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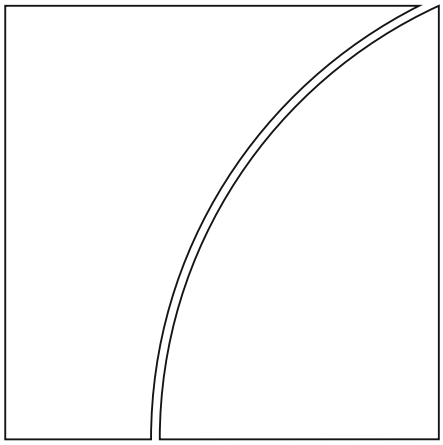

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Keywords: money markets; deregulation; market integration; monetary policy implementation; Eurodollars; Regulation Q

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Near-Money Premiums, Monetary Policy, and the Integration of Money Markets: Lessons from Deregulation

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The 1960s and 1970s witnessed rapid growth in the markets for new money market instruments, such as negotiable certificates of deposit (CDs) and Eurodollar deposits, as banks and investors sought ways around various regulations affecting funding markets. In this paper, we investigate the impacts of the deregulation and integration of the money markets. We find that the pricing and volume of negotiable CDs and Eurodollars issued were influenced by the availability of other short-term safe assets, especially Treasury bills. Banks appear to have issued these money market instruments as substitutes for other types of funding. The integration of money markets and ability of banks to raise funds using a greater variety of substitutable instruments has implications for monetary policy. We find that, when deregulation reduced money market segmentation, larger open market operations were required to produce a given change in the federal funds rate, but that the pass through of changes in the funds rate to other market rates was also greater.

Keywords: money markets; deregulation; market integration; monetary policy; Eurodollars; Regulation Q

JEL classifications: E50, G18, N22

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1. Introduction

The money market landscape has changed dramatically in recent decades. Easy access to short-term funding markets fueled the growth of the shadow banking sector, and these markets proved to be particularly vulnerable during the recent financial crisis. Subsequently, new regulations were introduced for important players in the money markets. For example, new liquidity rules encourage commercial banks to rely less on short-term financing and money market mutual funds to reduce the average maturity of the securities in which they invest.[1] Monetary policy developments have also affected money markets. In the United States, banking system reserves have grown enormously since December 2008, when the Federal Reserve lowered its federal funds rate target effectively to zero and subsequently engaged in large-scale asset purchases. Trading in the federal funds market has since diminished substantially and the counterparties most active in the market have changed. Market participants and policymakers are uncertain how a tightening of monetary policy and higher short-term interest rates might affect the federal funds market, or how closely linked the fed funds market will be to other money markets. This uncertainty is particularly great in light of other changes in the regulatory environment, such as the payment of interest on reserves, which influence the incentives of banks to borrow or lend in the federal funds market.

For insights into how money markets and the implementation of monetary policy are affected by changes in the regulatory environment, this paper examines bank funding markets in the 1960s and 1970s. This period witnessed considerable changes in regulation as well as an expansion in the types of securities available to market participants. Both Regulation Q, which put ceilings on the interest rates that banks could pay on deposits raised in the United States, and reserve requirements, which mandated that banks hold cash or balances at the Federal Reserve in proportion to certain types of liabilities, were changed multiple times during the 1960s and 1970s. Partly in response to these regulations, new money market instruments, such as negotiable certificates of deposit (CDs) and Eurodollars were introduced and their use grew rapidly. These new instruments allowed banks to circumvent regulations and access new wholesale funding markets, and thereby reduce their dependence on the federal funds market and domestic deposits for short-term funding.

This paper tests several hypotheses about the impact of changes in regulation and the availability of new funding sources. Money market instruments offered by the largest banks

[1] Some of the new regulation reference particular maturity points, for example by differentiating securities with maturities of more or less than 30 days. These reference maturity points could potentially create kinks in the money market yield curve.

the pricing and growth of negotiable CDs and Eurodollars reflected changes in the availability of safe, short-term public securities. We then examine whether banks adjusted their funding structures by substituting among different instruments in response to shifts in relative funding costs, at least to the extent permitted by extant regulations. Deregulation gave banks more flexibility to shift among alternative funding sources and promoted the integration of the various short-term funding markets. We test whether the integration of markets, in turn, affected the Federal Reserve's ability to influence the federal funds rate and thereby implement monetary policy.

We begin by investigating whether the new money market instruments displayed the characteristics of safe, near-money instruments as described in Gorton, Lewellen, and Metrick (2012); Krishnamurthy and Vissing-Jorgensen (2012, 2013); Carlson, Duygan-Bump, Natalucci, Nelson, Ochoa, Stein, and Van den Heuval (forthcoming); Gorton (2015); Greenwood Hanson and Stein (2015); and Sunderam (2015). This literature argues that investors have a preference, and will pay a "near money" premium, for assets that are safe, liquid, and easily convertible to cash. When the supply of risk-free and liquid public securities is insufficient to satisfy the demand for safe assets, private issuance of close substitutes will increase. Under this hypothesis, a decline in the supply of U.S. Treasury securities reduces the yields on those securities and close substitutes, but also tends to increase spreads between yields on privately-issued money market instruments and Treasury securities. Despite larger spreads, private firms will issue more securities because of the general decline in market rates. Thus, changes in the supply of Treasury securities should influence both the volume of private money market securities issued and the spreads between those instruments and comparable maturity Treasury securities. Following Greenwood et al. (2015) and Carlson et al. (forthcoming), we test whether the supply of Treasury bills in particular affected the use and pricing of negotiable CDs and Eurodollars in the 1960s and 1970s when those markets were in their infancy. We find that increases in the supply of Treasury bills reduced the spreads between the yields on private instruments and Treasury bills. Further, we find that issuance of negotiable CDs and Eurodollars grew more rapidly when Treasury bills were relatively scarce. Thus, our results show that even in the early years of these markets, pricing and volumes responded similarly to what the literature has found for money markets in more recent times.

Our research also finds that banks responded to incentives affecting their use of private money market securities by altering their issuance of other types of liabilities. Specifically, we find that changes in the supply of Treasury bills, as well as other factors influencing the issuance of CDs and Eurodollars led banks to adjust the composition of their liabilities, but not the growth of total bank liabilities. Thus, at least in the short run, money market developments did

not bring about changes in total bank leverage. This evidence is consistent with Gorton, Lewellen, and Metrick's (2012) description of how wholesale funding instruments and demand deposits have generally been substitutes in the post-war period.

Finally, we investigate how money market developments affected the implementation of monetary policy.[2] The introduction of the new marginal funding sources might have made the demand for federal funds more elastic with respect to price, which would have affected the Federal Reserve's ability to influence the federal funds rate.[3] Further, because regulations affected the extent to which banks could substitute new funding sources for federal funds, we conjecture that changes in regulation likely affected both the impact of the Fed's open-market operations on the federal funds rate, and how tightly the federal funds rate and other money market rates were linked. We focus in particular on the impact of the permanent suspension of Regulation Q for negotiable CDs and Eurodollars with a maturity of 90 days or more in mid-1973 (Kreicher 1982). We also examine whether these relationships differed during periods when regulations were more binding, either because Regulation Q ceilings were below market rates or because reserve requirements related to money market instruments had been increased

We find evidence that when regulations were tighter, the federal funds rate was more sensitive to Federal Reserve actions to implement monetary policy—measured either as the change in the Fed's holdings of government securities or changes in non-borrowed reserves. Moreover, when Regulation Q was binding, the Fed's open- market operations had an especially strong impact on the federal funds rate. However, stronger impact did not necessarily translate into greater control; deviations of the market funds rate from the Fed's target rate were higher in the early period, particularly when Regulation Q was binding. We speculate that a binding Regulation Q disrupted the normal supply and demand relationships in the federal funds market by cutting off certain types of money market funding.

After regulations were relaxed, arbitrage between markets became easier and banks were better able to substitute one form of funding for another. We find that by the mid-1970s, larger open-market operations were required to effect a given change in the federal funds rate.

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[2] Concern about the impact of these markets on the effectiveness of monetary policy have been around almost as long as the markets themselves. Frydl (1979/1980) discusses some of the earlier debates about whether the Eurodollar market in particular might undermine monetary control. The impact of the Eurodollar market and other financial innovations on monetary policy and financial stability are also discussed in an early report of the Committee on the Global Financial System (1986).

[3] It should be remembered that during this period the Federal Reserve was much more opaque about its preferences for monetary policy and its target for the federal funds rate. Communication was much less important in shaping monetary policy, and open market operations that changed the level of bank reserves were more important in managing the federal funds rate.

However, changes in the federal funds rate also passed through to other markets to a greater extent so that the Federal Reserve was able to more directly influence general funding conditions.

Our findings have several important policy implications. In showing that the nascent Eurodollar and Negotiable CD markets displayed the characteristics of modern, well-developed money markets, our findings illustrate how financial innovations can arise rapidly in response to changes in the macroeconomic environment and regulation. Further, we provide evidence on how the quantity and pricing of default-risk free assets, such as Treasury bills, affect the incentives of financial firms to issue various types of liabilities, which in turn has potential implications for both financial stability and monetary policy. For example, in finding that government issuance of money market securities influences the premiums on and volumes of money market securities issued by private firms, our results show that the Federal Reserve, which provides short-term safe assets (reserves) in exchange for longer-term safe assets (typically Treasury securities) through its conduct of monetary policy, can impact money market premia and the volume of private activity in money markets.[4]

Perhaps more importantly, we show how regulations that affect one money market can have ripple effects on pricing and issuance in other markets, and affect the degree to which markets are integrated. We find that the degree to which private money markets were integrated resulted in a trade-off for the Federal Reserve in the implementation of monetary policy; when regulations limited the ability of financial institutions to arbitrage across money markets, the Fed appears to have had more influence on the funds rate but less impact on conditions in other markets. Recently, after a period of relatively light regulation of money markets and bank liquidity, the introduction of new rules appear to have caused money market spreads to widen and likely limited the ability of financial institutions to arbitrage across money markets.[5] Bech and Keiser (2012), Duffie and Krishnamurthy (2016) and others have suggested that the new regulations add frictions between markets that could reduce the degree to which money market conditions change in response to changes in monetary policy. Our results indicate that the regulations in place in the 1960s and early 1970s had this effect. Thus, as the Federal Reserve or other central banks consider "normalizing" their monetary policy frameworks, our research suggests that they should be mindful of how regulatory changes can

[4] See also the discussion in a 2015 report by the Committee on the Global Financial System.
[5] Kreicher, McCauley, and McGuire (2013) find that a shift in the FDIC deposit insurance assessment fee from being based on insured deposits to being based on total liabilities made banks less willing to arbitrage between the federal funds market and other wholesale funding markets. News reports, such as Alloway (2016), indicate that the changes to money market fund regulation have increased rates in some interbank money markets, though the longer term consequences of these changes are unclear.

alter the transmission of monetary policy through bank funding markets and thereby affect empirical relationships used to guide the implementation of policy.[6]

The paper proceeds as follows: Section 2 describes the key regulations and developments in money markets in the 1960s and 1970s, and discusses some previous literature on arbitrage between those funding markets. Section 3 reports our investigation of the pricing of money market instruments and issuance volumes. Section 4 discusses the impact of regulation on bank liability structures. Section 5 examines the responsiveness of the federal funds rate to actions by the Federal Reserve, and how the pass through from changes in the federal funds rate to other money market rates changed over time. Section 6 concludes.

