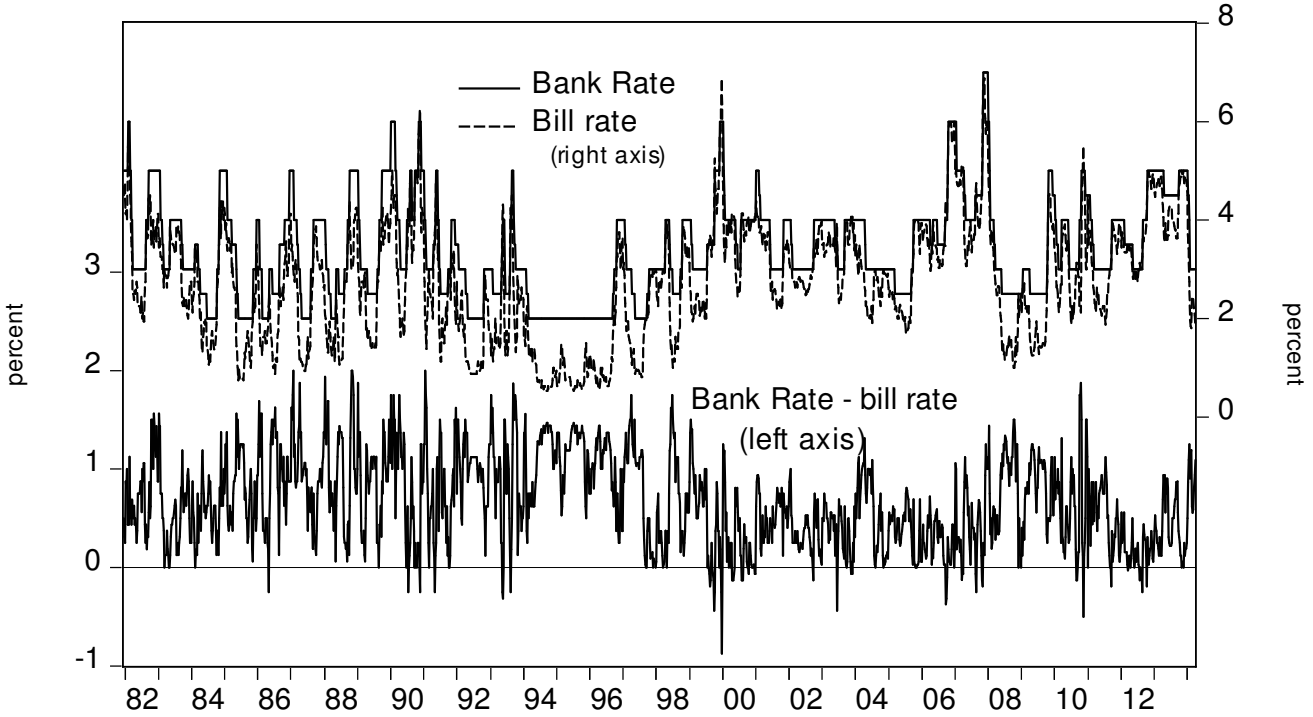

Figure 2 Bank Rate and call money rate, December 1881-March 1914, weekly (Friday)

