Monetary Policy Implementation:

A Microstructure Approach

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In classic central banking theory, the "discount house" played a central role (Bagehot 1873, Sayers 1957).[1] As holders of short term commercial bills, the discount houses financed the holding of goods on their way from producers to consumers, and in turn financed themselves primarily by borrowing from banks. Just so, an expansion of trade went hand in hand with an expansion of both the assets and liabilities of the discount houses, and also an expansion of both the assets and liabilities of the banking system. Looking through the balance sheet relationships, it was clear to observers that the expansion of trade was financed by an expansion of bank money, meaning the deposit liabilities of the banking system.

It was further clear to observers that the key to potential control of such a system was the regular exposure—not to say the systematic vulnerability—of the discount houses. In their search for profit, the discount houses regularly sought to expand their balance sheets to the maximum on a given capitalization base, while at the same time holding essentially no cash reserve. For their daily cash needs, they relied instead on inflows from maturing bills in their possession, on access to bank credit, and ultimately on a discount facility at the Bank of England.

The institutional importance of this discount facility is the fundamental reason for the central role in classic central banking theory of so-called Bank Rate, which was the rate charged by the Bank of England for the discount. Whenever the discount houses ran short of cash, they turned to the Bank of England as their lender of last resort and paid the posted price. This was so whether the shortage arose from some imbalance in the flow of

[1] The desperately brief summary that follows does justice to the sophistication neither of theory nor of practice. Most egregious probably is my singleminded focus on discount rate policy, to the exclusion of all other channels through which central banks attempted to influence market conditions. See Bloomfield (1959) and the extensive references therein for a more complete treatment.

their own discounts that banks were unwilling to accommodate, or because of imbalances elsewhere in the economy that caused banks to reduce their outstanding exposure to the discount houses.

It is important to emphasize here that normally Bank Rate was set somewhat above the prevailing market rate of discount. It was supposed to be a penal rate in order to discourage regular use, and also to permit the Bank of England to control its own balance sheet (and hence the central reserve) rather than to accept passively any and all requests for rediscount. When the Bank engaged in the market on its own initiative, buying or selling bills for its own account, it did so not at Bank Rate but rather at the prevailing market rate. Such open market operations, as we would now call them, had the effect of expanding or contracting the deposit liabilities of the Bank of England, and hence ultimately the cash reserves of the banking system.

What leverage the Bank enjoyed over the market rate of interest derived from its ability to make cash sufficiently scarce that banks would call in loans to the discount houses, which in turn would borrow from the Bank at Bank Rate. Seemingly, if it was prepared to apply enough pressure, the Bank could force market rate to equal Bank Rate. Hence, by application of somewhat less force, the Bank could presumably move market rate closer to or farther from Bank Rate. That was the theory anyway. In practice, banks could and sometimes did frustrate the intentions of the Bank by allowing their reserve ratios rather than their call loans to absorb open market operations. [2] (Even in classic central banking theory, the "velocity" of money was by no means a constant, neither in theory nor in practice.) Over time the problem of "making Bank Rate effective" became

[2] For example, Sayers (1936, 46) remarks that banks distinguished between "artificial" reserve contractions at the discretion of the Bank, and reserve contractions produced by international gold flows, being more inclined to frustrate the former and adjust to the latter.

all the more challenging as the size and sophistication of money and capital markets increased relative to the Bank's own balance sheet.

The underlying context for all this balance sheet activity was of course the working of the international gold standard, according to which net payment flows into and out of the country caused the gold reserve at the central bank to fluctuate. Every gold flow posed a policy choice for the Bank, whether to allow cash outstanding to fluctuate with gold holdings, or instead to allow the gold reserve ratio to fluctuate, or some policy in between. Phrased in terms of prices rather than quantities, the choice was whether to allow fluctuation of international reserves fully to affect the market rate of interest, or not at all, or something in between. This choice, it will be perceived, was analogous to the choice that individual banks faced when subject to fluctuation of their own reserve, and in line with that analogy central bank discretion proved to be an additional locus of potential elasticity in the velocity of money.

Simplified Balance Sheet Relationships

Banking System		**Discount Houses**		**Bank of England**	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Cash Loans	Deposits	Bills	Bank loans	Gold Bills	Cash

For various reasons, this classic mode of analysis fell into disfavor in the decades after WWII. One reason was the shift of the center of the world monetary system from

London to New York, where the commercial bill had never played such a central role. Another reason was war finance, which flooded the world with government paper, much of it in the form of long term bonds rather than the traditional short term Treasury Bills. And yet a third reason was the shift at Bretton Woods from a gold standard to a dollar standard. These institutional changes called for adjustment of the classic theory, and some such adjustments were forthcoming (Sayers 1957, 1960 Ch. 10), but they failed to carry the day. Instead a new style of analysis, that I have elsewhere called Monetary Walrasianism (Mehrling 1997), took the forefront, exemplified by the work of Patinkin, Modigliani, and above all James Tobin (1969).

Under the new theory, attention shifted from Bank Rate to the market rate, and to some extent from the short rate to the long rate, as attention shifted also from financing trade to financing capital investment. Now the central bank was supposed to derive its leverage over market rates from its ability to alter the relative supply of various financial assets outstanding, using its own balance sheet. In this way of thinking, open market operations were nothing more than the purchase of one asset and the simultaneous sale of another, and they produced their effect on the structure of asset prices depending on the relative demand elasticities of the final asset holders. The discount facility of the Federal Reserve System fell into disuse, and so too did the classic theory of central banking with its emphasis on Bank Rate.[3]

The new theory was perhaps well suited to the relatively rigid and highly regulated structure of banking and finance in the immediate decades after WWII. That was, after all, the institutional setting for which it was developed. (The new theory was

[3] The various submissions to the 3 volume collection, Reappraisal of the Federal Reserve Discount Mechanism (Board of Governors 1971-1972) mark the decisive confrontation of the new view with the old view.

also well suited to the new styles of academic discourse, but that is another story.) Subsequent decades however saw fundamental change in the institutional setting, including the revival of flexible private capital markets and the deregulation of banking. For this new institutional setting, Monetary Walrasianism had a big problem. The balance sheet of the central bank was simply dwarfed by the size of the markets in which it dealt. The idea that open market operations on any reasonable scale could have a significant effect on relative asset supplies was called into question (Friedman 2000). And the idea that changes in relative asset supplies could have significant effects on asset prices was further called into question by the rise of modern finance theory, with its implication that the demand for any particular financial asset should be highly elastic (Black 1970).