2. Background

In this section, we first review the regulatory environment, and then discuss the early development and use of the new money market instruments. We then describe the growth of these markets in the 1960s and 1970s that bear on our empirical analysis.

2.1 Regulation

The Banking Acts of 1933 and 1935 required U.S. bank regulators to impose ceilings on the interest rates that banks pay on time and savings deposits. Interest rates on demand deposits were set to zero by statute. Regulation Q covered most other types of liabilities. The intent of rate ceilings was to keep banks from engaging in "destructive" interest rate competition for funding, which in turn might lead them to make riskier loans (Ruebling 1970). The Federal Reserve established ceilings for commercial banks that were members of the Federal Reserve System while the FDIC set them for non-member commercial banks. The ceilings were made applicable to savings and loan associations that were members of the Federal Home Loan Bank system in 1966. Collectively, the structure of deposit rate ceilings was referred to as Regulation Q. Initially, deposit interest rate ceilings were set well above the prevailing level of market interest rates, and they did not become binding until the late 1950s when market rates rose with rising inflation and economic growth (Ruebling 1970). The rules pertaining to Regulation Q were initially simple, but became more complicated over time. For example, by the 1970s, the ceilings on time deposits varied by deposit maturity and size. Notably for our purposes, the ceilings applied to deposits of more than $100,000 with

[6] Recently, in considering its long-run monetary policy framework, the FOMC has noted that it might need to adjust how it implements monetary policy in the future as "various aspects of U.S. money markets, which determine short-term interest rates and are important for transmitting monetary policy, have changed since the financial crisis." (Minutes of the Federal Open Market Committee July 26-27, 2016)

maturities typical of money market securities—which would include most negotiable CDs—were distinct from those on other time deposits. Ceiling rates were also adjusted over time, particularly when policymakers became concerned that banks might be at a competitive disadvantage for funds.[7]

Market interest rates continued to rise in the 1960s, causing Regulation Q ceilings to bind more frequently. Figure 1 shows the level of interest rates in the secondary market for 3-month negotiable CDs and the applicable Regulation Q ceiling. The regulation was binding during periods when the interest rate (blue line) exceeded the ceiling (red line).

Notably, Regulation Q did not apply to Eurodollar deposits, i.e., dollar-denominated deposits in both non-U.S. banks and overseas branches of U.S. banks. Thus, U.S. banks with offshore subsidiaries or branches could raise funds in money markets at competitive rates even when Regulation Q limited their ability to obtain funds by offering domestic deposits.

Interest rate ceilings remained in place on most deposits throughout the 1960s and 1970s. However, ceilings on negotiable CDs were first suspended and then eliminated in the 1970s. The first change occurred in 1970, following the bankruptcy of Penn Central Company. Penn Central had been a major issuer of non-financial commercial paper and the market reaction to its bankruptcy prevented other firms from issuing commercial paper. In response, the Federal Reserve suspended interest rate ceilings on large time CDs with maturities of less than 90 days to enable banks to raise funds to meet the liquidity needs of their business customers that were suddenly shut out of the commercial paper market (Carlson and Wheelock 2015). The ceiling was never reinstated. The Federal Reserve subsequently suspended Regulation Q for large time CDs with longer maturities in May 1973 (Cook 1978). Interest rate ceilings were phased out for other types of savings and time deposits in the 1980s.

Whereas Regulation Q limited the rates that banks could pay for domestic deposits, reserve requirements forced banks to hold reserves equal to a fraction of their deposit liabilities. The requirements imposed on Federal Reserve member banks were generally higher than those imposed on non-member banks and thrifts.[8] The reserve requirement, which creates a demand for reserve balances, and open market operations, by which the Federal Reserve

[7] Cook (1978) argues that about 90 percent of banks were paying rates at or near the regulation Q ceilings on their savings and small time deposits for much of the mid-1970s.
[8] State-chartered non-member banks also faced reserve requirements, but often less stringent ones than Fed members. The Monetary Control Act of 1980 subjected all depository institutions to the reserve requirements imposed by the Fed on member banks.

controls the stock of reserves, are basic elements of the Federal Reserve's implementation of monetary policy.[9]

Prior to 2008, banks earned no interest on their reserves held at the Fed.[10] Therefore, as market interest rates rose during the 1960s, banks increasingly sought to minimize their reserve balances by substituting away from domestic deposits toward liabilities that were subject to lower or no reserve requirements. Originally, Eurodollar deposits were not subject to reserve requirements. In October 1969, the Federal Reserve placed an indirect reserve requirement on Eurodollar deposits by requiring banks to hold reserves against amounts due to their foreign branches and agencies.[11] Reserve requirements on both Eurodollar deposits and negotiable CDs were changed multiple times throughout the 1960s and 1970s. At various times, the Fed lowered requirements on member banks to discourage banks from leaving the Federal Reserve System (Feinman 1993). Other changes in reserve requirements, such as adding the reserve requirement on Eurodollars, were intended to influence the relative attractiveness of different types of liabilities. We control for these changes in our empirical analysis.[12]

2.2 Money Market Innovations

The two most important money market innovations in the 1960s were the Eurodollar market and negotiable certificates of deposit (CD's). Schenk (1998) argues that the Eurodollar market originated from interest rate arbitrage, and reports that Midland Bank found that bidding for dollar funding in London, selling dollars in the spot market and buying them back in the forward market, provided a comparatively cheap source of funding. Other banks soon began bidding for these deposits as well. Both Schenk (1998) and Ferras (1969) noted that U.K. regulations helped spur the development of the market as prohibitions imposed in 1957 on the use of sterling to finance non-sterling-area trade encouraged British banks to obtain dollar funding in the Eurodollar market to finance their dollar based activities. American banks had

[9] See Carlson and Wheelock (2014) for a discussion of the use of reserve requirements as a monetary policy tool from the 1930s through the 1950s.
[10] Congress authorized the Federal Reserve to pay interest on reserve deposits under the Emergency Economic Stabilization Act of 2008, and the Fed's ability to vary that interest rate has become an important tool for influencing the federal funds rate (see Chen, Clouse, Ihrig, and Klee 2014).
[11] See Federal Reserve (http://www.federalreserve.gov/monetarypolicy/reservereq.htm). The Federal Reserve imposed reserve requirements on balances due from foreign branches in part to moderate the flows of foreign funds between U.S. banks and their foreign branches that affected the balance of payments, and to remove a special advantage to member banks that had been able to use Eurodollars as a means of avoiding credit restraints (for further detail see the *Annual Report of the Board of Governors of the Federal Reserve System* for 1969).
[12] Shortly before our sample period starts, in December 1959, the Fed began to count a bank's vault cash toward its required reserves. This change did have an important impact on the scarcity, and thus price, of reserves but mostly for small banks which were less likely to use the wholesale funding instruments studied here.

also become quite active in the market by the early 1960s (Schenk 1998). Although Eurodollars and other Eurocurrencies were present in a number of countries, the London market remained the largest.

U.S. bank regulations also contributed to the growth of the Eurodollar market. U.S. banks found Eurodollars a desirable source of funding because at first Eurodollar deposits were subject to neither reserve requirements nor Regulation Q ceilings. Eurodollar deposits proved to be a more dependable source of funds than domestic deposits when interest rate ceilings bound and domestic wholesale funding options dried up (Friedman 1971). The Eurodollar market was further spurred by the presence of a clientele that was particularly interested in holding dollars and investing in dollar assets outside the United States, such as eastern European governments that feared confiscation if they purchased assets in the United States (Friedman 1971). Kreicher (1982) reports that members of OPEC also generally preferred to place funds in the Eurodollar market, and that a large amount of petro-dollars flowed to the market in 1973 and again in the late 1970s. Nevertheless, Gilbert (1966) reports that, at least in the early years of the market, non-bank business corporations were both the largest suppliers and largest demanders of Eurodollar funds.

The Eurodollar market quickly became an important source of funds for many banks. Gilbert (1966) reports that U.S. banks were actively competing for funds in the market by 1966 and that Eurodollars were becoming an important source of their money market funding. Nevertheless, he notes that interest rates in the Eurodollar market and in New York would occasionally diverge, indicating that the markets were not completely integrated. Ferras (1969) points to the continued importance of Regulation Q as a wedge preventing full arbitrage. However, contemporaries observed that banks increasingly were able to substitute across different types of liabilities. Similarly, Ferras (1969) notes that when the Federal Reserve attempted to tighten policy in the late 1960s, U.S. banks turned to the Eurodollar market to maintain their borrowing. He reports that large U.S. money center banks in particular took advantage of their access to the Eurodollar market to relieve funding constraints. Ferras notes that regulators subsequently took steps to limit banks' use of Eurodollar funding, for example by placing reserve requirements on the liabilities of banks to their foreign branches, which included their Eurodollar funding.

Negotiable CDs were first issued in 1961 by First National City Bank of New York, and Discount Corporation, a government securities dealer, agreed to make a market for them (Ruebling 1970). The existence of a secondary market made negotiable CDs more viable as a money market security. The innovation was successful, and other banks began issuing the

securities. Larger banks in particular found negotiable CDs to be an attractive funding source. By mid-1965, negotiable CDs funded about 7 percent of the balance sheets of large U.S. banks; by 1975, they funded over 17 percent (based on data reported in the Federal Reserve's *Banking and Monetary Statistics* and subsequent statistical volumes). As noted previously, unlike Eurodollar deposits, negotiable CDs were subject to Regulation Q ceilings until 1970, when the ceilings on short-term CDs were suspended, and 1973, when ceilings on all other negotiable CDs were lifted. Negotiable CDs were also subject to reserve requirements throughout the period.

By 1980, the Eurodollar and negotiable CD markets had become quite integrated. Kreicher (1982) describes how banks could arbitrage differences between rates in the two markets and the evolution of some of the regulatory wedges that allowed interest rate differentials to persist. Kreicher notes that by the middle of 1975, the remaining wedge was quite small.

3. Pricing and Issuance of Money Market Instruments

In this section, we test various hypotheses about the pricing and issuance volumes of Eurodollars and negotiable CDs when those markets were becoming important components of bank funding markets in the 1960s-70s.[13] As the previous sections describe, the emergence of those markets reflected the interaction of regulation and macroeconomic outcomes, especially rising inflation and interest rates. We seek to discern how closely the early Eurodollar and negotiable CD markets conformed to the predictions of recent studies on money markets, and the extent to which market pricing and issuance volumes reflected the effects of regulation and deregulation.

