OVERCOMING THE ZERO BOUND ON INTEREST RATE POLICY

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August 2000

Abstract: The paper proposes three options for overcoming the zero bound on interest rate policy: a carry tax on money, open market operations in long bonds, and monetary transfers. A variable carry tax on electronic bank reserves could enable a central bank to target negative nominal interest rates. A carry tax could be imposed on currency to create more leeway to make interest rates negative. Quantitative policy--monetary transfers and open market purchases of long bonds--could stimulate the economy by creating liquidity broadly defined. A central bank needs more fiscal support than usual from the Treasury to pursue quantitative policy at the interest rate floor.

JEL Nos. E3, E4, E5, E6

Keywords: banking, carry tax on money, deflation, fiscal policy, inflation tax, monetary transfers, narrow and broad liquidity services, negative nominal interest, payments technology, public debt, quantitative monetary policy, transmission mechanism, zero bound on interest rates.

*Senior Vice President and Policy Advisor. Forthcoming in the Journal of Money, Credit, and Banking, (November 2000, Part 2). The paper was prepared for the Federal Reserve System Conference "Monetary Policy in a Low-Inflation Environment," Woodstock, VT, October 1999. It benefited from conversations with A. Broaddus, M. Dotsey, B. Hetzel, T. Humphrey, R. King, J. Lacker, B. McCallum, J. Reese, A. Stockman, J. Weinberg, V. Wieland, and A. Wolman, and from the discussants at the conference, R. Bryant and C. Freedman. The paper also benefited from a preliminary workshop at the European Central Bank and presentations at the Bank of Finland, the Bank of Portugal, Carnegie Mellon University, the International Monetary Fund, Indiana University, UCLA, UC Riverside, UCSD, and the University of Toronto. The views expressed are the author's and not necessarily those of the Federal Reserve Bank of Richmond or the Federal Reserve System. Correspondence: Marvin.Goodfriend@rich.frb.org.

I. Introduction

Price stability creates a problem for interest rate policy. In the decade following the Korean War, CPI inflation averaged about 1.5 percent per year in the US and the three-month nominal Treasury bill rate ranged between 1.5 and 3.5 percent. With fully credible price stability, nominal short rates could average as low as 1 percent.[1] Fisher (1930) pointed out that if a commodity could be stored costlessly over time, then the rate of interest in units of that commodity could never fall below zero.[2] Fisher's reasoning is self-evident in the case of money. No one will lend money at negative nominal interest if cash is costless to carry over time. Therefore, the power of open market operations to lower short-term interest rates to fight deflation and recession is strictly limited when nominal rates are already low on average.[3]

Keynes (1936) was very much concerned with the consequences for macroeconomics and monetary policy of the zero bound on nominal interest rates.[4] That concern was revived by Summers (1991,1996) and Fischer (1996). Summers and Fischer argue that central banks should target inflation in a range as high as 3 percent per year so that the inflation premium would make room for nominal interest rates to fall an additional 3 percentage points before hitting the zero bound. In Section 2 I review this and other suggestions for dealing with the zero bound that have appeared in the literature. None of the alternatives is entirely satisfactory.

In the main body of the paper I propose three options which could allow a central bank to overcome the zero bound on interest rate policy: a carry tax on money, open market purchases in long bonds, and monetary transfers. The first half of the paper considers the mechanics of lowering the floor on nominal interest rates by imposing a storage (carry) tax on money. The second half explores the power of open market purchases and monetary transfers to stimulate the economy when nominal interest rates are at the zero (or lower) bound given by the cost of carry on money.

Following Fisher's insight, I recommend that a central bank put in place systems to raise the cost of storing money by imposing a carry tax on its monetary liabilities. If a cost of carry

were imposed on money, then expansionary open market operations could make nominal interest rates negative. Lenders could be made to accept negative nominal interest on loans rather than pay the carry tax on money. Although Keynes (1936) and others mentioned the possibility of taxing money for this purpose, the idea has never been taken seriously because of its administrative costliness, and because the zero bound was not an issue until the return to price stability.[5] In light of recent advances in payments technology and the less than satisfactory alternatives, imposing a carry tax on money seems to be a reasonable way of dealing with the zero bound. I present and develop a proposal for imposing a carry tax in Section 3.