Given this state of affairs, it may be time to reconsider classic banking theory, albeit in suitably updated form. To recapitulate, the classic theory emphasized not the direct effects of open market operations, but rather the indirect effects on the balance sheets of financial intermediaries. Given institutional change, it seems clear that an updated version of the classic theory should emphasize security dealers rather than discount houses. Financing their long bond positions largely with repurchase agreements, and their short bond positions largely with reverse repurchase agreements, modern security dealers operate simultaneously in both capital and money markets, playing a key role in both but most importantly providing the key link between the two markets. From the point of view of classic central banking theory it is here, if anywhere, that the modern central bank must acquire its leverage over the asset prices that influence spending decisions.

Indeed, from the classic point of view, it is surprising how little attention has been paid in the modern literature to the money market in general, and to the repo market in particular. On the one hand, the tradition of Monetary Walrasianism has offered well developed theories of the demand and supply of money proper, but that has meant mainly bank deposits and almost nothing on money markets more broadly (Tobin 1969; Modigliani, Rasche and Cooper 1970). On the other hand, the newer financial economics has offered well developed theories of the microstructure of capital markets, but that has meant mainly stocks and bonds, and again almost nothing on money markets (Harris 2003). The repo market has largely fallen between these two intellectual stools.

Recent bridge building between the two intellectual traditions of monetary and financial economics has begun to remedy this gap. From the monetary side, we have seen the growth of a literature on monetary policy implementation, a literature that takes seriously the operations of the financial markets in which the central bank intervenes (Bindseil 2004). From the finance side, we have seen the growth of a literature on the microstructure of foreign exchange markets, a literature that expands the concerns of finance from capital markets to currency markets (Lyons 2001, Evans and Lyons 2005). The present paper uses the microstructure approach of the latter as a theoretical entrypoint for the practical problems addressed by the former.[4]

[4] The closest predecessor of the present paper is probably BIS (1999), but that paper is mainly empirical.

I. The Repo Market

In both the U.S. and Europe, repo markets have grown enormously over the postwar period.[5] One survey reports U.S. outstanding volume of repo and reverse repo (both DVP and tri-party) as $5.2 trillion (Bond Market Association 2005).[6] (By comparison, the most recent measure of the M1 money supply is about $1.4 trillion, which includes $621 billion checkable deposits against $43 billion aggregate reserves, much of which is held in the form of vault cash. Depository institution reserves held at the Fed are only $21 billion.[7]) Within the enormous repo market, dealer-to-dealer transactions account for more than half of the volume, but the range of other counterparties includes essentially all types of financial institutions, both public and private, as well non-financial corporations. Of particular interest for this paper, the Federal Reserve Bank is identified as the counterparty in only 1.2% of non-dealer DVP transactions.[8]

Given the scale of the market, it is fair to say that the overnight repo rate is the best general measure of the cost of funds in the money market, but there are two other

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[5] An early and prescient account is Minsky (1957). The best sources on how this market now works have been written for practitioners: Stigum (1990, Ch. 13), Taylor (1995), Choudhry (2002). Garbade (2006) provides a useful account of the maturation of repo contracting conventions.

[6] The official data on repo outstanding can be found in Table L.207 "Federal Funds and Security Repurchase Agreements" published by the Federal Reserve Board as part of the Flow of Funds accounts. These numbers however report only net issue of repo by commercial banks ($1131.3 billion) and by brokers and dealers ($817.8 billion), and so neglect the very large interbank and interdealer market. Further, the statistical discrepancy of $481.2 billion between the measure of total repo held and the measure of total repo issued suggests that much of the activity in this market escapes the statistical net entirely. The most recent flow discrepancy of $278.0 billion (Table F.207) is by far the largest instrument discrepancy in the entire set of accounts (Table F.12).

[7] Table L.108 "Monetary Authority"

[8] For comparison, another survey reports European outstanding volume as EUR 5.9 trillion (International Capital Market Association 2006), but this number is not strictly comparable to the U.S. number because the European survey explicitly excludes all repo transactions with the central bank. The reason is not that such transactions are unimportant, but rather the reverse. Repurchase agreements (mainly against the public debts of the various member governments) are the dominant form of domestic credit held by the European Central Bank. As a consequence of its balance sheet, the ECB is thus a much bigger part of the repo market than is the Fed, and there is no question of its losing contact. See Bindseil (2004, Ch. 2).