[13] Bank and finance company issuance of commercial paper also grew rapidly in the 1960s (see Calomiris, Himmelberg and Wachtel 1995), and beginning in the mid-1970s banks began to offer interest-bearing retail deposit accounts, such as negotiable order of withdrawal (NOW) accounts (money market deposit accounts (MMDAs) were subsequently introduced in the 1980s). We focus on the markets for Eurodollars and Negotiable CDs here because data on financial commercial paper issuance in the 1960s and 1970s are both limited and inconsistently reported, while NOW accounts were not introduced until late in our period of focus. However, we obtain similar empirical results for the pricing and issuance of commercial paper that we report for Eurodollars and Negotiable CDs though the statistical significance is reduced (results available from the authors upon request). Other studies, such as Carlson et. al (forthcoming), have found that pricing and issuance of commercial paper is influenced by the amount of T-bills outstanding using a more recent sample period. In addition to new funding sources for banks and other money market borrowers, the 1960s and 1970s also saw innovations on the part of suppliers of funds, including money market mutual funds, which invests exclusively in money market instruments while also offering investors liquidity services.

3.1 Pricing of Private Money Market Instruments

Our research contributes to a recent but rapidly growing body of work that examines the role that safe assets play in the financial system and how the supply of government-issued securities affects the pricing of close substitutes issued by the private sector (e.g., Gorton, Lewellen, and Metrick 2012; Gorton 2015; Krishnamurthy and Vissing-Jorgensen 2012, 2013; Greenwood, Hanson and Stein 2015; Sunderam 2015; Carlson, et al., forthcoming).[14] This work argues that the demand for safe liquid assets is fairly constant, at least in the short run, and that changes in the availability of publicly-issued, default-risk free securities will affect incentives for private parties to issue close substitutes. When the supply of risk-free liquid government securities falls, for example, the yields on those securities decline both absolutely and relative to yields on the closest substitutes issued by the private sector.

Following this literature, we estimate an empirical pricing model to investigate how changes in the supply of risk-free liquid government securities and other market and regulatory conditions affected the pricing of Eurodollars and negotiable CDs when those securities were first coming into widespread usage during the 1960s and 1970s. Although the model is a reduced form, by using a model that closely follows recent work we can both examine whether the nascent markets of the 1960s had the characteristics of modern money market instruments and shed light on how changes in regulation can affect pricing and issuance in such markets. Following Greenwood et al. (2015) and Carlson et al. (forthcoming), we use U.S. Treasury bills (T-bills) for the alternative, safe asset, and estimate models of the spreads between market interest rates on Eurodollars and CDs and T-bill yields. T-bills are very liquid and have short maturities and duration, which makes them particularly advantageous to investors seeking to hold safe liquid assets. Short-term negotiable CDs, commercial paper, and other short-term privately-issued securities have similar characteristics, but by being exceptionally liquid and default-risk free, T-bills command a "near-money" premium over such instruments. Thus, while a reduction in the stock of T-bills available to the market increases the demand for privately-issued alternatives and puts downward pressure on their yields, because the private alternatives are close, but not perfect substitutes for T-bills, yield spreads will likely increase.

[14] Studies of the relationship between Eurodollar rates and Treasury yields are almost as old as the Eurodollar market. Herdershott (1967), for example, examines the response of Eurodollar rates to changes in Treasury bill yields and to other stock and flow effects between the late 1950s and mid-1960s. More recently, the pricing of money market instruments has been considered in various contexts. For example, various studies find that the spread between the rates on Eurodollars and Treasury bills reflected financial market stress during the recent financial crisis (see for instance Stock and Watson 2012). The spread also widened during earlier episodes of stress, such as occurred following the failure of Herstatt Bank in 1974. However, here we are more interested in the lower-frequency, longer-term determinants of these spreads.

Hence, we expect that increases (decreases) in the supply of Treasury bills increased (reduced) spreads between interest rates on Eurodollars and negotiable CDs and bill yields.[15]

Whereas spreads are likely affected by the changes in the volume of risk-free liquid securities, Nagel (forthcoming) argues that the spreads also depend on the opportunity cost of holding money or non-interest bearing liquid assets. An increase in the opportunity cost of money (reflected in the level of very short-term interest rates) will increase the demand for the next least risky/most liquid interest earning assets (e.g., Treasury bills in our case), and result in a larger spread between yields on privately issued money market securities (Eurodollars and negotiable CDs) and T-bills. We include the overnight federal funds rate in our model to test whether changes in the opportunity cost of money influenced yield spreads and issuance volumes of Eurodollars and negotiable CDs. We expect that increases (decreases) in the funds rate increased (decreased) yield spreads.

Eurodollars and negotiable CDs were innovations driven by regulation, and it is likely that regulation and changes in regulation strongly influenced market pricing for those instruments. Regulation Q limited the extent to which CD interest rates could rise with market rates on alternative assets. We exclude periods when Regulation Q ceilings were binding, i.e., when secondary market rates on negotiable CDs exceeded the applicable Regulation Q ceilings on large value CDs, from our pricing regressions for CDs. We expect, however, that Regulation Q influenced the Eurodollar market. By limiting the ability of banks to use negotiable CDs as a funding source, we expect that banks relied more heavily on Eurodollar funding when Regulation Q was binding, resulting in increased Eurodollar volumes and yields relative to T-bills.

Market pricing of Eurodollars and negotiable CDs were also likely affected by reserve requirements. Reserve requirements acted as a tax on negotiable CDs and other deposits to which they were applied, and thus an increase in reserve requirements would tend to reduce the supply of the affected instruments and lower their interest rates relative to T-bills. At the

[15] Following Greenwood, Hanson, and Stein (2016) and Krishnamurthy and Vissing-Jorgensen (2012), we assume that the supply of T-bills is exogenous. This assumption seems reasonable as the primary drivers of changes in T-bill supply are tax payments, reflected in a regular seasonal pattern in bill supply at tax payment times, and the overall budget deficit (the supply of bills is strongly correlated with the size of the government deficit). As described by Baker (1979), Treasury officials typically would announce their quarterly refunding schedule and then follow it closely, which suggests that, at least in the short run, the Treasury did not make many opportunistic adjustments to T-bill supply. Baker (1979) also reports that Treasury debt management officials paid some attention to the cost of debt, but also to the frequency with which the Treasury might have to access the market and to rollover risks when determining the composition of securities to issue. Amid all these considerations, the assumption that T-bill supply is exogenous in the short run seems reasonable.

same time, an increase in reserve requirements on CDs would encourage banks to supply more Eurodollar deposits, which might increase their interest rates relative to T-bills. By the same token, an increase in reserve requirements that applied to Eurodollars—in this case reserve requirements on balances due to foreign branches—should have increased issuance of negotiable CDs and pushed up their spreads against T-bills. Similar reasoning applies for the way a change in the reserve requirements on deposits due *from* branches of U.S. banks would have affected the negotiable CD market. An increase in this reserve requirement would have made issuing CDs more attractive, increased supply, and therefore increased the spread to T-bills. However, the effect of an increase in the reserve requirement on deposits due from branches of U.S. banks on Eurodollar pricing is uncertain for reasons that reflect the specifics of that market. A higher reserve requirement would have made it less attractive for U.S. banks to issue Eurodollar liabilities which, following the reasoning above, would reduce supply and likely the spread relative to T-bills. However, there is another factor at play. U.S. banks generally paid lower rates to borrow in the Eurodollar market than banks of other countries (Clarke 1983). Thus, if U.S. banks reduced their Eurodollar deposits, the market rate spread could still rise, so the effect of an increase in reserve requirements applicable to deposits due from foreign branches on the spread between market Eurodollar rates and T-bill yields is ambiguous.

To test the hypotheses described above we estimate regressions that use as dependent variables the spreads between the 3-month Eurodollar rate and the yield on 3-month T-bills and between the 3-month negotiable CD rate and the yield on 3-month T-bills. Rates for negotiable CDs and T-Bills are secondary market rates, Eurodollar rates are the going market rates. We calculate the spreads by first calculating the average weekly rate from daily data for each instrument and then subtracting the weekly T-bill rate from the weekly rate on the private security. See Appendix 1 for additional details about the data.

We regress the money market spreads in week t on the federal funds rate prevailing in that week, the ratio of T-bills outstanding to GDP in the previous month $m-1$, the regulations prevailing in week t, and an indicator for the Herstatt crisis.[16] The Herstatt crisis was a substantial shock to both the Eurodollar and the negotiable CD markets, boosting risk premiums

[16] Gorton, Lewellen, and Metrick (2012) argue that the demand for safe assets relative to the size of the economy is constant over time. Hence, we scale Treasury bills by GDP. Data on Treasury bills are monthly, i.e., month-end, while nominal GDP is quarterly. Following Krishnamurthy and Vissing-Jorgensen (2012) and others, we use data on the stock of T-bills in the hands of private investors. We also tried scaling by a narrow money stock measure (M1), which might better reflect the general size of the financial factor. The results of our empirical analysis were similar, if not stronger.

during the period from when Herstatt Bank failed until early 1975 (June 1974 – January 1975).[17] To deal with the episode, we include a dummy variable for the crisis period (*Herstatt*).

$$Spread_t = \alpha + \beta_1 \begin{pmatrix} Fed \\ funds \\ rate_t \end{pmatrix} + \beta_2 \begin{pmatrix} TBills \\ to \\ GDP_{m-1} \end{pmatrix} + \beta_3 Regulations_t + \beta_4 Herstatt_t + \varepsilon_t \quad (1)$$

Regulations includes an indicator for whether Regulation Q was binding and the contemporaneous levels of the reserve requirements for large time deposits and deposits due to foreign branches. Our indicator for whether Regulation Q was binding is that the secondary market rate for negotiable CDs exceeds the Regulation Q ceiling for the primary market for these securities. Recall that Regulation Q was suspended for negotiable CDs of 90 days or more after May 1973 (see the appendix for details). We estimate the regressions using ordinary least squares. The standard errors are robust and are clustered at the monthly level. We also adjust for serial correlation; here we find the errors follow a second-order autoregressive process. The estimation period is from July 1963 to October 1979, which results in approximately 800 observations. Summary statistics of the weekly data used in the analysis, as well as data at other frequencies used subsequently, are provided in Table 1.

Tables 2 and 3 report the results for Eurodollar and negotiable CD spreads, respectively. We find support for both the hypotheses that spreads increased in response to a higher level of money market rates and fell with greater supply of T-bills. In the Eurodollar spread regression, the coefficient on the (lagged) ratio of T-bills outstanding to GDP of -0.012 implies that a one standard deviation increase in the ratio would narrow the spread between rates on Eurodollars and T-bills by 8 basis points. The effect of changes in T-bills outstanding on the spread between rates on CDs and T-bills is of a similar magnitude. As the spreads typically were about 160 basis points and 80 basis points, respectively, the reductions are modest but economically meaningful. These results are also comparable to the finding of Greenwood, Hanson, and Stein (2015) who report similar impacts of changes in the volume of T-bills on the premiums investors are willing to pay to hold four-week T-bills. Similarly, the coefficient on the federal funds rate is approximately 0.15 in all specifications, and implies that a one standard deviation decrease in the federal funds rate (about 2 percentage points in this period) would result in a

[17] In June 1974, the Herstatt bank was closed while it had an open position in the foreign exchange market (it had received funds as part of the transaction, but had not yet delivered funds). This failure made banks and regulators much more aware of, and concerned about, settlement risk in foreign exchange markets. While Herstatt did not have any Eurodollars, and the Eurodollar market was not implicated in any way, heightened concerns about all types of foreign currency transactions caused Eurodollar contract rates to surge. It was not until early 1975 that rates and spreads on Eurodollar contracts returned to more normal levels (Kreicher 1982).

decline in the Eurodollar to T-bill spread and negotiable CD to T-bill spread of about 41 basis points and 34 basis points, respectively. These effects are also clearly economically meaningful.