Under my proposal, the floor on short-term nominal interest rates would be determined by the carry tax imposed by a central bank on electronic reserve balances. When interest rates are pressed against that floor, a monetary policy committee could vary the carry tax in order to adjust its interest rate target. The carry tax would anchor the short end of the yield curve much as, say, the intended federal funds rate does today in the United States. To assure that the carry tax on electronic reserve balances sets the economy's nominal interest rate floor, a carry tax could also be imposed on currency and vault cash. I discuss how this might be done, too.

In Section 4 I recommend that a central bank supplement its carry tax (interest rate) policy with quantitative monetary policy--open market operations and monetary transfers. When the short-term nominal interest rate is pressed against the cost-of-carry floor, a central bank can pursue independently a monetary aggregate target. The variable carry tax would be a powerful policy instrument. However, making interest rates increasingly negative would create stress for lenders and people heavily dependent on interest income. Open market purchases and monetary transfers could stimulate spending without lowering the interest rate floor. More importantly, a central bank could use quantitative policy to see to it that a contraction of monetary assets or an excess demand for liquid assets in the economy does not precipitate or exacerbate a downturn, or preclude a recovery.[6]

I begin the analysis in Section 4 by distinguishing between narrow and broad notions of liquidity. Liquidity is provided in the narrow sense when the medium of exchange makes possible a saving of "shopping time" in transactions.[7] The economy is satiated with liquidity services in the narrow sense when the nominal interest rate is pressed against the cost-of-carry floor. I define liquidity broadly as a service yield provided by assets according to how easily they can be turned into cash, either by a sale or by serving as collateral for external finance. Liquidity services defined broadly are valued because they can be used to minimize one's exposure to the external finance premium in the sense of Bernanke and Gertler (1995). In my view, liquidity broadly defined is at the heart of the leverage that quantitative policy can exert when the nominal interest rate is at the cost-of-carry floor.

Building on the notion of broad liquidity services, I describe in detail the transmission mechanism by which open market purchases would help to offset an adverse aggregate demand shock when nominal and real interest rates are bounded at zero. The mechanism involves the portfolio rebalancing channel stressed by monetarists such as Friedman (1969) and Meltzer (1995) and the credit channel stressed by Bernanke and Gertler (1995) and follows from the attempt on the part of asset holders to rearrange their portfolios after an injection of liquidity. To be effective at the zero bound, open market purchases have to be undertaken in longer-term rather than short-term securities. This has potentially far-reaching fiscal consequences that I consider in detail.

I conclude Section 4 by evaluating the feasibility and desirability of transferring money to the public in order to stimulate spending. For a central bank committed to price stability it turns out that money transfers could not exert an effect on spending by permanently relaxing budget constraints. However, money transfers could stimulate spending through the portfolio rebalancing and credit channels. Given a commitment to price stability, I recommend that monetary transfers be used in conjunction with open market purchases as a means of injecting

money into a depressed economy. The need to drain money to stabilize inflation after the economy recovers (by reversing monetary transfers or by selling long bonds with unexpected capital losses) could greatly increase government debt in the hands of the public. I identify the perceived burden of the additional public debt as a potential cost of using quantitative policy to stimulate the economy.

In Section 5 I consider a number of practical issues that arise in connection with the carry tax and quantitative policies. Clearly, the central bank and the Treasury would need legislation in order to impose a carry tax on money. The most serious objection to the carry tax is that the public might not hedge itself adequately against negative nominal interest rates. The public could do so by holding long bonds. But the public is shy of the inflation risk in bonds. To reassure the public, the legislature should mandate a price stability objective for the central bank. The Treasury should provide an adequate supply of long bonds. And the central bank should use its economic education programs to teach the public the benefits of holding long bonds.

One of the main points of the paper is that quantitative monetary policy needs more fiscal support from the Treasury than usual to be effective at the interest rate floor. To make large-scale open market operations in long bonds credible, the Treasury must indemnify the central bank against unexpected capital losses. Fortifying the central bank against capital losses would commit the Treasury to expand the public debt, perhaps substantially, in support of monetary policy. That fiscal commitment might require legislation. If so, then quantitative monetary policy might need new legislation, too, in order to be effective when the nominal interest rate is at its cost-of-carry floor.