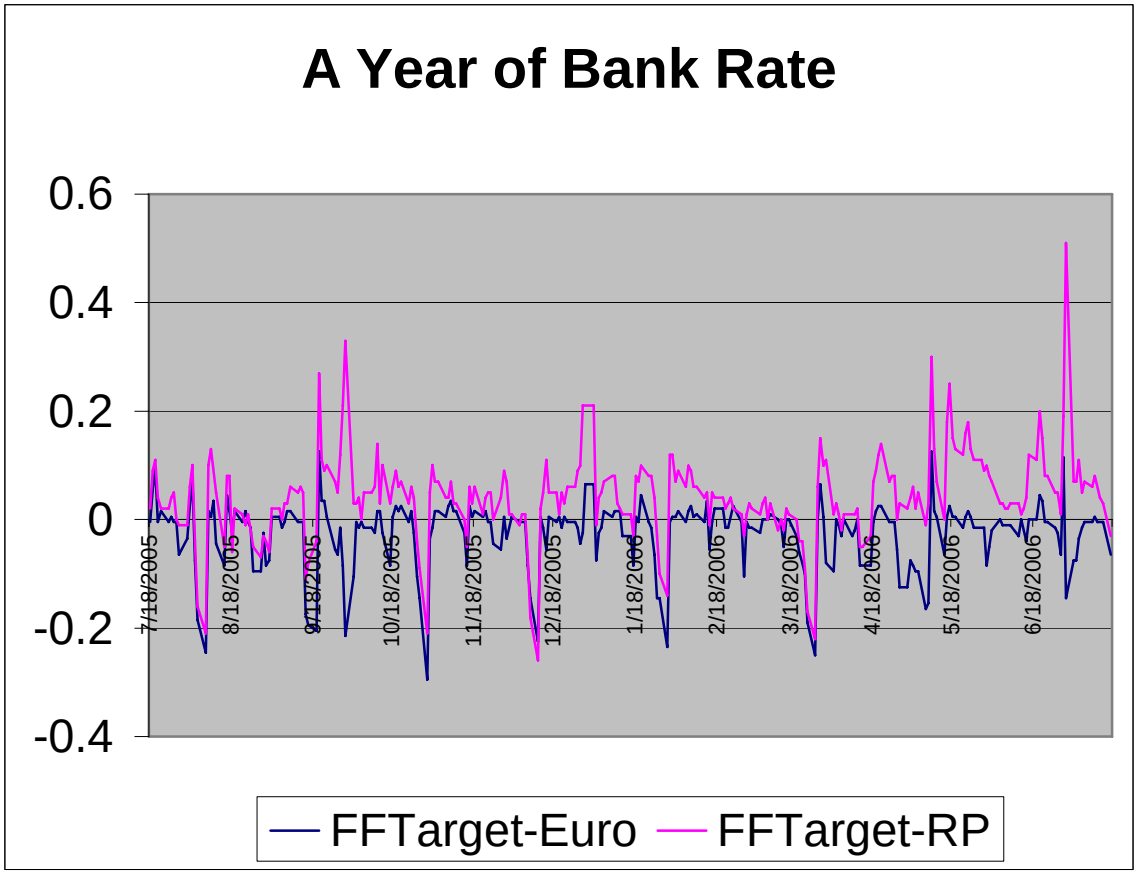
more specialized interbank rates that tend to receive more attention. The Eurodollar rate, more often today called US LIBOR to distinguish it from Euro LIBOR, is the rate banks charge both bank and non-bank clients for their own overnight interbank deposits. Even more specialized, the Fed Funds rate is the rate banks charge other banks for overnight deposits at the Federal Reserve. [9] In general the three money markets are closely integrated and all three rates move together (Demiralp, Preslopsky, and Whitesell 2004; Bartolini, Hilton and Prati 2005). However, on average (though not always) the repo rate has been lower than the Fed Funds rate, and the Eurodollar rate slightly higher than the Fed Fund sate.[10]

As an illustration, the chart below shows a year of variation of the overnight repo rate and the overnight Eurodollar rate around the Fed Funds target. Except for days immediately preceding a target hike, when market rates typically rise above the current target in anticipation, the repo rate was consistently below the target. Indeed the dates of target hikes stand out by contrast: August 9, September 20, November 1 and December 13 in 2005, and January 31, March 28, May 10, and June 29 in 2006.

The reason for this rate pattern is, in my view, an open question. Credit risk is the standard answer since repo is secured credit while Fed Funds are unsecured, but this answer is not convincing. No one lends $10MM overnight if there is even the slightest perceived risk of default, nor has there been historical experience of default in the Fed

[9] Henckel at al (1999) have coined the evocative terminology of "Treasury money," "clearinghouse money," and "central bank money" to describe the instrument traded in each of these three markets.
[10] The repo market is heterogeneous and the rate charged depends on the underlying collateral. The phrase "the repo rate" should be understood therefore as a shorthand for "the repo rate on general Treasury collateral" which tends to be higher than the repo rate on any specific Treasury security, but still below the Fed Funds rate.

Funds market; default risk is handled by strict controls on credit lines, not by price.[11] To anticipate the argument below, I suggest alternatively that the Fed Funds rate should be viewed as analogous to the classic Bank Rate, a penal rate that lies normally above the repo rate which is analogous to the classic market rate.



The Fed Funds rate is the rate targeted by the Federal Reserve, but the operational implementation of that rate involves almost daily trading in the much larger repo market at the repo rate of interest. In 2005, the Fed undertook 256 separate short term temporary

[11] Another reason sometimes offered is the fact that corporate lenders can invest in repo but not Fed Funds. That could possibly explain why repo can be below Fed Funds, if it were not for the fact that corporate lenders can invest in Eurodollars which are also persistently above repo.

operations in the repo market, with an average size of $6.54 billion (Federal Reserve Bank of New York, 2006). By design, the Fed is typically a lender in the market, and it increases its repo assets by increasing its deposit liabilities, so increasing system reserves.[12] The size of these daily interventions is tiny in comparison to the size of the repo market, but huge in comparison to the stock of reserves.[13] (Recall that total depository institution reserves held at the Fed are only $21 billion). The perceived importance of the Fed Funds market for monetary policy has stimulated an extensive empirical literature to understand how it works.[14] By comparison repo markets are almost entirely unstudied; the Fed does not even publish a repo rate series among its extensive statistical coverage of interest rates.

What we know about the repo market comes mainly from balance sheet data for the subset of so-called primary security dealers who commit to bid at Treasury debt sales. As dealers, they stand ready at all times to buy and sell securities at posted bid and ask prices, and hence operate as suppliers of liquidity to the bond market.[15] But their net positions in the market as of March 15, 2006 show more than that. (See Table 1.) As arbitrageurs, buying in one market and selling in another closely related market, dealers

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[12] If the stock of reserves were higher, then on days when the Fed currently injects minimal short term reserves, it would have to withdraw reserves through reverse repo, or securities lending, in order to achieve the same total reserves target. As a matter of policy, apparently the Fed has decided to devote its securities lending facility to a different task, that of providing specific securities that happen to be temporarily in short supply.

[13] The Fed itself prefers to think of its interventions as soaking up fluctuations in so-called "autonomous factors" that influence the demand for reserves. These daily fluctuations are large relative to the outstanding supply of depository reserves, but not large relative to the size of the Fed's entire balance sheet.

[14] Hamilton (1996, 1997); Furfine (1999, 2000); Bartolini et al (2005); Hilton (2005); McAndrews (2005); Carpenter and Demiralp (2006).