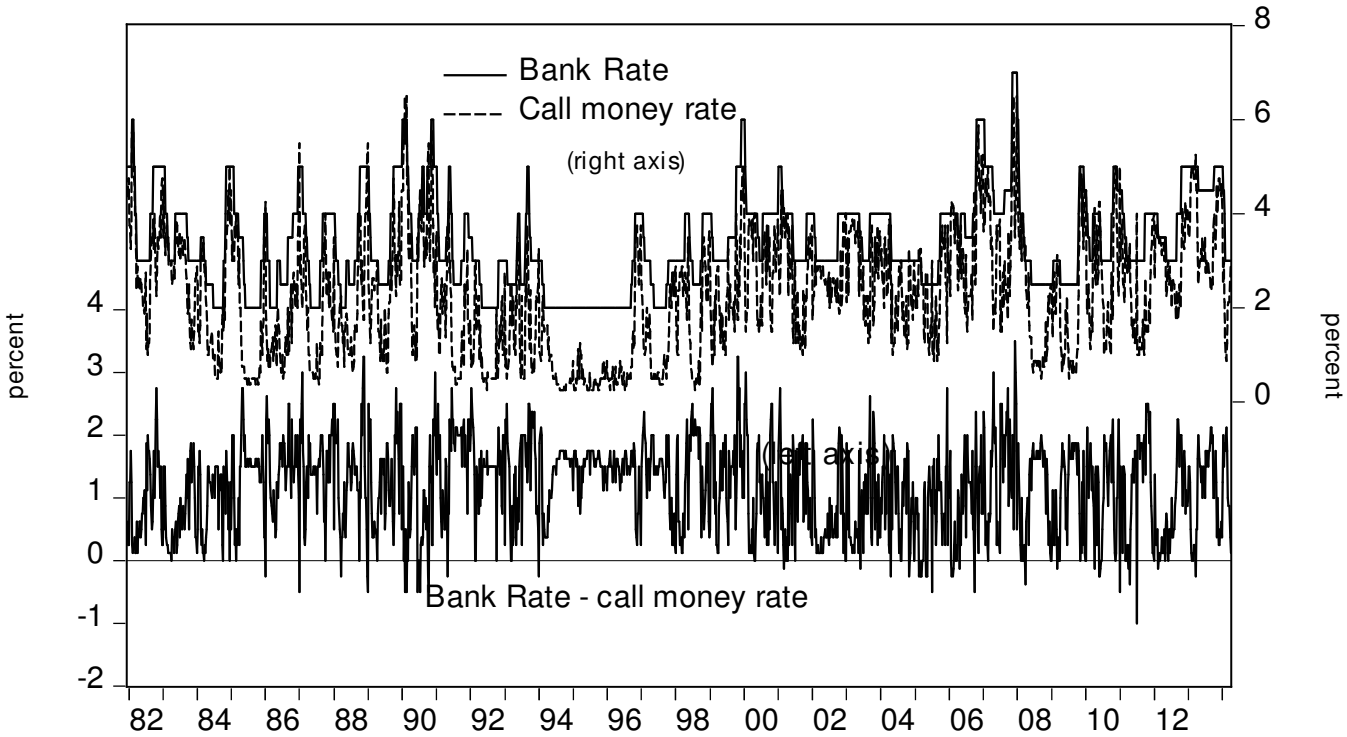

Figure 3

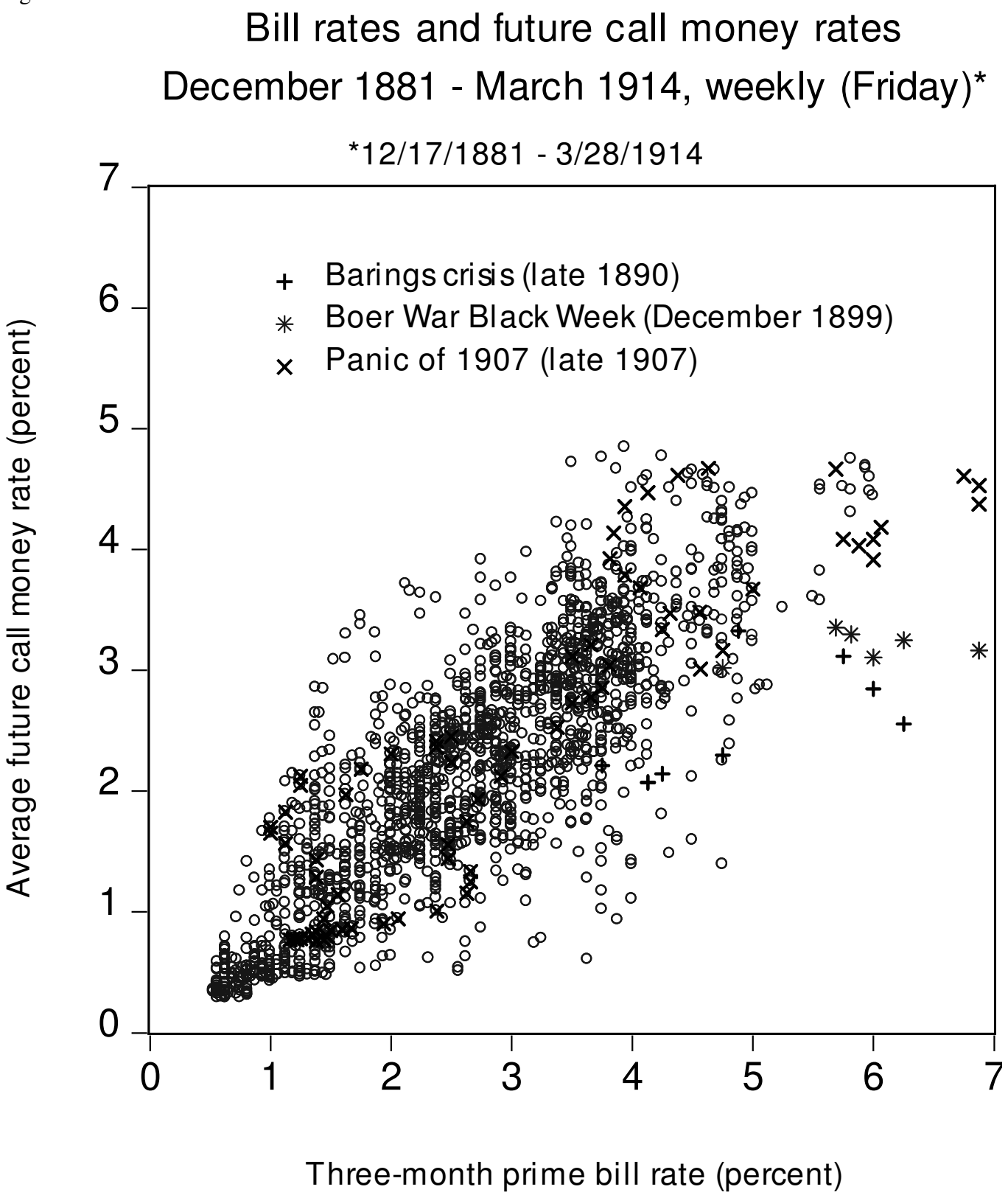
Bill rates and future call money rates
December 1881 - March 1914, weekly (Friday)*
*12/17/1881 - 3/28/1914
Barings crisis (late 1890)
Boer War Black Week (December 1899)
Panic of 1907 (late 1907)
Average future call money rate (percent)
Three-month prime bill rate (percent)
0
1
2
3
4
5
6
7