As expected, we also find that the Eurodollar to T-bill spread widened when Regulation Q was binding. We do not find a statistically significant relationship between reserve requirements and spreads, however, though the coefficients typically have the expected signs (or are very imprecisely estimated). Spreads were decidedly wider during the Herstatt crisis period.

3.2 Eurodollar and CD Volumes

We expect that the factors affecting the Eurodollar and CD yield spreads also affected the volumes that banks supplied to the market. The literature argues that a reduction in the stock of T-bills outstanding will increase the demand for privately-issued alternatives, but also cause yield spreads to widen. Financial institutions will respond by supplying more short-term securities to the market, in part because increased demand for money market securities pulls down the front end of the yield curve, making it more attractive for banks to issue at shorter maturities than at longer ones. Thus, a reduction in the stock of short-term Treasury securities available to the market should cause outstanding volumes of Eurodollar deposits and CDs to rise as banks respond to increased demand for T-bill alternatives by supplying more securities to the market.

An increase in the opportunity cost of holding money, i.e., a higher level of short-term interest rates, should increase the demand for interest-earning safe private money market securities. The higher demand should pull down the interest rates on these securities relative to longer-maturity securities and make it more attractive for banks and other issuers to supply more shorter-term instruments, Thus, even though spreads between rates on private money market instruments and T-bills tend to increase with the level of market rates, we expect that issuance of private money market securities will also rise with the level of short-term market interest rates..

Our regressions for Eurodollar and CD volumes include the same regulatory and interest rate variables as in Equation (1). The data on issuance of these instruments are the outstanding amounts of negotiable CDs at large U.S. banks as reported by the Federal Reserve, and amounts of Eurodollar deposits in the United Kingdom and elsewhere in Europe as reported by the Bank for International Settlements (BIS).

We measure issuance as the change in the ratio of the outstanding value of Eurodollar deposits or negotiable CDs relative to U.S. GDP over particular windows. For negotiable CDs, we consider one-month changes in the outstanding amount of negotiable CDs on the last Wednesday of the month for large weekly reporting banks, so that changes are month-end to month-end. Given the relatively high frequency of these data, we examine how conditions at time *t* affected the change in negotiable CDs between time *t* and time *t+1*. For Eurodollars, we only have quarterly data. We consider several measures of the size of the Eurodollar market. First, we examine changes in the ratio of the dollar liabilities of banks to non-bank entities for nine large European countries relative to U.S. GDP.[18] This series on bank to non-bank liabilities consists of quarterly observations from 1968 to 1979. We also consider the total dollar liabilities of banks in these nine European counties and, as it was the largest market, just in the United Kingdom. These totals are available for a longer period. As with negotiable CDs, we examine how conditions at time *t* affected the change in the ratio of Eurodollars to U.S. GDP between time *t* and time *t+1*.

We expect that regulations reduced the use of affected securities and provided a boost to alternatives. When Regulation Q was binding, outstanding amounts of negotiable CDs likely fell while banks increased their reliance on Eurodollar deposits. Given that we are uncertain whether our Regulation Q indicator fully captures the impact of rate ceilings on the use of negotiable CDs, we estimate two specifications: one with an indicator for when Regulation Q was binding, and another that excludes such periods from the estimation. Increases in reserve requirements on a particular type of money market instrument should have made it less attractive for banks to supply them and thus reduced issuance of that type of instrument and lifted amounts issued of the alternative. The effects of Regulation Q and reserve requirements should be less obvious for Eurodollar rates and volumes than for negotiable CDs as the regulations affected U.S. banks but not other banks that issued Eurodollar deposits.

We include macroeconomic controls in our regressions. In the case of negotiable CDs, where banks were likely seeking funds to lend to U.S. firms and households, we include a measure of the slope of the shorter end of the yield-curve—specifically, the yield on three-year Treasury securities minus the federal funds rate. We focus on the shorter-end of the yield curve because most bank funding is fairly short-term. We also include two lags of the growth of industrial production and two lags of the inflation rate. For Eurodollars, the relevant economy is

[18] These countries are West Germany, France, Netherlands, Belgium, Luxembourg, Switzerland, the United Kingdom, Italy, and Sweden.

less clear, and so we include year fixed effects rather than U.S. variables as controls. We continue to include a dummy for the Herstatt crisis period.

The regression is then slightly different for Eurodollars, where we use year dummies, than for negotiable CDs, where use economic variables.[19] Otherwise they have the same form:

$$\Delta\left(\frac{Eurodollars}{GDP}\right)_{t-(t-1)} = \alpha + \beta_1\begin{pmatrix} Fed \\ funds \\ rate_{t-1}\end{pmatrix} + \beta_2\begin{pmatrix} TBills \\ to \\ GDP_{t-1}\end{pmatrix} + \beta_3 Regulations_{t-1} + \beta_4 Herstatt_t + \gamma * years + \varepsilon_q \quad (2)$$

$$\Delta\left(\frac{CDs}{GDP}\right)_{t-(t-1)} = \alpha + \beta_1\begin{pmatrix} Fed \\ funds \\ rate_{t-1}\end{pmatrix} + \beta_2\begin{pmatrix} TBills \\ to \\ GDP_{t-1}\end{pmatrix} + \beta_3 Regulations_{t-1} + \beta_4 Herstatt_t + \gamma Economic\ controls_{t-1,t-2} + \varepsilon_t \quad (3)$$

Eurodollar data are quarterly while the negotiable CD data are monthly. For the federal funds rate, we use the average rate over the relevant period. Regulatory controls include whether Regulation Q was binding and the average levels of reserve requirements. We use ordinary least squares to estimate the regressions. The standard errors are robust. We also adjust for serial correlation; here we find the errors follow a first-order autoregressive process. The estimation period for Eurodollars is from either 1964q1 or 1968q4 to 1979q3, while the estimation period for negotiable CDs is from 1965m7 to 1978m12.

Tables 4 and 5 report the results for Eurodollars and negotiable CDs, respectively. We find evidence that a reduction in the outstanding volume of Treasury bills resulted in greater issuance of both money market instruments, which is consistent with previous work on the impact of safe assets on issuance of private securities in more recent times (Sunderam 2015; Carlson, et al., forthcoming). The coefficient relating changes in Eurodollars liabilities to nonbank institutions to the ratio of T-bills to GDP is –0.10 (first column of Table 4), which implies that a one dollar increase in the amount of Treasury bills outstanding would result in a decrease in Eurodollars issued to non-banks relative to U.S. GDP of about 10 cents over the next quarter (alternatively, a one standard deviation increase in T-bills to GDP would reduce

[19] In 1973, the Bretton Woods exchange rate regime ended and the dollar began to float against other currencies. Efforts to prop up the Bretton Woods regime included a number of voluntary and less-voluntary capital regulations and controls, some of which placed restrictions on banks (see Neely 1999; Sylla 2002). Once these restrictions were lifted, also around 1973-1974, banks were further able to arbitrage differences in funding markets, especially the Eurodollar market. See Bordo and Humpage (2014) for a further discussion of the decline of the Bretton Woods regime. The year dummies in our Eurodollar specification would also capture the effects from these changes in regulations.

Eurodollars to U.S. GDP by one standard deviation). The corresponding coefficient of –0.09 for negotiable CDs shown in Table 5 implies that a one dollar increase in the amount of Treasury bills outstanding would be followed by a decrease in negotiable CDs of 9 cents over the next month. These findings are similar to those of Sunderam (2015) who studies the impact of changes in T-bill supply on issuance of the asset-backed commercial paper. For the impact of the federal funds rate, the coefficient of 0.36 in specification 1 of Table 5 means that a one standard deviation increase in the federal funds rate (about 2 percentage points) led to an increase in the ratio of negotiable CDs to GDP over the next month of 0.76 percentage points, or nearly half a standard deviation. Thus, we find that pricing and outstanding volumes of Eurodollars and negotiable CDs in the early years of these markets generally responded to changes in the relative availability of safe assets similarly to what has been found for modern money markets.

We find that regulations had some effect on issuance of the money market instruments as well. As shown in Table 5, the supply of negotiable CDs tended to decline when the reserve requirements on these instruments were higher. Also, use of negotiable CDs was reduced when Regulation Q was binding.[20] Eurodollars contracted notably during the Herstatt episode.

4. Changes in Bank Liability Structure

In the previous section, we found that that issuance of both negotiable CDs and Eurodollars rose when T-bills became relatively scarce. In this section, we examine other parts of bank liability structures to determine whether the increased use Eurodollars and negotiable CDs was part of a general expansion of bank balance sheets or simply a substitution away from other liabilities. This distinction has important financial stability implications as it indicates whether changes in the supply of public short-term securities affect bank preferences for leverage or the maturity profile of their liabilities and, hence, the potential for maturity mismatches.[21] Given available data, we focus more on how parts of bank balance sheets moved with respect to changes in the volume of negotiable CDs; since negotiable CDs were *de facto* unavailable as a funding source when Regulation Q was binding, we drop those periods from the analysis.

[20] Evidence suggesting an ability to use alternative sources of funds when Regulation Q was binding is consistent with Koch (forthcoming), who finds that the effects of Regulation Q interest rate ceilings were smaller, though still important, for larger banks.

[21] Stein (2012) makes a similar argument in the context of monetary policy. He notes that when the Federal Reserve purchases large amounts of longer-maturity Treasury securities and provides the financial system with reserves that trade in short-term markets, then term premia can fall and encourage banks to rely more on longer-term financing. He argues that this shift should promote financial stability.

We first investigate whether total bank liabilities responded to changes in T-bill supply, controlling for the level of the federal funds rate, reserve requirements, and macroeconomic conditions. As shown in Table 6, we find little evidence that changes in the volume of T-bills outstanding (relative to GDP) affected total bank liabilities (also scaled by GDP). We find that bank liabilities declined relative to GDP during the Herstatt episode and when the shorter end of the yield curve was steeper. We find only modest connections in the short-run between macroeconomic variables and the ratio of bank liabilities to GDP.