[15] Here I follow the terminology of the microstructure literature in finance, where liquidity means the ability to make a trade, quickly, in size, and at low cost. The mechanics of payment are thus pushed to the background, and instead attention focuses on the mechanics of trading and the institutions of exchange (O'Hara 1995, Harris 2003). Since limit orders to buy or sell at stated prices provide the opportunity for other people to trade if they want to, such orders are considered to <u>offer</u> or supply liquidity. By contrast, market orders to buy or sell take advantage of the opportunity offered by limit orders, and such orders are considered therefore to <u>take</u> or demand liquidity.

operate also as "porters" of liquidity from one market to another. With long positions in agency and corporate securities, and short positions in Treasuries, dealers are long the credit spread. Similarly, with long positions in Treasury bills and short positions in Treasury bonds, they are short the Treasury term spread. For our purposes, however, the most important arbitrage implicit in the dealers' balance sheet is the net long outright position of $179,618 million. This position represents a speculation on the direction of rates of course,[16] but more important it represents a positive inventory that must be financed, either by the dealers' own capital (which is relatively small), or by borrowing. The dealers are thus net long bonds, but short money. If we think of them as net suppliers of liquidity in the bond market, they must also be net takers of liquidity in the money market.

Table 2 speaks to the way that dealers finance their gross bond holdings, and reveals the overwhelming importance of the repo market for that purpose. "Securities in" includes all the multitudinous ways that a security might come to be delivered to a dealer, including reverse repurchase agreements. "Securities out" includes all the multitudinous ways that a security might come to be delivered out from a dealer, including repurchase agreements. The net financing need of the dealers is the difference between securities out and securities in, which is $309,818 million in this case.[17] Of that amount, the net financing provided by the repo market (repurchase agreements minus reverse repurchase

[16] It is important to add the caveat that the table does not capture the entire balance sheet, or the entire risk exposure. The most important omission is exposure in futures and options markets, no longer reported since 2001.

[17] The difference between the net position in Table 1 and the net financing in Table 2 is apparently largely an artifact of institutional peculiarities of the mortgage-backed securities market which trades with significantly delayed settlement. See Adrian and Fleming (2005) for details.

Table 1: Primary Dealer Positions

in U.S. Government, Federal Agency, Government Sponsored Enterprise, Mortgage-backed, and Corporate Securities,
as-of close of trading March 15, 2006,
in Millions of Dollars

Type of Security		Net Outright Position
U.S. Government Securities		
Treasury Bills	23,556	
Coupon Securities		
due in 3 years or less	-48,088	
due in 3-6 years	-46,342	
due in 6-11 years	-36,638	
due in more than 11 years	-13,505	
Treasury Inflation Index Securities (TIIS)	655	
Total		-120,362
Federal Agency and Government Sponsored Enterprise Securities		
Discount Notes	45,283	
Coupon Securities		
due in 3 years or less	41,022	
due in 3-6 years	15,837	
due in 6-11 years	-58	
due in more than 11 years	5,826	
Total		107,910
Mortgage-backed Securities		14,148
Corporate Securities		
due in 1 year or less	46,027	
due in more than 1 year	131,895	
Total		177,922

Source: Federal Reserve Bank of New York

Table 2: Primary Dealer Financing

Amount Outstanding as of March 15, 2006,
in millions of dollars

Type of Financing	Overnight &Continuing	Term	Total
Securities In			
U.S. Treasury Securities	1,185,692	1,277,214	2,462,906
Federal Agency and Government Sponsored Enterprise Securities	154,650	247,641	402,291
Mortgage-backed Securities	93,198	392,368	485,566
Corporate Securities	111,338	92,913	204,251
Securities Out			
U.S. Treasury Securities	1,168,625	1,108,254	2,276,879
Federal Agency and Government Sponsored Enterprise Securities	304,618	169,951	474,569
Mortgage-backed Securities	553,068	241,313	794,381
Corporate Securities	261,687	57,316	319,003
Memorandum			
Reverse Repurchase Agreements	736,926	1,630,826	2,367,752
Repurchase Agreements	2,011,693	1,488,624	3,500,317

Source: Federal Reserve Bank of New York

agreements) was $1,132,565 million. Dealers raise a lot more funds in this market than they require for the financing needs of their security portfolio.

The point to emphasize here is that there are two sides to the operations of the primary security dealers. On the one hand, as dealers in securities, they hold inventories of securities that they finance by borrowing in the money market. On the other hand, they are also dealers in money; they are not simply takers of liquidity in the money market, but also providers of liquidity. To see this, rearrange the numbers in Table 2 as below, treating repo (borrowing money) as a liability and reverse repo (lending money) as an asset.

Security Dealers as Money Dealers

Assets		Liabilities	
736	Overnight reverse RP	2,011	Overnight RP
1,630	Term reverse RP	1,488	Term RP
1,132	Net financing		

These numbers reveal furthermore that the money market operations of security dealers are about more than simple liquidity provision. The dealers are apparently porters of liquidity in the money market as well. They are net long in term repo (reverse holdings are greater than repo), and net short in overnight and continuing repo. In other words, the security dealers are long the money market term spread. From the standpoint of liquidity provision, this arbitrage represents the transport of liquidity from one market

to another. From a money point of view, the dealers are borrowing short (overnight) and lending long (term). They are acting, in fact, like banks.[18]

They are acting like banks, but with essentially no cash reserve. For their daily cash needs, they rely instead on the daily cash flow from their money market operations, and ultimately on access to bank credit. (Unlike the classic discount houses, they have no guaranteed access to the discount facility at the central bank.) The balance sheets of U.S. commercial banks quite typically contain well over $100 billion of security credit to brokers and dealers, both RP credit and outright loans, so commercial banks provide a significant fraction of the finance needed to operate a dealer operation.[19] For our purposes, however, the important relationship is largely off-balance-sheet, through the lines of credit that function as the dealers' lender of last resort. If dealers require cash, their banks stand ready to provide it. Significantly, these dealer loans typically key off the Federal Funds rate, with a spread of 25-50 basis points.