Figure 4

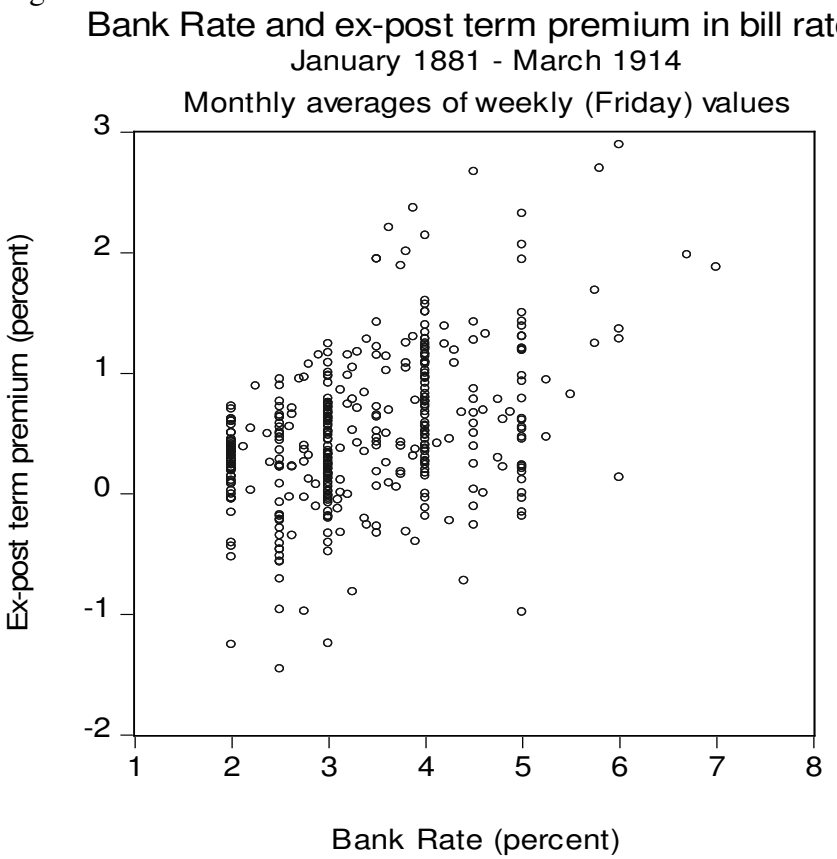

Figure 5

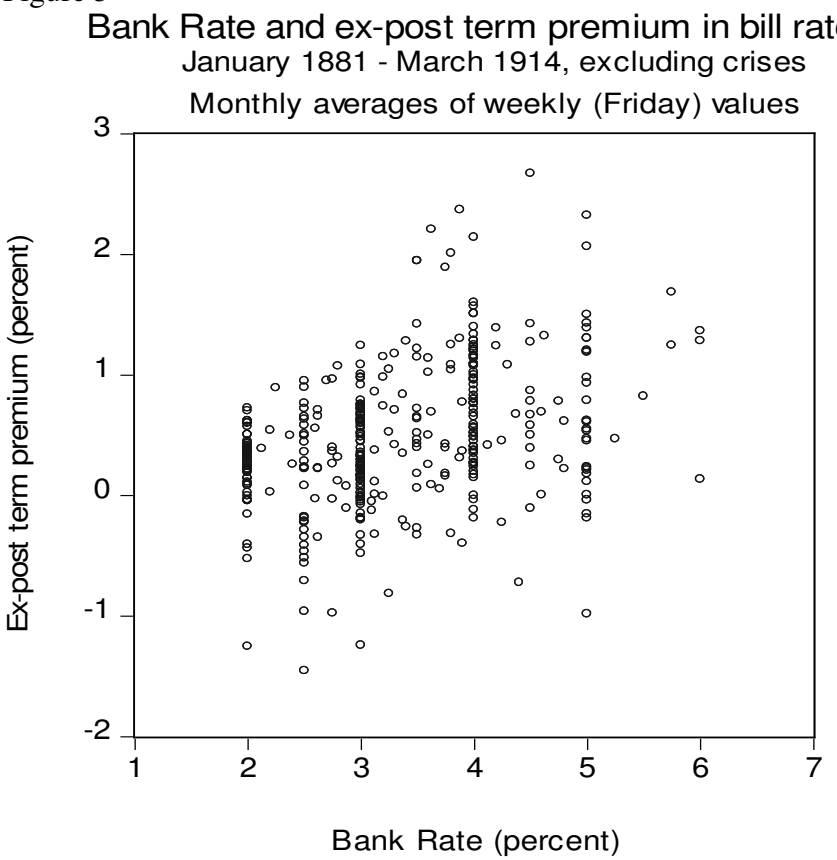

Figure 6

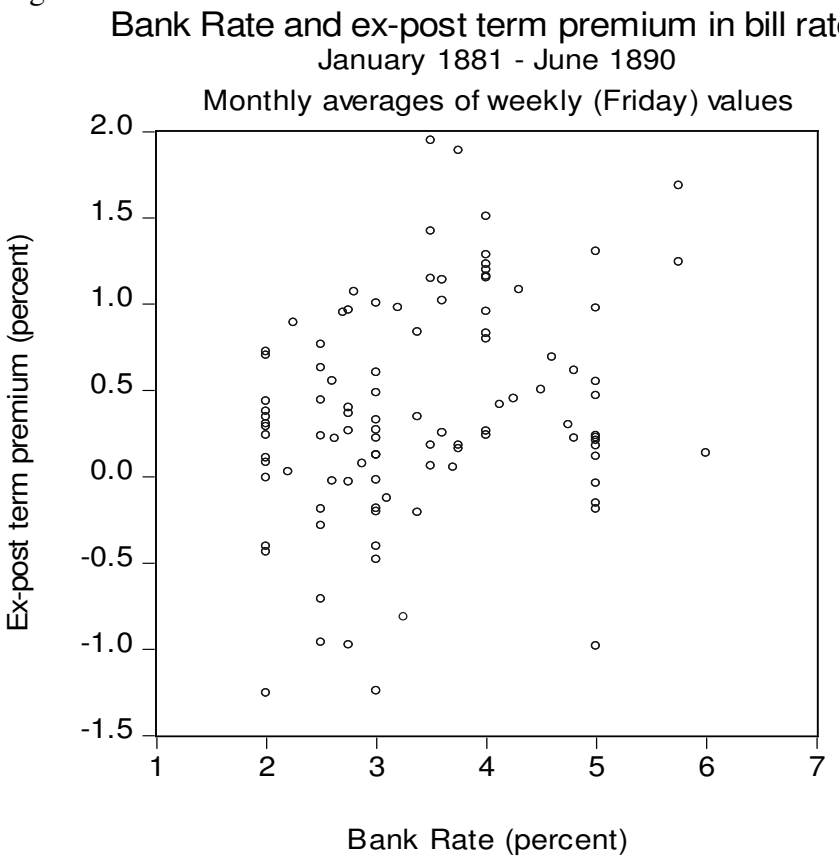

Figure 7

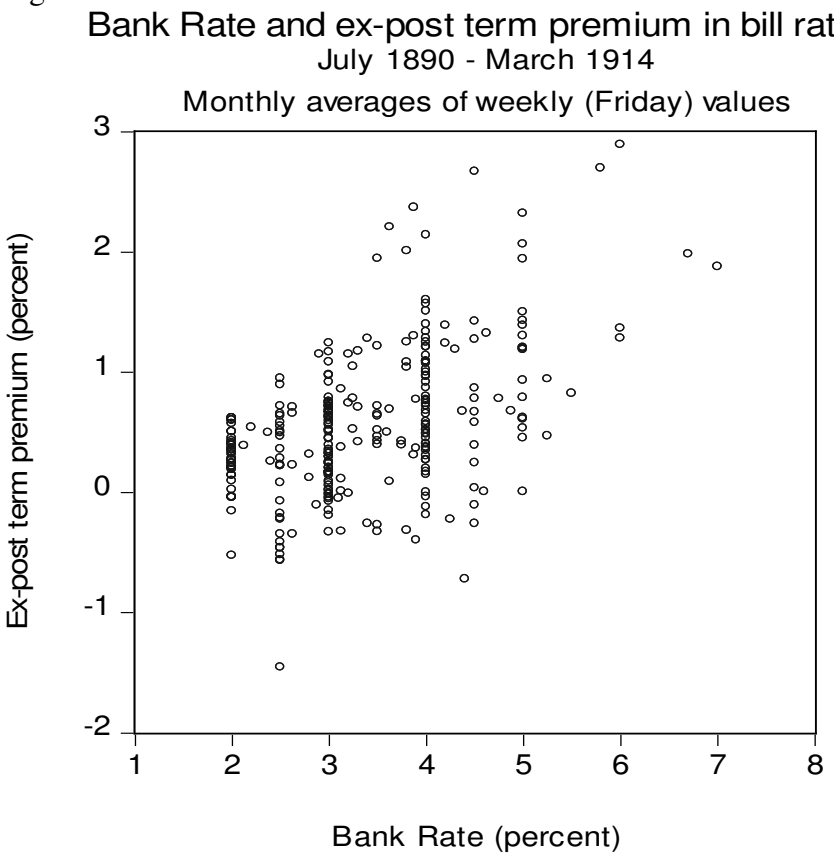

Table 1 Bank Rate and ex-post term premium in bill rate
January 1881-March 1914, excluding crises
Monthly averages

Coefficient
[SE]
p-value

Coeff.	January 1881 - June 1890				July 1890 - March 1914			
on	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i^{BR}	0.389	0.367	0.364	0.369	0.386	0.456	0.449	0.456
	[0.086]	[0.090]	[0.090]	[0.088]	[0.051]	[0.054]	[0.054]	[0.054]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
i^{Consol}		2.583	1.880			0.008	-0.419	
		[1.576]	[0.855]			[0.910]	[0.153]	