The paper concludes with a brief summary.

2. A Review of Prior Proposals

The zero bound problem arises because real interest rates must fluctuate to stabilize the economy over the business cycle. When a central bank has full credibility for maintaining price stability, inflation expectations are firmly anchored and a central bank produces the required real interest rate movements by managing its target for short-term nominal interest rates. With zero expected inflation, however, the zero bound on nominal interest rates implies that expected real interest rates cannot be negative.

The zero bound is a potential problem for two reasons. First, negative real interest rates may have helped the economy to recover from recessions in the past, particularly in periods of financial market stress. Second, deflation expectations in economic downturns can actually raise expected real interest rates when nominal rates are at the zero bound, with perverse effects on demand and employment.[8] The possibility of a deflation spiral worries economists and central bankers alike.[9] Nominal interest rates might only need to be negative occasionally and temporarily. If they are not free to do so, however, recessions could be much deeper and longer than otherwise.

The zero bound is more than an academic concern. Short-term nominal interest rates hit the zero bound in the Great Depression and are zero in Japan today.[10] Reports of deflation and unemployment in Japan and China, in particular, have sensitized the press and the public around the world to the problem of deflation and deficient aggregate demand.[11] The concern on the part of economists, central bankers, and the public about these issues has given rise to a series of suggestions for dealing with the zero bound.

As mentioned in the introduction, Summers and Fischer suggest that a central bank should target an average rate of inflation of up to 3 percent. Their recommendation gets support from macroeconometric studies that suggest that the risk in more frequent and longer lasting recessions associated with zero inflation may be significant but that an inflation rate of 1 to 3

percent may be sufficient to alleviate most of that risk.[12]

The problem with this proposal is that it accepts some risk of a potentially disastrous outcome. Much higher inflation on average would be needed to rule out the disastrous outcome with confidence. Yet, the costs of substantially higher inflation are significant in themselves. Thus, higher inflation does not really afford a satisfactory solution to the problem.

Krugman (1998, 1999) proposes that if the zero bound is actually hit, a central bank should hold the nominal rate down and target a moderate rate of inflation for some period of time to make the real interest rate negative. The problem with this recommendation is that Krugman does not explain how a central bank could create inflation at the zero bound. One would think that a central bank with the power to create inflation would have the power to stimulate spending directly.

In practice it would be difficult for a central bank to steer an economic recovery after deliberately unleashing inflation.[13] Moreover, the resort to inflation whenever the zero bound was hit would create an environment in which inflation scares could become a problem. The central bank would not know when and how much inflation might be needed to respond to a given downturn in the economy. Hence, the public's expectations of inflation could become highly variable. Inflation scares could themselves become a significant destabilizing source of shocks to the economy.

Wolman (1998) shows that a fully credible policy rule might make the zero bound irrelevant for monetary policy. Wolman's point is that if prices are sticky but inflation is flexible, then a credible policy rule could overcome the zero bound by moving inflation and inflation expectations around a zero inflation average. But Wolman also points out that if inflation is sticky, then his argument loses much of its force. Moreover, in practice a central bank may not have enough credibility for such an activist rule to work well.[14]

McCallum (2000) suggests that a central bank confronting the zero bound should adopt

the foreign exchange rate as its policy instrument. Specifically, he proposes following a monetary policy rule that varies an exchange rate policy instrument to stabilize inflation and output. This is not the place to discuss the operating characteristics of McCallum's exchange rate rule. To get an idea of how an exchange rate instrument might work, however, suppose that a country pegged its currency at a much depreciated foreign exchange rate. The exchange rate depreciation, then, would create an increase in net exports, the nominal short interest rate would immediately match the foreign currency interest rate, and prices would move up over time in proportion to the exchange rate depreciation. The expected inflation would imply a low or even negative real interest rate for a while.

The problem with an exchange rate oriented monetary policy is that it could be perceived as working at the expense of its trading partners, and it might not work very well at all for a very large country such as the United States. If the United States adopted such a policy to lift itself out of a deflationary, zero bound trap, it might export deflation and recession without helping itself much.