Why does the dealer loan rate key off of Fed Funds? Because the Fed Funds rate is the marginal cost of funds for the banking system as a whole. Indeed, just as the banking system is the lender of last resort for the security dealers, so too the Fed is the lender of last resort for the banking system. The important point to emphasize is that, under current institutional arrangements, it is the Fed Funds rate and not the discount rate which is the relevant cost of this lender of last resort facility. The discount rate (now called the primary credit facility) stands at 100 b.p. over the Fed Funds target, and it is

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[18] "In providing that service, the dealer takes in securities on one side at one rate and hangs them out on the other side at a slightly more favorable (lower) rate; or to put it the other way, the dealer borrows money from his repo customers at one rate and lends it to his reverse customers as a slightly higher rate. In doing so, the dealer is operating like a bank, and dealers know this well." (Stigum 1990, 446)

[19] Table L.224 "Security Credit" in the Flow of Funds accounts reports $257.1 billion security credit from commercial banks to broker dealers, of which $101.8 billion is direct and $155.3 is channeled through foreign banking offices in the U.S.

available as a backup for individual banks that might get into trouble. But the marginal source of funds for the market as a whole is the Fed's daily intervention in the market as a whole, an intervention that is designed to stabilize the Fed Funds rate around the target (Taylor 2001). So long as individual banks have access to the Fed Funds market, the Fed's lending to the market might as well be a discount facility available to each individual bank (albeit with one day lag).

Indeed, although individual banks rarely make use of the loan facility offered at the discount window, the banking system as a whole always makes considerable use of the closely analogous loan facility offered at the daily repo auction. When the Fed lends to the market using repo, the consequence is an increase in some primary dealer's net position with its clearing bank, and an increase in that bank's reserve position at the Fed, which position the clearing bank can then lend on to whatever bank needs it at the Fed Funds rate. Looking through the balance sheets, it is clear that the Fed provides the funds that the needy bank borrows, just like the classic discount window albeit more indirectly. The Fed lends at the repo rate, while the needy bank borrows at the Fed Funds rate.

Daily Open Market Operations as a Discount Facility

Central Bank		**Dealer**		**Clearing Bank**		**Needy Bank**	
A	L	A	L	A	L	A	L
+RP	+reserves		+RP -dealer Loan	+FF loan -dealer loan		+reserves	+FF loan

Classic central banking theory revolved around the difference between the market rate of interest and Bank Rate. In modern banking, the closest analogue to market rate is apparently the repo rate, and the closest analogue to Bank Rate is apparently the Fed Funds rate. As in the classic theory, the Fed Funds rate tends to be a penal rate above the repo rate. The modern version of the classic question how to make Bank Rate effective must be about the effect of Fed operations not on the Fed Funds rate but on repo rate. Why can the Fed affect repo rate, despite its negligible importance in the repo market? I suggest it is because the Fed can affect the Fed Funds rate which affects the dealer loan rate, which then affects the repo rate that dealers are willing to offer to finance their operations. Before developing that suggestion further, it will be helpful to review the current state of professional discussion which has focused instead almost exclusively on determination of the Fed Funds rate.

II. Monetary Policy Implementation

The monetary policy implementation literature has focused narrowly on the problem of a central bank trying to achieve a target market rate of interest i_M by manipulating the variables under its control, namely the standing facility lending rate R, the standing facility deposit rate r, and the net monetary injection M.[20] In the U.S. context, the target is the Fed Funds rate set by policy makers, around which the actual Fed Funds rate fluctuates depending on the forces of supply and demand. Considerations

[20] I take Bindseil (2004) to be an exemplary contribution, but the literature is much larger. The approach has been eagerly embraced in central banking circles (Woodford 2001, Whitesell 2003, Bernanke 2005, Clews 2005) and has already made it into the textbooks (Mishkin 2004, Cecchetti 2005). For the European context which is Bindseil's experience, the market rate of interest to which the theory refers is taken to be the repo rate, because of the much larger presence of the ECB in that market.

of arbitrage lead to the idea that the market rate of interest is a weighted average of the two standing rates,

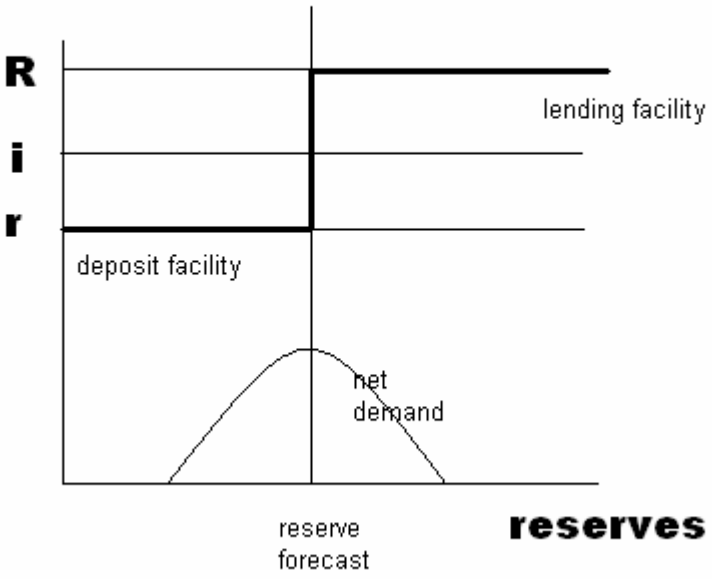
$$i_M = \pi_B R + \pi_L r,$$

where the probabilities are determined by the projected stochastic fluctuation of the net demand for reserves at the end of the reserve maintenance period. Further considerations of arbitrage over time during the reserve maintenance period lead to the idea that the current-day market rate of interest is just the expectation of the last-day market rate of interest,

$$i_{MT-n} = E(i_{MT}).$$

The whole point of the exercise is to inform the operational practice of central bank intervention (see Figure 1). Considerations of symmetry lead to the idea that the right operational goal for the managers of open market operations is to set the standing rates equidistant on either side of the interest rate target, and then to inject sufficient reserves to equalize the probabilities that the system will end the period short (hence borrowing at rate R) and long (hence lending at rate r). In this way of thinking about the implementation problem, open market operations set the supply of reserves equal to the expected demand. The practice of lagged reserve accounting means that in any reserve maintenance period, central bankers already know the quantity of required reserves, so they focus their attention on forecasting the autonomous factors. If they do a

Figure 1: Monetary Policy Implementation



good job, then the expected market rate of interest should be equal to the target rate of interest, although of course stochastic fluctuation will cause some deviation from day to day.