If banks issued more negotiable CDs when T-bills were scarce and their total liabilities were unchanged, then banks must have reduced other types of liabilities. To explore how the structure of bank liabilities changed in response to changes in the volume of T-bills, we consider four liability categories: i) negotiable CDs; ii) demand deposits of individuals, partnerships and corporations, savings banks, commercial banks, foreign banks, US government deposits as well as federal funds bought; iii) other demand deposits (largely of municipal and foreign governments); and iv) time deposits other than negotiable CDs. We examine whether the ratios of these liability categories to total bank liabilities responded to either the level of interest rates or supply of T-bills. The results, reported in Table 7, indicate that negotiable CDs declined as a share of total bank liabilities when the supply of T-bills rose and when interest rates were lower, while other categories of liabilities increased.

These movements are consistent with the conclusion of Gorton, Lewellen, and Metrick (2012) that since the 1950s, demand deposits at banks and money market instruments have been substitutes (although that study focuses on longer-run trends in annual data rather than the shorter-run responses noted here). The evidence from Section 3 suggests that changes in the supply of safe short-term public debt affected the pricing and supply of Eurodollars and negotiable CDs. Here we find that changes in the supply of T-bills had a stronger influence on the composition of bank liabilities, and thus on the amount liquidity risk, than on total bank liabilities or leverage. We also find that banks issued more negotiable CDs and fewer other time deposits when short-term interest rates rose. Finally, we find some indication that the structure of bank liabilities responded to regulations, such as reserve requirements. CDs also became a smaller portion of banks' liability base when inflation rose.

5. Money Market Integration and Monetary Policy

In this section we consider how closely interest rates in the negotiable CD market and the Eurodollar market were linked to the effective federal funds rate, and the implications for monetary policy. We start by examining the extent to which changes in the federal funds rate

were co-integrated with changes in the other market rates during our sample period. We then consider the implications of market integration for the Federal Reserve's ability to control the federal funds rate and impact other market rates through its open market operations.

5.1. Correspondence of changes in the federal funds rate and other rates

We expect that the removal of interest rate ceilings and the adoption of more uniform reserve requirements reduced many of the wedges between the federal funds market and other money markets in which banks were active borrowers. We thus examine whether changes in the rates on Eurodollars and negotiable CDs were more closely linked to changes in the federal funds rate after Regulation Q ceilings on negotiable CDs were removed in May 1973.

The explanatory power of the first principal component of changes in the three interest rates provides a measure of market integration. We find that the first principal component explains 47 percent of the variance of week-to-week changes in the rates in the early period and 69 percent in the later period. That a single factor explains more of the changes in the different interest rates suggest that the markets increasingly moved together.

Co-integration tests provide additional evidence of the relationship between rates on Eurodollars, negotiable CDs, and federal funds. Following Engle and Granger (1987), we estimate a long-run equilibrium equation, test for stationarity of the residuals, and then estimate an error-correction model. Over the longer-run, interest rates in these markets should behave similarly as they are all short-term bank funding instruments; however, there may be short-run market specific factors that lead to temporary deviations. The error correction analysis indicates the degree to which changes in the federal funds rate explain changes in the other interest rates and the pace of convergence to the longer run relationship.[22] For the long-run relationship, we estimate:

$$\begin{pmatrix} money \\ market \\ rate \end{pmatrix}_t = \alpha_1 + \beta_1 \begin{pmatrix} fed \\ funds \\ rate \end{pmatrix}_t + \mu_t \qquad (4)$$

The error correction model is then:

[22] One might also expect that the Fed discount rate strongly influences the relationship. To control for any such impact, we created adjusted rates by subtracting the discount rate from the federal funds rate, the Eurodollar rate, and the CD rate. Repeating the analysis here using these adjusted rates produced similar results.

$$\Delta\begin{pmatrix} money \\ market \\ rate \end{pmatrix}_{t-(t-1)} = \alpha_2 + \delta_1\Delta\begin{pmatrix} money \\ market \\ rate \end{pmatrix}_{(t-1)-(t-2)} + \delta_2\Delta\begin{pmatrix} fed \\ funds \\ rate \end{pmatrix}_{(t-1)-(t-2)} + \delta_3 * (\mu)_{t-1} + \varepsilon_t \quad (5)$$

We perform the co-integration tests using weekly interest rates for two periods: i) June 1963 to May 1973 and ii) May 1973 to October 1979 (before and after deregulation). As before, for the negotiable CD rate, we exclude periods when Regulation Q was binding.

The results, shown in Table 8, indicate that the markets were co-integrated in both periods. We are interested in whether the impact of changes in the federal funds rate on changes in the Eurodollar rates and negotiable CD rates increased after May 1973. The error correction model estimates indicate that the impact was, indeed, stronger in the later period, as the coefficient on lagged changes in the federal funds rate increases from –0.02 to 0.26 for Eurodollars and from 0.04 to 0.19 from negotiable CDs. The coefficient on the lagged error term also increases in magnitude from the first period to the second period, indicating that convergence toward the long-run relationship was faster after deregulation. Like the principal component analysis, these results suggest that the markets were more integrated after deregulation.[23]

Our finding that Eurodollar rates were more closely integrated with the federal funds rate after 1973 is consistent with assertions of contemporary observers and earlier researchers who described the federal funds market as actively anchoring the Eurodollar market by the mid-1970s. The results also support Kreicher (1982), who argues that the corridor in which the Eurodollar rate could fluctuate without resulting in arbitrage opportunities between Eurodollars and CDs narrowed substantially in 1973-74.[24]

5.2 Open Market Operations and changes in the Federal Funds rate

Next we investigate how deregulation might have affected the relationship between changes in the supply of bank reserves and the federal funds rate. Consider the following simplistic scenario: If the Fed sought to tighten policy, it could do so by engaging in open market operations, such as selling Treasury securities, to reduce the supply of bank reserves. With a smaller supply of reserves, banks that routinely borrowed in the federal funds market would

[23] As yet another indicator of the integration of markets, we conducted Granger causality tests of changes in the federal funds rate and the money market rates for our two sub-periods. In this approach, which allows the federal funds rate to both affect and be affected by other rates, we again find that the relationships between different interest rates was much stronger in the later period than in the earlier period.

[24] Interestingly, Duffee (1996) finds that in the early 1980s, shortly after our sample period ends, yields on Treasury-bills begin to move more idiosyncratically and becomes less connected to the rest of the Treasury yield curve.

compete more for those funds and push up the federal funds rate. If money markets become more integrated, allowing banks to more easily turn to a different funding market, then a larger reduction in the supply of reserves would be required to produce a given size response in the federal funds rate.

There is some question about the degree to which the Fed targeted the federal funds rate in the 1960s and 1970s. Early in the period, the Fed may have used the funds rate more as a guidepost, along with other interest rates and qualitative indicators, than as a formal target. However, by the 1970s, the federal funds rate was clearly among the Fed's main targets, if not the only target. According to Meek and Thunberg (1971, p. 80), the FOMC's directives "meant that the Manager [of the open market desk] would begin by seeking to hold mainly the following within ranges designated by the Committee: the federal funds rate, member bank borrowings from the Reserve Banks, and free or net borrowed reserves…." Similarly, Axilrod (1971, p. 10) argues that the framework in place since the late 1960s meant that open market operations were importantly connected to the federal funds rate: "The net reserve position and the federal funds rate are basic elements of money market conditions influencing the Manager's day-to-day decisions as to whether to buy or sell securities." For the first part of our analysis, we are interested in the impact of Fed operations on the federal funds rate, regardless of whether it was the Fed's target or a merely a guidepost in achieving goals. In subsequent analysis below, however, we are decidedly interested in the federal funds rate specifically as a target.

First, we test whether the federal funds rate was less responsive to Fed actions after markets became more integrated in the 1970s. We estimate the impact of the Fed's open market operations on the federal funds rate using, alternatively, changes in the Fed's government securities holdings (both outright and via repurchase agreements) and changes in non-borrowed reserves as the measure of open market operations. (See, for instance, Christiano and Eichenbaum (1991) for evidence linking changes in non-borrowed reserves to changes in the federal funds rate.) For each, we use changes from one week to the next divided by the average amounts during the four preceding weeks; this procedure adjusts for growth in the balance sheet of the Fed over time.[25] We estimate separate regressions for June 1963 to May 1973 and June 1973 to October 1979 to account for the suspension of Regulation Q ceilings on large CDs in May 1973. The change in Fed operating procedures in October 1979 provides an obvious end point for our analysis. Our regressions control for a variety of other factors that might affect the

[25] Based on the available data, we use the contemporary change in average reserves and lagged changes in end of period Treasury holdings. As an alternative to using the change relative to average amounts, we also used the log differences in holdings of government securities or in non-borrow reserves yields similar results.

federal funds rate, such as changes in the Fed's discount rate, whether Regulation Q was binding, and changes in the reserve requirements applicable to negotiable CDs and to balances due from foreign branches. We include contemporaneous changes in the discount rate as these should have had an immediate effect on pricing (in part because of the signal they provided about monetary policy intentions). It may take a few days for banks to react to changes in reserve requirements, so we used lagged changes (by one week) in these variables. For the early period, we also interact our measure of open-market operations with the indicator for whether Regulation Q was binding. If our hypothesis is correct, when Regulation Q was binding and the ability of the banks to substitute into negotiable CDs was reduced, the Fed's actions should have had a stronger impact on the federal funds rate. The regression then takes the form:

$$\Delta\begin{pmatrix} fed \\ funds \\ rate \end{pmatrix}_{(t+1)-t} = \alpha + \beta_1 \Delta \begin{pmatrix} Disc \\ rate \end{pmatrix}_{(t+1)-t} + \beta_2 \Delta(OMO)_{t-(t-1)} + \beta_3 \Delta(regulations)_{t-(t-1)} + \beta_4 \left(\Delta OMO_{t-(t-1)} * \Delta regulations_{t-(t-1)}\right) + \varepsilon_t \quad (6)$$

We estimate the regression using ordinary least squares with robust standard errors. As elsewhere, we also adjust for serial correlation; here we find the errors follow a second-order autoregressive process.

In testing for differences in the responsiveness of the federal funds rate to actions by the Fed, we benefit from the fact that in the 1960s and 1970s the Fed did not announce changes in its target for the federal funds rate. Thus, changes in the funds rate were driven by the Fed's actual open market operations more than they might be now that FOMC communications and market expectations about policy play a large role in the implementation of monetary policy.

The results, reported in Table 9A (government securities holdings) and Table 9B (non-borrowed reserves), suggest that larger open-market operations were required to induce a given size change in the federal funds rate after money markets had become more integrated following deregulation. For instance, when looking at the impact of a change in the Fed's government securities holdings on changes in the federal funds rate, the coefficient declines in absolute value from −12.4 before deregulation to −1.7 after deregulation, which implies that a given change in securities holdings resulted in a change in the federal funds rate roughly one-eighth the size as before. Moreover, we find some evidence that open market operations had an

even greater impact on the federal funds rate at times when Regulation Q was binding during the earlier period.[26] Our control variables are generally not significant.

Next, we investigate whether the magnitude of the impact of open market operations on the funds rate depended on the prevailing level of reserve requirements. When reserve requirements on various money market instruments were higher, a larger change in the federal funds rate was likely required before a bank that typically borrowed in the federal funds market would find it attractive to turn to an alternative funding source. Thus, when reserve requirements were higher and there was less substitutability across markets, a given size open-market operation would induce a larger change in the federal funds rate than when reserve requirements were lower.