Finally, consider a collection of policy possibilities discussed by Clouse et al (1999) more closely related to current central bank practices.[15] These authors doubt that open market purchases of long bonds could push long-term interest rates much closer to zero. According to the expectations theory of the term structure of interest rates, Clouse et al note that to move long rates closer to zero a central bank must somehow credibly commit itself to maintain zero short-term rates even if higher short rates turn out to be desirable in the future. Clouse et al suggest that a central bank could write options on future short rates at zero interest to give itself more incentive to keep rates down. Whether this could work is questionable given the overwhelming pressures to take interest rate policy actions that seem correct at a particular point in time. Moreover, the marginal gain to be had by moving long-term interest rates closer to zero might not be worth the loss of credibility for price stability after a recovery was underway.

Clouse et al also consider purchases of private sector debt and more extensive discount window lending. The idea is that such policies could reduce private credit spreads and help finance credit constrained firms. The credit channel plays an important role in the transmission mechanism. But it doesn't follow that credit allocation by a central bank is beneficial. Direct lending to individual firms at reduced credit spreads crowds out private lenders who require higher spreads. Deciding which firms deserve credit assistance puts a central bank in a difficult political situation. Credit allocation is incompatible with central bank independence.[16]

Subsidized lending involves the assumption of credit risk. The assumption of credit risk in the absence of increased monitoring and controls creates moral hazard. Therefore, central bank lending should be used sparingly only to stabilize financial markets. Lending should not be used as part of a package of policies to stimulate economic recovery more generally.[17]

3. Imposing a Carry Tax on Money

My goal in this section is to show how a variable carry tax on electronic bank reserves at a central bank could be made to function like an interest rate policy instrument when the zero bound on short-term nominal interest rates is a constraint on monetary policy. First, I describe the nature of the zero bound when there is currency but no banking system. Second, I add a banking system and describe the interaction of the various types of monetary instruments and interest rates that would coexist. Third, I explain how a carry tax imposed by a central bank on electronic bank reserves would affect the interbank rate, deposit rates, the loan rate, and bond rates. Fourth, I consider the technological feasibility of imposing a carry tax on money. Fifth, I compare the costs of the carry tax and the inflation tax alternatives for dealing with the zero bound on nominal interest rates.

3.1 The Zero Bound in a Currency Economy

McCallum (2000) points out that the behavior of the nominal interest rate near zero depends decisively on the behavior of the net marginal service yield on money with respect to increases in the quantity of real money balances. If the net marginal service yield asymptotes to zero, and money is costless to carry at the margin relative to nominal bonds, then the nominal interest rate also asymptotes to zero.[18] There is a zero bound in this case, but the nominal rate never reaches it. No matter how large real money balances become, people will hold more with a small reduction in the nominal interest rate. Lucas's (2000) "shopping time" model of money demand exhibits this behavior. Money demand is never satiated in Lucas's model.

On the other hand, if the marginal service yield becomes zero beyond some quantity of real money balances and there is no cost of carry, then the nominal interest rate could hit the zero bound, and people could become indifferent between holding money or bonds. This possibility arises in the "cash in advance" model studied in Cole and Kocherlakota (1998).

A more realistic model might have a shopping time transactions technology and a small marginal physical cost of storing currency relative to bonds. The net marginal service yield on currency would then asymptote to a slightly negative value reflecting the small physical cost of storing currency.[19] The nominal interest rate could become negative in this case, but only slightly so.

3.2 Banking and the Zero Bound

A banking system gives the public the opportunity to obtain monetary services from deposits in addition to currency. Moreover, banks themselves get monetary services from vault cash and from electronic reserve balances at a central bank. Here I discuss how the various forms of money coexist and what determines their relative demands and interest rates near the zero bound.

As is common practice, suppose that a central bank does not charge a storage cost or a user fee for the transaction services it provides on electronic reserve balances. Further assume that banks' demand for reserves exhibits a declining marginal service yield as in Frost (1971). The absence of storage costs and user fees on electronic reserve balances at the central bank sets a zero interest rate floor on the interbank interest rate regardless of the physical cost of storing currency.