The European practice has been fairly close to this stylized model, with a 100 basis point spread on either side of the target, reduced to 25 basis points on the last day of the two-week maintenance period, and with intervention focused on the start of each maintenance period. In European experience, banks find themselves using the standing facilities relatively often, to the extent of 300 million Euro outstanding on average (Bindseil 2004, p. 74).[21] In such a context, it makes sense that changes in the standing facility rates would translate immediately into changes in the market rate of interest, as the model suggests.

In the US, by contrast, the Fed currently sets the primary credit facility at 100 basis points over the target, and sets the rate on Fed deposits at zero, but intervenes almost daily to maintain the Fed Funds rate close to the target. As a consequence, the standing facilities are hardly used. In 2005, there were only 7 business days when the Fed arranged no short-term RPs, and there were only 15 days when borrowing at the primary credit facility was $100 million or more (FRBNY 2006, pp. 13, 23). It is therefore hard to believe that the standing facility rates have much to do with the determination of the Fed Funds rate. If the Fed were to reduce the rate on the primary credit facility by 50 basis points, the model suggests that the Fed Funds rate should fall, ceteris paribus. But if the probability of having to resort to that facility is near zero, as it appears to be, such a change should have no effect on the market rate. In the US context,

[21] That number has come down in recent years but still averages over 100 million Euro daily, according to ECB Annual Report 2005.

it is the daily intervention, and the market's expectation of future daily intervention, that keeps the Fed Funds rate tracking the target.

The difference between Europe and the U.S. on the details of monetary policy implementation reflects further difference in broader financial development within the two systems. The depth and breadth of the market in Europe is, even now, no match for the U.S. It is the imperfection of money markets that accounts for the continuing importance of standing facilities in Europe. And it is the perfection of money markets that accounts for their insignificance in the U.S. The entire U.S. payments system is able to function smoothly on deposit reserves at the Fed of $21 billion only because of the significant netting of payments that occurs elsewhere in the system before final settlement on Fedwire. It is precisely this efficiency of the netting system outside the Fed that has raised concerns about a possible decoupling of the Fed from the larger financial system it is supposed to be controlling. Such concerns are clearly not allayed by arguments about how standing facilities work in economies that are less financially developed than the U.S.

To explore these concerns further, it seems reasonable to start with the idea that, in the U.S. case, daily intervention more or less absorbs all fluctuation in net reserve demand. The question however remains whether fluctuation in individual reserve demand might provide some leverage. To answer that question requires more detailed consideration of the various channels for netting payments that allow individual payors to avoid reserve flows. To fix ideas, focus on a stylized example of fluctuation in the individual demand for reserves that stems from an end-of-day imbalance in the payments system.

Consider the position of two among many economic agents, both of whom start the day with zero transactions balances. Over the course of the day they make and receive payments of all kinds, perhaps running daylight overdrafts and surpluses for the purpose, but always with the goal of ending the day back at zero. By the end of the day they are almost back, but A is ahead by $10 and B is behind by $10. In this scenario, B is overdrawn, so let us consider the variety of ways that this untenable situation can be corrected.

Note first that if B has some asset worth $10 that A is willing to purchase, they could both make this final transaction and achieve their goal. More relevantly, B could use the asset as collateral for an overnight loan, and A could invest its excess transaction balance in the resulting fully secured instrument. The opportunity cost to B of ending the day overdrawn, and the opportunity cost to A of ending the day in surplus, provide bounds for the negotiation of a satisfactory overnight interest rate. The wide gap between these bounds presumably leaves room for a dealer spread, so we may imagine the payment imbalance being resolved on the balance sheet of a repo dealer (see Table 3). In this case the last two transactions of the day would be a payment from A to the dealer, and a payment from the dealer to B, allowing everyone to end the day with zero transaction balances. Note that in this case, there is zero demand for central bank reserves and so the central bank hits its reserve target exactly.

But suppose that B does not have collateral, and so cannot use the repo market, and consider instead how the banking system can help. Suppose A holds its transaction account at Bank α, and B at Bank β, so the payment imbalance between A and B shows

Table 3: Payment System Imbalance

Case 1: Repo Dealer Intermediation

Agent B		Repo Dealer		Agent A	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
	+10 repo	+10 reverse	+10 repo	+10 reverse	

Case 2: Eurodollar Intermediation

Agent B		Bank β		Bank α		Agent A	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
	+10 bank loan	+10 loan	+10 Euro borrowing from α	+10 Euro lending to β	+10 deposit	+10 bank deposit	

Case 3: Central Bank Standing Facilities Intermediation

Bank β		Central Bank		Bank α	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
	+10 lombard loan	+10 lombard loan	+10 deposit	+10 deposit	

up as a payment imbalance between α and β. The two banks can resolve their own imbalance by an overnight loan from α to β, which then enables each bank to resolve the imbalance of their respective clients. Bank α funds the interbank loan with A's transaction balance, and passes along some of the interest received on the loan to make it worth while to A. Bank β raises the money to pay the overnight interest on the interbank loan by on-lending the money to its overdrawn client B at a somewhat higher rate of interest. In this second case there are two dealer spreads rather than one (actually three if we include a commission on the interbank loan) but it remains the case that there is still zero excess demand for reserves, so the central bank can hit its target. The difference is that there has been an expansion of bank deposits (to Agent A) which may possibly result in additional required reserves in the next reserve maintenance period.

Now suppose that α and β cannot arrange a loan between themselves to offset the payment from B to A. In this case the payment imbalance remains at the end of the day in the two banks' transactions balances at the central bank. Here finally is where the standing facilities come into play with an overnight loan to β at rate R and an overnight deposit by α at rate r. (For simplicity, the Table does not show agents A and B, who are the ultimate recipients of the deposit and loan respectively.) Only in this third case is the payments imbalance resolved by a one-for-one expansion of reserves in line with the increase in demand.