To test whether the impact of open market operations on the federal funds rate depended on the level of reserve requirements, we must account for the fact that the reserve requirements applicable to negotiable CDs and to balances due to foreign branches differed in levels and were sometimes changed in opposite directions. Thus, we construct time period dummies for different levels of the relevant reserve requirements and interact open-market operations with these dummies. This procedure allows open-market operations to affect the federal funds rate differently in each period while the coefficients on the other independent variables are constrained to be constant over time.

The results, shown in Table 10, indicate that that the funds rate did respond more strongly to the Fed's actions when reserve requirements were higher. When reserve requirements were held at 6 percent for negotiable CDs and increased from 0 to 10 percent for balances due to foreign branches, the impacts of Fed operations on the effective federal funds rate increased, e.g., the coefficient for the impact of a change in the Fed's government securities holdings increased (in absolute value) from −1.7 to −2.7. Conversely, when the reserve requirements applicable to negotiable CDs and the reserve requirement applicable to due to foreign branches were changed from 8 percent each to 6 percent and 4 percent, respectively, the coefficient indicating the responsiveness of the federal funds rate to a change in government securities holdings fell from −0.67 to −0.04.

Our results point to a tradeoff for the Fed in implementing policy. On the one hand, when markets were less integrated, the size of the open market operation required to produce a

[26] Although neither the coefficient on the change in nonborrowed reserves nor the coefficient on the interaction of nonborrowed reserves with Regulation Q binding is individually statistically significant in Table 9B, the two coefficients are jointly significant.

given change in the federal funds rate was smaller than when markets were more integrated, but the influence on other rates was smaller and less predictable. After markets had become more closely connected, a larger open market operation was required to bring about a given change in the funds rate, but the pass through to other markets was greater. Presuming that the Fed's ultimate objective was to influence monetary conditions in general, and not the funds rate per se, it probably would have preferred greater integration of markets, even if that necessitated larger open-market operations.

5.3 Deviations from Target

It is worth noting that a greater impact of open market operations on the federal funds rate does not necessarily mean that the Fed was better able to hit its target for the funds rate. We reviewed the historical record to determine the Federal Open Market Committee's intended target for the federal funds rate.[27] Starting in 1967, the FOMC's *Memoranda of Discussion* refer to specific levels of the federal funds rate that members viewed as consistent with their desired amount of restraint or ease on money market conditions. We take these references as indicating that policymakers viewed the funds rate as an instrument for implementing policy, rather than merely an indicator of market conditions. We do not find the same degree of specificity in the record before 1967, and so do not include those years in our comparison of the actual or "effective" funds rate with the FOMC's desired rate.

As shown in Table 11, the average absolute difference between the effective funds rate and the target rate was higher in the earlier period (21 basis points) than in the later period (15 basis points). The larger average deviations in the early period are due entirely to months when Regulation Q was binding; outside those periods the average deviations were similar in the two periods. Axilrod (1971) notes that Federal Reserve actions to influence bank reserves and interest rates caused larger and more immediate adjustments of bank balance sheets than usual when Regulation Q ceilings were binding. Conceivably, the more intense response could have made calibrating the appropriate size of Federal Reserve operations more difficult, which might explain why deviations between the effective and intended funds rate were larger at those times.[28]

[27] Specifically, we reviewed the "Memoranda of Discussion" and meeting transcripts for descriptions by the Manager of the System Open Market Account of the funds rate target and the preferences of the Open Market Committee about the target. In some cases the Committee members refer to the alternatives suggested by the staff rather than stating numbers themselves; in this case we use the targets provided in the Bluebook. Where a range for the funds rate is provided, we use the mid-point for the range unless the Committee members specified clearly that they preferred a particular point in that range.

[28] Of course, the FOMC may have been less concerned about hitting a particular funds rate target at different times, especially early in the sample period when it was first starting to discuss specific target values in its

6. Conclusion

Regulations on bank liabilities, such as reserve requirements and interest rate ceilings, strongly influenced the development of new money market instruments and the composition of bank liabilities in the 1960s and 1970s. In this paper we investigate the behavior of these new instruments, including the responsiveness of their market pricing and issuance volumes to changes in regulation, the supply of Treasury bills, and the opportunity cost of holding money. Further, we examine how the presence of these markets and their regulation affected the Fed's ability to influence the federal funds rate.

Our research finds that, even when the Eurodollar and negotiable CD markets were in their infancy, they behaved as predicted by modern theories of financial market pricing. We find that the pricing and use of the new instruments were strongly related to drivers of near-money premiums, and behaved similarly to modern money market instruments. Consistent with the findings of Greenwood, Hanson, and Stein (2015) and Carlson et al. (forthcoming), we find that reduced availability of short-term safe public assets, specifically Treasury bills, increased the spreads between the rates on the new instruments and Treasury bill yields, but at the same time tended to boost their market volumes. And, similar to the findings of Nagel (forthcoming), we find that spreads widened when short-term interest rates rose.

These findings have important lessons for financial stability and monetary policy. The shadow banking system relies substantially on near-money instruments, such as asset-backed and financial commercial paper, for funding. Factors that affect the use and pricing of these near-money securities thus matter for financial stability and the distribution of risks across the financial system. In finding that the level of the short-term interest rates affects near-money premia, our results suggest that when interest rates are higher, financial regulators should be most alert to increased reliance on near-money instruments and the potential for that to increase maturity mismatches. We also find that the supply of high-quality short-term securities affects the pricing and use of money market instruments. As it explores options for an exit from exceptionally low interest rates, the Federal Reserve has experimented with offering term deposits to banks and overnight reverse repurchase agreements (ON-RRPs) to banks and non-bank counterparties (Ihrig, Meade, and Weinbach 2015). Extensive use of such instruments, which are risk-free short-term securities, could substantially affect near-money premia, and thus private sector issuance of money market securities (Stein 2012).

meetings. Nonetheless, our findings show that deviations from target were similar outside of months when Regulation Q was binding. For whatever reason, the FOMC was either unable or unwilling to take actions to control the funds rate as tightly during those months.

We also find that the development and regulation of new funding market instruments can affect the implementation of monetary policy. When regulations created greater segmentation of money markets, the Federal Reserve could influence the federal funds rate with smaller open market operations, but at the same time, the Fed's operations had less pass through to other funding markets. When the regulations were lifted, larger operations were needed to influence the federal funds rate but these effects had greater impact on other funding markets. These findings suggest that the central bank's ability to control a particular interest rate is affected both by the depth of the market in which it seeks to operate and the integration of that market with other financial markets. Regulations that place a wedge between different segments of the money market can reduce the ability of the monetary authority to influence funding conditions. Further, changes in regulation can affect empirical relationships that central banks rely upon for calibrating the size of open market operations required to achieve their monetary policy targets, and thereby hinder the implementation of monetary policy or potentially increase financial market volatility. Thus, financial regulatory changes that constrain or change the incentives of private issuers, or affect integration across financial markets, have potential ramifications for monetary policy as well as financial stability.

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Appendix: Data and sources

The interest rate series used in this paper include the effective federal funds rate, the secondary market rate for 3-month negotiable CDs, the secondary market rate for 3-month T-bills, the rate on Eurodollar deposits, and the yield on the 3-year constant maturity Treasury security. Where possible, we use daily data on interest rates and average available observations for the week (ending Wednesday) to produce our weekly series. In some cases, such as for the negotiable CD data in the early part of the sample, only one observation is available per week; in those cases, that observation comprises our weekly average. Data on 3-month negotiable CD rates, 3-month T-bill yields, the yield on the 3-year constant maturity Treasury security, and the Federal Reserve discount rate are from the Federal Reserve's H.15 statistical release. Eurodollar rates are from the BIS.

Information on the target federal funds rate comes from the FOMC's "Memoranda of Discussion" and Bluebooks (http://www.federalreserve.gov/monetarypolicy/default.htm).

Data on the volume of Eurodollars outstanding are from BIS international banking statistics as reported in the BIS Annual Report or "Statistics of Euro-Currencies" releases. We use total U.S. dollar liabilities and liabilities to the non-bank sector of banks located in the U.K. or in other selected European countries.

Data on balance sheets of large U.S. banks are from the Federal Reserve's *Banking and Monetary Statistics (*https://fraser.stlouisfed.org/scribd/?title_id=41&filepath=/docs/publications/bms/1941-1970/BMS41-70_complete.pdf). Data are available for "Large Commercial Banks" on a weekly basis starting in July 1965. Large negotiable CDs are a memo item that is a subset of time deposits.

Federal Reserve balance sheet data, data on required and excess reserves, and data on end of month Treasury bills outstanding are from the Federal Reserve's *Banking and Monetary Statistics,* subsequent statistical annuals, and the Federal Reserve *Bulletin*.

Data on quarterly GDP and M1 were downloaded from Federal Reserve Economic Data (FRED). For M1, we use the non-seasonally adjusted series.

Information on Regulation Q is from Ruebling (1970) for the period before 1970. We use the ceiling on single maturity deposits of $100,000 or more with a maturity of 90-179 days (or of the category that would include such a liability). After 1970, we follow the description in Cook (1978). We consider Regulation Q to be binding if the rate in the secondary market on three-month negotiable CDs equals or exceeds the Regulation Q ceiling.

Information on reserve requirements are from Feinman (1993), Kreicher (1982), and the Federal Reserve (http://www.federalreserve.gov/monetarypolicy/reservereq.htm). For reserve requirements on negotiable CDs, we use the series for time deposits of more than $5 million with a maturity of 30-179 days (where applicable). Reserve requirements on "due from foreign branches" were uniform for all such liabilities.

The Herstatt crisis period lasts from June 24 1974 until January 31, 1975.