		0.10	*0.03*			*0.99*	*0.01*	
i^{RR}		-0.545		0.711		-0.368		-0.361
		[0.977]		[0.521]		[0.765]		[0.130]
		0.58		0.18		0.63		0.01
N. obs.	103	103	103	103	264	264	264	264
$\bar{R}^2$	0.48	0.49	0.50	0.48	0.46	0.47	0.47	0.47

Table 2 Long-run relationship between reserve supply and interest rates, December 1881-June 1914 excluding crisis periods December 1890, December 1899, December 1907

Coefficient
[Robust (White) SE]
p-value

June, December

	(1)	(2)	(3)	(4)	(5)	(6)
i^O	-0.111	-0.111	-0.043		-0.048	-0.045
	[0.047]	[0.046]	[0.033]		[0.021]	[0.034]
	0.02	*0.02*	*0.20*		*0.02*	*0.19*
i^B	0.120	0.085		0.019		
	[0.05]	[0.043]		[0.038]		
	0.01	*0.05*		*0.62*		
i^{BR}	-0.043		0.022	-0.041		-0.005
	[0.035]		[0.037]	[0.041]		[0.035]
	0.23		*0.55*	*0.32*		*0.88*
i^*					0.046	0.048
					[0.026]	[0.025]
					0.08	*0.06*
Ln(D)	0.366	0.372	0.397	0.394	0.368	0.367
	[0.086]	[0.084]	[0.088]	[0.097]	[0.082]	[0.083]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Time	0.006	0.005	0.006	0.008	0.009	0.009
	[0.010]	[0.009]	[0.010]	[0.012]	[0.009]	[0.009]
	0.57	*0.58*	*0.58*	*0.47*	*0.31*	*0.31*
Time sqr./ 1000	0.112	0.116	0.120	0.096	0.844	0.083
	[0.092]	[0.091]	[0.096]	[0.102]	[0.858]	[0.087]
	0.23	*0.21*	*0.22*	*0.35*	*0.33*	*0.35*
June	0.00	0.009	0.014	0.017	0.012	0.011
	[0.024]	[0.023]	[0.023]	[0.026]	[0.474]	[0.025]
	0.97	*0.69*	*0.56*	*0.52*	*0.63*	*0.67*
N. obs.	63	63	63	63	63	63
R^2	0.95	0.94	0.94	0.94	0.94	0.94