This series of three examples has been designed to suggest a story about the relationship between three money markets: the repo market, the Eurodollar market, and the Fed Funds market. They offer, it is clear, alternative ways to resolve a payment imbalance at the end of the day, but the central bank is not indifferent between them.

From the point of view of control over its own balance sheet, the central bank would like to ensure that as much of the imbalance as possible gets resolved elsewhere, meaning in the repo market or the banking system. The banking system is the lender of last resort in the event that the repo market solution fails, and the central bank is the lender of last resort in the event that the banking system solution fails. The objective of the central bank is to establish a system in which these failures are few and far between, and in fact recourse to the central bank balance sheet is rare in the U.S.

In practice, the daily operation of the payments system typically involves sequential use of these three mechanisms.[22] Repo markets are most active in the (New York) morning when dealers arrange financing for continuing balance sheet positions and settle security trades made the previous day (or two). The Eurodollar market is then most active during the day, and the Fed Funds market is most active at the end of the day. Just as the Fed tries every morning to forecast the autonomous factors that may hit its balance sheet during the day, so too does everybody else, and the repo market is available to everyone to make the anticipated adjustments. After that, the interbank Eurodollar market picks up the slack, and unanticipated imbalances show up as swings in the Eurodollar rate which naturally pulls the effective Fed Funds rate with it. Only at the end of the day do the standing facilities come into play.

Why does the central bank care whose balance sheet resolves a payment imbalance? One reason, as I have stated, is the desire to retain control over its own balance sheet. A second reason is the enforcement of payments discipline in the market as a whole. During the day, elasticity is the objective, and daylight overdrafts at all

[22] I thank Spence Hilton for repeatedly insisting on this feature of the system, but without implicating him in my interpretation of its importance.

levels of the system are permitted in order to facilitate payments. But overnight, discipline is the objective and that means that credit expansion is ideally kept off the books of the banking system, and certainly off the books of the central bank. The point is to provide an ongoing incentive for economic agents to settle their debts, and not simply to roll them over to the next day. That incentive is the price of overnight money. In practice, the way the central bank imposes payments discipline is by setting the bid-ask spread for overnight money on its own balance sheet (R-r) sufficiently wide to encourage the development of credit arrangements at a narrower bid-ask spread on the balance sheet of the banking system, and an even narrower bid-ask spread on the balance sheet of repo dealers.

The important point to emerge from this discussion is that the more successful the central bank is in its institutional objective to push the resolution of payment imbalance off of its own balance sheet, the less likely it is that the central bank's standing facilities will be needed. But if the standing facilities are not needed, then the story of how the market rate of interest is determined by the probability weighted average of those facility rates loses some of its appeal. Clearly the repo rate and the Eurodollar rate will lie inside the wide bounds set by any standing facilities, but payments imbalances provide scant reason for expecting such rates to track a target set somewhere in the middle of these bounds. This is the specter of decoupling.

But the specter of decoupling arises only because we have been adopting a narrowly payments-oriented view of the money markets. After all, in a closed economy payments <u>always</u> net to zero, so the more perfect is the credit system, the less need for cash reserve. In what follows, we sketch an alternative theory of monetary policy

implementation that focuses not on the Fed's role in the payments system, but rather its role as a lender of last resort to the dealers and banks who act as market makers in the money market.

III. A Model of Microstructure

Return therefore to the earlier focus on the primary security dealer. He posts bid and ask prices for each security in which he deals, and in doing so in effect offers liquidity to the security market. The bid-ask spread compensates him for the risk involved in offering liquidity, which is partly inventory risk (the risk that the value of his security holding will change), and partly adverse selection risk (the risk that the counterparty who takes the offered liquidity has better information than the dealer himself about the true value of the security).[23] In the case of fixed income securities, the former source of risk is probably relatively more important than the latter, for the simple reason that bond prices depend mostly on relatively unforecastable macroeconomic factors, so that inside information is less important. Indeed, it might be argued that dealers themselves are likely to be more informed than non-dealers about the value of fixed income securities because of their ability to observe order flow.[24] In any event, the fact is that bid ask spreads in the most actively traded fixed income markets are considerably tighter than in equity markets.

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[23] Biais, Glosten, and Spatt (2005) provide a synthetic model that encompasses most of the existing theoretical literature. They emphasize market power as a third potential source of the bid-ask spread, but this seems likely to be more important in equity markets than fixed income. I thank Larry Glosten for stimulating criticism of an earlier draft in this regard, but without implicating him in my current position.
[24] Here I take my cue from Lyons (2001) who finds that order flow provides a much better forecast of exchange rate fluctuations than macroeconomic variables.

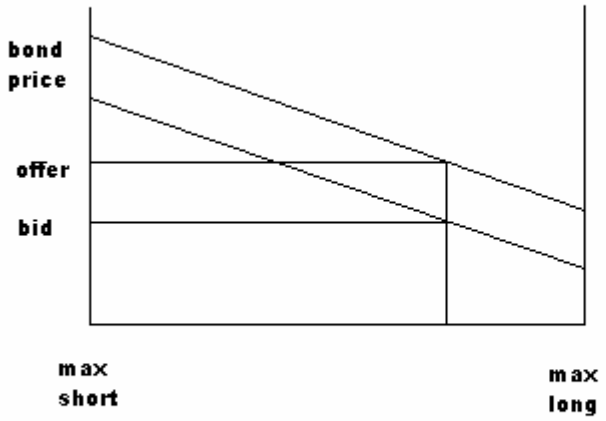
Figure 2 shows one stylized model of the economics of the dealer function (Treynor 1987).[25] Imbalances in order flow, whether intentional or not, have the effect of moving dealer inventories in one direction or another, and the resulting exposure to inventory risk causes dealers to change the level of prices they quote. If dealers have been building up a long position, they lower price to compensate for the added inventory risk; if they have been building up a short position, they raise price in order to compensate for the added inventory risk. The important point is that the dealer quote curve is downward sloping; for simplicity and without loss of generality for what follows we take it to be linear.