Figure 1
Interest rates and the Regulation Q ceiling

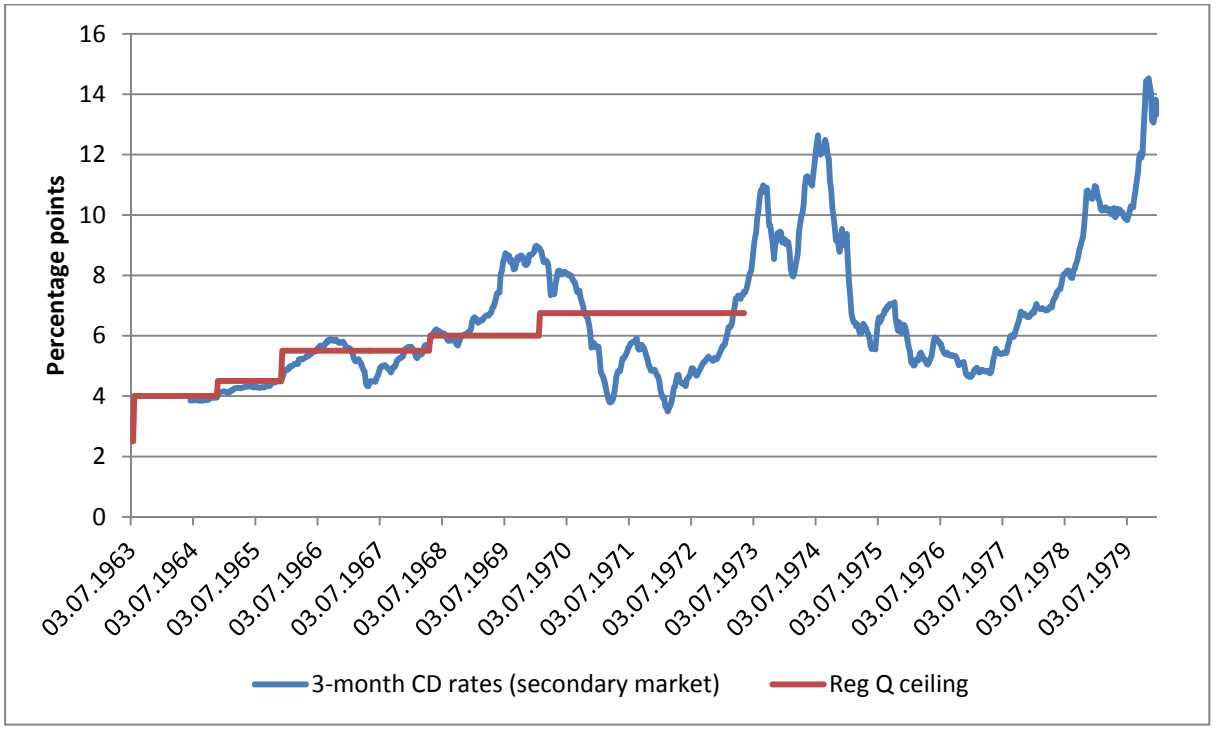

Figure 2
Evolution of reserve requirements affecting CDs and Eurodollars

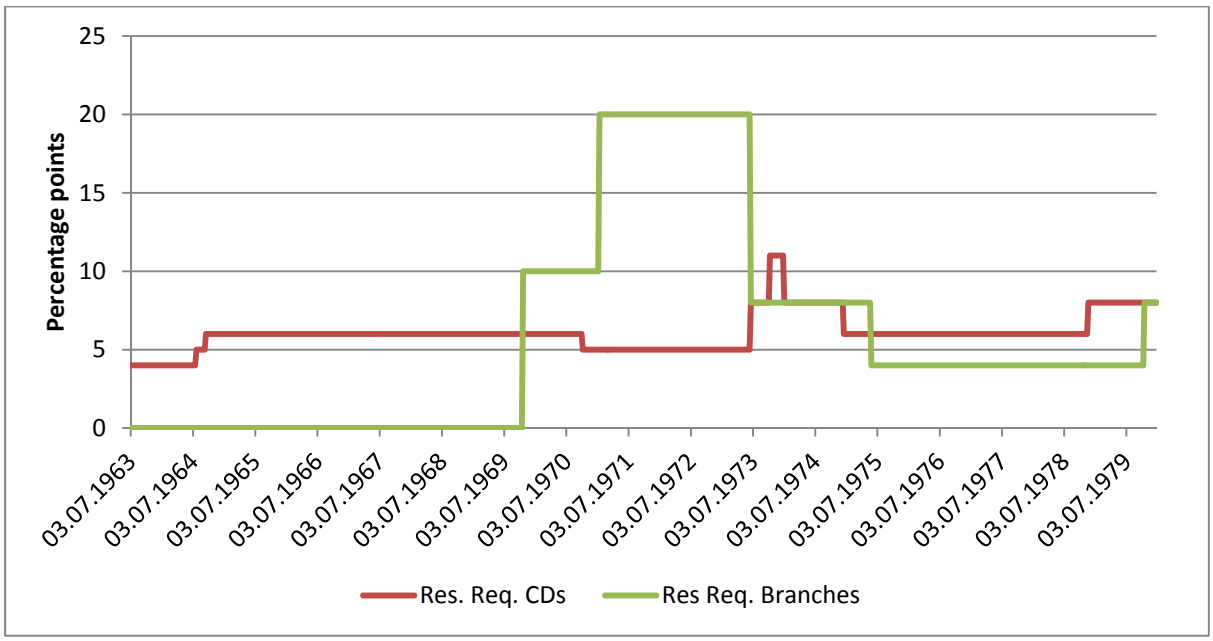

Table 1
Summary Statistics

Name	N	Mean	Standard Deviation	Min.	Max.
Weekly variables					
Eurodollar rate (3 month)	801	7.3	2.3	4.2	15
Negotiable CD rate (3 month)	801	6.6	2.1	3.5	14
Treasury bill rate (3 month)	801	5.7	1.6	3.0	12
Week to week change in the Eurodollar rate	801	.02	.26	-1.2	1.1
Week to week change in the CD rate	800	.01	.16	-.90	.92
Eurodollar – Treasury bill spread	801	1.6	.99	.36	6.4
CD – Treasury bill spread	801	.84	.68	.12	5.1
Effective fed funds rate	801	6.4	2.3	3.1	14
Ratio Treasury bills held by private investors ($ millions) to GDP ($ billions)	801	55	6.7	44	71
Indicator for Regulation Q binding	801	.21	.41	0	1
Reserve req. for CDs	801	5.9	1.3	4	11
Reserve req. for branches	801	6.1	6.8	0	20
Indicator for Herstatt episode	801	.07	.25	0	1
Monthly variables					
Δ ratio of CDs ($ millions) to gdp ($ billions)	161	.12	1.5	-5.3	4.5
Δ ratio of bank liabilities to GDP	123	.19	6.8	-19	16
Δ ratio of CDs to bank liabilities (pct. pnts.)	123	.06	.48	-1.1	1.5
Δ ratio of selected demand dep. to bank liabilities (pct. pnts.)	123	-.01	.84	-2.6	1.7
Δ ratio of other demand dep. to bank liabilities (pct. pnts.)	123	-.02	2.4	-17	18
Δ ratio of time dep. to bank liabilities (pct. pnts.)	123	-.02	.64	-1.4	2.1
Effective fed funds rate	161	6.3	2.1	3.2	14
Treasury bills held by private investors ($ millions) to GDP ($ billions)	161	55	5.9	44	68
Indicator for Regulation Q binding	161	.23	.43	0	1
Reserve req. for CDs	161	5.9	1.1	4	11
Reserve req. for branches	161	6.7	7.0	0	20
Indicator for Herstatt episode	161	.08	.27	0	1
Short-term yield curve	161	.17	1.5	-5.2	2.3
Growth in IP (pct. pnts)	161	.31	.87	-3.5	2.4
Growth in CPI index (pct. pnts)	161	.47	.29	-.09	1.8
Quarterly variables					
Δ ratio of eurodollars due to nonbanks in Europe ($ millions) to US GDP ($ billions)	42	.26	.59	-1.5	1.7
Δ ratio of eurodollar liabilities in Europe ($ millions) to US GDP ($ billions)	56	2.0	3.8	-6.0	12
Δ ratio of UK Eurodollar liabilities ($ millions) to US GDP ($ billions)	56	1.0	1.6	-1.5	7.2
Effective fed funds rate	57	6.1	2.1	3.5	12
Treasury bills held by private investors ($ millions) to GDP ($ billions)	57	56	6.6	45	70
Indicator for Regulation Q ever binding	57	.33	.47	0	1
Mean reserve req. for CDs	57	5.8	1.2	4	11
Mean reserve req. for branches	57	6.3	7.1	0	20
Indicator for Herstatt episode	57	.04	.18	0	1

Table 2
Factors affecting the Eurodollar spread

Dependent variable: spread between the interest rates for 3-month Eurodollars and for 3-month T-bills

Federal funds rate	.18*** *(.03)*
Ratio T-bills to GDP (lagged)	-.012** *(.006)*
Reg. Q binds	.16** *(.06)*
Reserve Req. on CDs	-.005 *(.08)*
Reserve Req. on due from branches	.013 *(.015)*
Herstatt crisis	.88** (.37)
Constant	1.0 *(.62)*
AR(lag 1)	1.06
AR(lag 2)	-.14
Observations	801
Wald χ^2	2970.4

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a second-order autoregressive process. Standard errors are clustered at the monthly level. Data are weekly and cover the period from July 1963 to October 1979; data on T-Bills outstanding and in the hands of private investors are available monthly and divided by quarterly GDP. See the Appendix for data sources.

Table 3
Factors affecting the negotiable CD spread

Dependent variable: spread between the interest rates for 3-month negotiable CDs and for 3-month T-bills

Federal funds rate	.15*** (.03)
Ratio T-bills to GDP (lagged)	-.011** (.005)
Reserve Req. on CDs	-.04 (.03)
Reserve Req. on due from branches	.006 (.005)
Herstatt crisis	.64*** (.27)
Constant	.66 (.40)
AR(lag 1)	1.05
AR(lag 2)	-.14
Observations	632
Wald χ^2	1220.9

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a second-order autoregressive process. Standard errors are clustered at the monthly level. Data are weekly and cover the period from June 1964 to October 1979; data on T-Bills outstanding are available monthly and divided by quarterly GDP. Periods when Regulation Q was binding are excluded from the analysis. See the Appendix for data sources.

Table 4
Factors affecting size of the Eurodollar market

Dependent variable: change in the ratio of the size of the Eurodollar market to US GDP

	European Eurodollar market (due to non-banks)	European Eurodollar market (all liabilities)	UK Eurodollar market (all liabilities)
Average Federal funds rate	.09 *(.18)*	-1.23* *(.71)*	-.46 *(.45)*
Ratio T-bills to GDP	-.10** *(.05)*	-.44*** *(.14)*	-.36** *(.09)*
Reg. Q was binding during the quarter	.83 *(.75)*	1.6 *(2.2)*	1.6 *(1.43)*
Average reserve Req. on CDs	-.18 *(.48)*	.31 *(1.6)*	-.65 *(1.1)*
Average reserve Req. on due from branches	-.06 *(.10)*	.25 *(.36)*	.05 *(.23)*
Herstatt crisis	-2.0* *(1.2)*	-16.0*** *(4.3)*	-10.6*** *(2.8)*
Constant	5.6 *(5.2)*	32.4*** *(12.0)*	27.6*** *(7.7)*
Year dummies	Yes	Yes	Yes
Rho (serial correlation coef.)	-.62	-.65	-.70
Observations	41	56	56
F-stat	1.6	3.0	3.8
Adjusted R^2	.52	.41	.49

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a first-order autoregressive process. Data are quarterly and cover the period from December 1968 (column 1) or March 1965 (columns 2 and 3) to December 1978. See the Appendix for data sources.