Table 3 Determinants of advances and discounts, excluding crisis weeks

Coefficient
[Robust (White) SE]
p-value

	London				Country	
	1881-1890		1890-1914		Advances + discounts	
	Advances	Discounts	Advances	Discounts	1881-1887	1888-1914
	(1)	(2)	(3)	(4)	(5)	(6)
D_{-1}	0.451	0.932	0.70	0.914	0.933	0.996
	[0.056]	[0.018]	[0.040]	[0.016]	[0.033]	[0.002]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	
i^O	0.859	0.018	0.794	0.140	0.013	0.058
call money	[0.139]	[0.007]	[0.121]	[0.035]	[0.017]	[0.008]
rate	*0.00*	*0.01*	*0.00*	*0.00*	*0.43*	*0.00*
i^B	-0.074	0.099	-0.156	0.426	0.038	-0.066
bill rate	[0.159]	[0.014]	[0.168]	[0.057]	[0.027]	[0.013]
	0.64	*0.00*	*0.35*	*0.00*	*0.15*	*0.00*
i^{BR}	-0.617	-0.118	-0.630	-0.618	-0.051	0.021
Bank Rate	[0.112]	[0.015]	[0.209]	[0.069]	[0.014]	[0.014]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.13*
N. obs.	451	451	1197	1197	319	1328
R^2	*0.49*	*0.95*	*0.54*	*0.90*	*0.91*	*0.99*

Table 4 Determination of weekly changes in the call-money rate, 1881-1914

Coefficient

LHS variable: Δi^{O}_{Fri} [Robust (White) SE]

p-value

		Exc. crisis weeks 1881-1890		Inc. crisis weeks 1881-1914	
	1881-1890	adv. only	disc+adv	adv. only	disc+adv
	(1)	(2)	(3)	(4)	(5)
$\Delta(R^S - D)$	-0.142	-0.102	-0.103	-0.098	-0.106
	[0.025]	[0.011]	[0.012]	[0.010]	[0.012]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*
ΔD	-0.075	-0.049	-0.056	-0.040	-0.058
	[0.029]	[0.008]	[0.008]	[0.007]	[0.008]
	0.01	*0.00*	*0.00*	*0.00*	*0.00*
ΔZ	0.145	0.148	0.148	0.152	0.154
(clearings)	[0.056]	[0.369]	[0.037]	[0.037]	[0.038]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*
Δi^{B}	0.731	0.80	0.801	0.821	0.808
(London bills)	[0.108]	[0.082]	[0.082]	[0.079]	[0.079]
	0.00	*0.00*	*0.00*	*0.00*	*0.00*
Δi^{BR}	0.310	0.246	0.218	0.242	0.197
(Bank Rate)	*[0.110]*	[0.102]	[0.101]	[0.098]	[0.097]
	0.00	*0.02*	*0.03*	*0.01*	*0.04*
Δi^{*}	0.075	0.082	0.067	0.087	0.056
	[0.116]	[0.080]	[0.080]	[0.080]	[0.081]
	0.52	*0.31*	*0.41*	*0.28*	*0.49*
December	0.373	0.243	0.212	0.339	0.0297
report	[0.237]	[0.124]	[0.123]	[0.130]	[0.128]
	0.12	*0.05*	*0.08*	*0.01*	*0.02*
Following	-1.037	-0.475	-0.448	-0.482	-0.413
week	[0.296	[0.157]	[0.157]	[0.149]	[0.154]
	0.00	*0.00*	*0.00*	*0.00*	*0.01*
June report	0.163	0.0665	0.668	0.650	0.666
	[0.149]	[0.181]	[0.183]	[0.180]	[0.183]
	0.27	*0.00*	*0.00*	*0.00*	*0.00*
Following	-0.425	-0.654	-0.645	-0.664	-0.641
week	[0.183]	[0.204]	[0.203]	[0.206]	[0.202]
	0.02	*0.00*	*0.00*	*0.00*	*0.00*
N. obs.	450	1197	1197	1233	1233
R^2	*0.53*	*0.42*	*0.42*	*0.42*	*0.43*