Now, if the order flow imbalance continues, notwithstanding successive price changes, then eventually the dealer will run up against his position limit, a limit imposed by his ability and/or willingness to finance the burgeoning inventory, which is to say by the risk aversion of his bank or himself. At that point, he must find someone willing to take his excess inventory. For simplicity, and without loss of generality for what follows, we take that position limit to be a single point, and the price at which the dealer can unload his position to be a single price.

When the dealer hits his position limit, the job of providing liquidity passes over to the value trader, who trades only when price deviates significantly from what he considers to be true value, but who is willing to step up in size when the price is right. Value traders are thus "liquidity suppliers of last resort" (Harris 2003, 227). Dealers

[25] The vast academic literature reviewed by Biais, Glosten, and Spatt (2005) does not typically cite Treynor's paper, but that paper's focus on the economics of the dealer function makes it arguably the more relevant for the concerns of the present analysis. Treynor was a very early contributor to this literature, writing under the pseudonym Walter Bagehot (1971), republished as Treynor (1995). His subsequent writings are well known in practitioner circles, especially his chapter in the reader Managing Investment Portfolios (Maginn and Tuttle 1983).

Figure 2: Economics of the Security Dealer



provide immediacy, but value traders supply depth. (Indeed, it is because value traders supply depth that dealers are able to supply immediacy; they know that if their positions get too far out of balance, they can rely on value traders for support.) For concreteness, take these value traders to be institutional investors such as pension funds and insurance companies whose naturally vast capitalization enables them to take advantage of an opportunity to pick up a bargain, on either side of the market. This is more or less the standard model, familiar from the standard market microstructure literature in finance.

Now we know, from Section I, that dealer operations are quite a bit more involved than this. If dealers decide to take a long position in the credit spread, for example, they accomplish this by raising the bid on corporate and agency securities and lowering the ask on Treasuries. Similarly, if dealers decide to take a short position in the Treasury term spread, they accomplish this by raising the bid on bills and lowering the ask on notes and long bonds. In both cases, the object is to use order flow to establish a desired portfolio position. The point to emphasize is the relationship between the spreads and the size of the dealers' position. Dealers will be willing to take a large position only if they are compensated by an apparently large spread. In this way the dealer model of Figure 2 extends naturally.

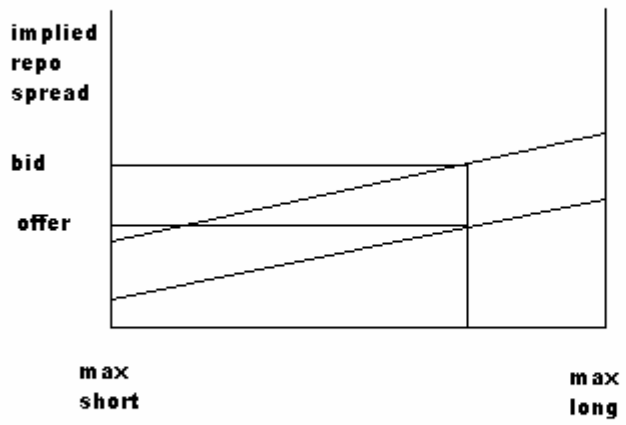
For our purposes, it is useful to focus attention on one particular spread, that between the actual repo rate and the so-called implied repo rate. Dealers pick up this spread by means of the so-called "cash and carry" arbitrage, which works as follows (Stigum 1990, 748-9). Consider a trade with three elements: purchasing a 6-month Treasury bill, financing that bill with 3-month term repo, and hedging the tail risk by selling Treasury bill futures. The bill and futures positions taken separately amount to a

three month investment with a return called the implied repo rate. The overall trade is profitable when the actual term repo rate is less than the implied repo rate, and the opposite trade is profitable when the reverse is the case. Note that a cash and carry trade like this would show up in the weekly dealer reports to the Fed as an increase in outright bill holding and a simultaneous increase in repo financing (a pattern that matches the current data).

For our purposes the importance of the cash and carry trade is that it links up the bill rate with the repo rate, and so also the capital market with the money market. Such an arbitrage opportunity can persist only if there is some risk involved that limits the willingness of dealers to exploit it. However, it can't be inventory risk in the case of the cash-and-carry trade because that risk is perfectly hedged with the futures contract. Instead, I suggest that the key is liquidity risk, a kind of risk that does not appear in the usual accounts of market microstructure.

To see the presence of liquidity risk, suppose that there is a liquidity premium in the term structure so that long rates are higher than the sequence of future expected short rates. Then the futures price of short bills will be below the expected spot price. But at maturity the futures price must equal the spot price, so the futures price must be expected to increase over the life of the trade. It follows that daily mark-to-market of a short futures hedge must be expected to require cash outflow over the life of the trade. A dealer who is long the cash-and-carry trade must be prepared to meet that likely cash flow consequence, and moreover to meet it at any moment during the life of the trade since the convergence to spot need not be smooth. This is liquidity risk, and the relevant cost of that risk is the rate of interest on the dealers' line of credit with his clearing bank.

Figure 3: Economics of the Repo Dealer



It is this liquidity risk that prevents dealers from extending their positions far enough to eliminate the implied repo spread. And it is this liquidity risk that links up the Fed Funds rate with the repo rate.

To see this link more clearly, Figure 3 extends the dealer model to the case of cash-and-carry arbitrage. The dealer quote curve is now upward sloping because the vertical axis is a yield (spread) rather than a price. Using the diagram, now consider the effect of contractionary open market operations on the dealer's desired position. Whether we think of such operations as a reduction in the quantity of dealer reserves, or an increase in the Fed Funds rate that drives the price of such reserves, the effect on the dealer will be to contract his desired position limits. He will be willing to hold his current position only if the implied repo spread increases, so he will change his bid and ask in order to increase that spread. As a consequence, other things equal, his position in the cash-and-carry trade can be expected to shrink as order flow responds to the new quoted spread.[26] In this way, the immediate effect of contractionary open market operations is a contraction of the balance sheet of the dealers. This is a channel of monetary transmission that does not depend on any imperfection in the payments system, but rather only on the dealer's problem of managing the liquidity risk involved in making markets.

[26] Other things may not of course be equal. Most important, the dealer's position depends on how his customers respond to the new spread and that depends, in part, on their own balance sheet positions as well as expectations about the future.

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