Table 5
Factors affecting the growth of the negotiable CD market

Dependent variable: change in the ratio of the size of negotiable CDs to US GDP

	Specification 1 (Includes periods when Reg. Q was binding)	Specification 2 (Excludes periods when Reg. Q was binding)
Average Federal funds rate	.36** *(.16)*	.43*** *(.10)*
Ratio T-bills to GDP	-.09** *(.04)*	-.07** *(.04)*
Reg Q binds	-.72** *(.33)*	
Average reserve Req. on CDs	-.45** *(.18)*	-.58*** *(.17)*
Average reserve Req. on due from branches	.01 *(.02)*	-.01 *(.02)*
Herstatt crisis	-.39 *(.70)*	.65 *(.61)*
Short-term yield curve (lagged 1 month)	.10 *(.19)*	-.02 *(.17)*
Growth in IP (lagged 1 month)	-.08 *(.14)*	-.08 *(.14)*
Growth in IP (lagged 2 months)	.08 *(.13)*	.16 *(.14)*
Inflation rate (lagged 1 month)	-.91* *(.48)*	-1.09** *(.50)*
Inflation rate (lagged 2 months)	-.45 *(.49)*	-.16 *(.51)*
Constant	5.0* *(2.7)*	4.6* *(2.6)*
Month dummies	Yes	Yes
Rho (serial correlation coef.)	.27	.12
Observations	161	117
F-stat	4.0	5.2
Adjusted R^2	.29	.43

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a first-order autoregressive process. Data are monthly and cover the period from July 1965 to December 1978. See the Appendix for data sources.

Table 6
Factors affecting the growth of total bank liabilities

Dependent variable: change in the ratio of the size of bank liabilities to US GDP

	Change in all bank liabilities
Average Federal funds rate (lagged)	-.19 *(.32)*
Ratio T-bills to GDP (lagged)	-.04 *(.06)*
Average reserve Req. on CDs	-.46 *(.31)*
Average reserve Req. on due from branches	.01 *(.04)*
Herstatt crisis	-4.4*** *(1.2)*
Short-term yield curve (lagged 1 month)	-.92*** *(.32)*
Growth in IP (lagged 1 month)	-.83** *(.39)*
Growth in IP (lagged 2 months)	.43 *(.37)*
Inflation rate (lagged 1 month)	-.26 *(1.4)*
Inflation rate (lagged 2 months)	.79 *(1.4)*
Constant	-7.8 *(4.7)*
Month dummies (January omitted)	Yes
Rho (serial correlation coef.)	-.42
Observations	123
F-stat	18.1
Adjusted R^2	.75

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a first-order autoregressive process. Data are monthly and cover the period from July 1965 to December 1978. See the Appendix for data sources.

Table 7
Factors affecting distribution of bank liabilities

Dependent variable: change in the ratios of different bank liabilities to total bank liabilities

	Change in CDs	Change in selected demand deposits	Chang in other demand deposits	Change in time deposits (ex. CDs)
Average Federal funds rate (lagged)	.16** *(.05)*	-.14** *(.06)*	-.03 *(.19)*	-.07* *(.04)*
Ratio T-bills to GDP (lagged)	-.02** *(.01)*	.02* *(.01)*	-.02 *(.04)*	.02* *(.01)*
Average reserve req. on CDs	-.20*** *(.06)*	.17*** *(.07)*	-.06 *(.18)*	.11*** *(.04)*
Average reserve req. on due from branches	-.001 *(.01)*	.02* *(.01)*	-.01 *(.03)*	.003 *(.01)*
Herstatt crisis	-.13 *(.21)*	-.12 *(.26)*	-.08 *(.72)*	.47*** *(.14)*
Short-term yield curve (lagged 1 month)	.03 *(.06)*	-.04 *(.07)*	.02 *(.19)*	.03 *(.04)*
Growth in IP (lagged 1 month)	.02 *(.05)*	-.01 *(.08)*	.18 *(.24)*	.01 *(.05)*
Growth in IP (lagged 2 months)	.01 *(.05)*	-.06 *(.08)*	-.05 *(.22)*	-.02 *(.04)*
Inflation rate (lagged 1 month)	-.32* *(.17)*	.36 *(.31)*	.45 *(.90)*	-.02 *(.18)*
Inflation rate (lagged 2 month)	-.11 *(.18)*	.17 *(.30)*	-.46 *(.88)*	-.08 *(.17)*
Constant	2.1*** *(.83)*	-3.5*** *(1.0)*	1.2 *(2.8)*	.35 *(.57)*
Month dummies	Yes	Yes	Yes	Yes
Rho (serial correlation coef.)	.08	-.43	-.52	-.31
Observations	123	123	123	123
F-stat	3.6	5.6	.6	12.5
Adjusted R^2	.31	.44	.04	.66

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a first-order autoregressive process. Data are monthly and cover the period from July 1965 to December 1978. Selected demand deposits include demand deposits by individuals, partnerships, and corporations, demand deposits by foreign banks, demand deposits by savings banks, federal funds purchased, and "other borrowings." See the Appendix for other information regarding the data sources.

Table 8
Co-integration tests of the federal funds rate and other interest rates

	Eurodollar rates		Negotiable CD rates	
	Before May 1973	After May 1973	Before May 1973	After May 1973
Long run relationship: dependent variable is the level of the interest rate				
Federal funds rate	1.02*** *(.02)*	.99*** *(.01)*	.79*** *(.02)*	.92*** *(.01)*
Constant	1.02*** (*.10)*	.69*** *(.10)*	1.32*** *(.10)*	.73*** *(.08)*
Observations	469	332	300	332
Adjusted R^2	.87	.95	.83	.96
Augmented Dickey-Fuller Test statistics (using MacKinnon critical values)				
	-8.3****	-8.3***	-7.5***	-10.0***
Error correction model: dependent variable is the change in the money rate				
Change in dependent variable (lagged)	.25*** *(.04)*	.27*** *(.05)*	.51*** *(.05)*	.44*** *(.05)*
Change in the federal funds rate (lagged)	-.02 *(.03)*	.26*** *(.05)*	.04* *(.02)*	.19*** *(.04)*
Error term from long run (lagged)	-.10*** *(.02)*	-.14*** *(.03)*	-.07*** *(.02)*	-.10*** *(.02)*
Constant	.007 *(.01)*	.01 *(.01)*	.004 *(.005)*	.01 *(.01)*
Observations	469	332	300	332
F-stat	20.3	36.6	49.9	55.2
Adjusted R^2	.11	.24	.33	.33

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Regressions involving negotiable CD rates exclude periods in which Regulation Q was binding. Standard errors are in parentheses and italics. Data are weekly and cover the period from July 1963 (Eurodollars) or June 1964 (negotiable CDs) to October 1979. See the Appendix for data sources.

Table 9A
Factors affecting the federal funds rate

Dependent variable: change in the federal funds rate (in basis points)

	Prior to May 1973		After May 1973
Change in discount rate	.91*** *(.17)*	.91*** *(.19)*	.66*** *(.11)*
Change in securities holdings	-3.1*** *(.94)*	-1.8* *(1.1)*	-.44* *(.27)*
Interaction changes in securities * Reg Q binds		-4.2** *(2.0)*	
Change in whether Reg. Q binds	.11 *(.07)*	.12* *(.07)*	
Change in Reserve Req. on CDs (lagged 1 week)	-.08 *(.15)*	-.09 *(.15)*	.07* *(.04)*
Change in Reserve Req. on due from branches (lagged 1 week)	-.01 *(.02)*	-.01 *(.02)*	-.03 *(.05)*
Constant	.01 *(.01)*	.01 *(.01)*	-.005 *(.07)*
Rho (serial correlation coef.)	-.40	-.42	-.03
Observations	439	439	325
F-stat	8.5	8.1	12.6
Adjusted R^2	.08	.09	.13

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a first-order autoregressive process. Data are weekly and cover the period from January 1965 to October 1979. See the Appendix for data sources.

Table 9B
Factors affecting the federal funds rate

Dependent variable: change in the federal funds rate (in basis points)

	Prior to May 1973		After May 1973
Change in discount rate	.88*** *(.18)*	.88*** *(.18)*	.64*** *(.11)*
Change in non-borrowed reserves	-.71* *(.37)*	-.48 *(.44)*	-.45** *(.22)*
Interaction changes in NBR * change in Reg Q binding		-.80 *(.79)*	
Change in whether Reg. Q binds	.10 *(.07)*	.09 *(.07)*	
Change in reserve req. on CDs (lagged 1 week)	-.05 *(.15)*	-.04 *(.15)*	.05 *(.04)*
Change in reserve req. on due from branches (lagged 1 week)	-.01 *(.02)*	-.01 *(.02)*	-.02 *(.05)*
Constant	.01 *(.01)*	.007 *(.01)*	-.002 *(.01)*
Rho (serial correlation coef.)	-.33	-.32	.04
Observations	439	439	325
F-stat	6.4	5.5	10.3
Adjusted R^2	.06	.06	.10

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a first-order autoregressive process. Data are weekly and cover the period from January 1965 to October 1979. See the Appendix for data sources.

Table 10
Factors affecting the federal funds rate

Dependent variable: change in the federal funds rate (in basis points)

	Federal Reserve operations measured by:	
	Change in government securities holdings	Change in non-borrowed reserves
Change in discount rate	.58*** *(.08)*	.56*** *(.08)*
Impact of Fed operations when RRCD=4, 5, or 6 and RRDTFB=0	-3.0** *(1.5)*	-1.7** *(.69)*
Impact of Fed operations when RRCD=6 and RRDTFB=10	-5.8 *(4.9)*	-2.7*** *(.62)*
Impact of Fed operations when RRCD=5 and RRDTFB=20	-.76 *(.79)*	-.61* *(.36)*
Impact of Fed operations when RRCD=8 and RRDTFB=8	-1.2* *(.71)*	-.67* *(.41)*
Impact of Fed operations when RRCD=6 and RRDTFB=4	-.31* *(.17)*	-.04 *(.34)*
Change in whether Reg. Q binds	.13* *(.07)*	.12* *(.07)*
Change in reserve req. on CDs (lagged 1 week)	.08 *(.07)*	.06 *(.07)*
Change in reserve req. on due from branches (lagged 1 week)	-.04 *(.03)*	-.05** *(.02)*
Constant	.01 *(.01)*	.01 *(.01)*
Observations	761	761
F-stat	9.2	10.4
Adjusted R^2	.09	.10

Note. The symbols ***, **, and * indicated statistical significance at the 1, 5, and 10 percent levels respectively. RRCD is the reserve requirement on negotiable CDs and RRDTFB is the reserve requirement on due to foreign branches. Standard errors are in parentheses and italics. Regressions control for serial correlation with errors found to follow a first-order autoregressive process. Data are weekly and cover the period from January 1965 to October 1979. See the Appendix for data sources.

Table 11
Differences between the target federal funds rates and effective federal funds rate
(percentage points)

	Early period			Late period
	All times	Regulation Q binds	Reg. Q does not bind	
Average absolute value of differences	.21	.28	.16	.15
Lowest quartile	.05	.07	.05	.04
Median	.15	.22	.10	.09
Top quartile	.30	.40	.22	.20
Observations	*334*	*137*	*197*	*332*

Note. Data are weekly. The early period lasts from January 1967 to May 1973. The late period starts in June 1973 and ends in October 1979. See the Appendix for data sources

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