The interbank rate represents a cost of loanable funds for a particular bank. Hence, if a central bank pushed the interbank rate to zero, banks would respond by lowering the bid rates on other sources of loanable funds such as certificates of deposit and time deposits. Banks would try to purchase securities to earn higher yields. Competition among banks would pull short rates down to zero and move longer-term rates down with the average of expected future short rates over the relevant horizon. Loan rates and rates on risky securities would come down as far as their credit spreads would allow.

Banks would trim costs by eliminating interest on transactions deposits and imposing a fee to cover transactions services. Competitive pricing of transactions services would have two parts, a per period, per dollar fee to cover the overhead cost of providing the services (with average or minimum balance requirements), and a marginal fee per transaction.[20] The public would hold transactions deposits to the point where the marginal service yield was zero, net of the per period, per dollar service fee. Insured time deposits would pay zero interest and incur a smaller service charge than transactions deposits. Finally, currency would be held up to the point where its marginal service yield, net of storage costs, was also zero. If, for example, the marginal service yield behaved according to Lucas's version of the shopping time transactions technology, then the demand for currency would be satiated at the zero bound if there were a small marginal physical cost of storing currency.[21]

To repeat, in the presence of a banking system there is a zero bound on nominal interest rates regardless of the physical cost of storing currency. The zero bound, however, results from the fact that a central bank typically charges no user fee for the transactions services on electronic reserve balances and stores bank reserves for free.

3.3 Imposing the Carry Tax

What would happen if a central bank were to impose a per period, per dollar carry tax on electronic bank reserves when the interbank interest rate was pressed to zero by an abundance of reserves? Competition among banks to avoid the carry tax would push the interbank rate below zero by the cost of carry. The interbank rate would go no lower because banks would not lend reserves at a loss greater than the storage cost on electronic reserves. As long as open market purchases maintained the downward pressure on interest rates, the interbank rate would be governed by the carry tax.

Banks would continue to charge service fees on deposits, but they would match the negative cost of funds in the interbank market by offering equally negative interest on deposits. Banks would reach for higher (zero) yields on short-term securities. However, they would only succeed in pushing short-term interest rates below zero by the size of the cost of carry. Likewise, long-term interest rates would become negative if banks expected the central bank to sustain negative short-term interest rates sufficiently far into the future. Loan rates and rates on risky securities would be bid down and could also become negative if the carry tax were large enough.

Thus, it is feasible for a central bank to make nominal interest rates negative throughout the economy by imposing a cost of carry on electronic bank reserves. The only qualification is that nominal interest rates could not be made more negative than the dollar value of the physical cost of storing vault cash or currency. Otherwise, banks would store reserves as vault cash; and

the public would not lend at negative interest greater than the marginal physical cost of storing currency.

The inconvenience and expense of storing large volumes of currency and vault cash would probably preclude large-scale hoarding if nominal rates were made only slightly negative for a relatively short period of time. If negative rates of perhaps 4 or 5 percent were expected to persist for a year or more, however, banks and the public would probably hoard currency rather than lend it, setting a floor closer to zero below which a central bank could not push nominal interest rates.

To deal with this problem a central bank could also impose a carry tax on vault cash and currency.[22] The carry tax on currency could be varied with the carry tax on electronic reserves. Or the carry tax on currency could be fixed temporarily high enough, say, at 5 percent per year, so that the central bank could move nominal interest rates in a range from zero to negative 5 percent by varying the carry tax on electronic bank reserves alone.[23]

3.4 Technological Feasibility

Modern payments system technology makes it possible to impose and vary a carry tax on electronic bank reserves at the central bank. With a system to do so in place, the zero bound would cease to be a technological constraint on interest rate policy. Whenever the intended target for the interbank interest rate reached zero, the policy committee could activate a daily tax on electronic reserve balances that would make the interbank rate negative. By calibrating the daily tax as a percent per annum, the policy committee could adjust the cost of carry so as to move the interbank rate in 25 basis point steps and continue to make interest rate policy exactly as it does today. [24]

To supplement the carry tax on electronic reserves, a carry tax could be imposed on currency by imbedding a magnetic strip in each bill. The magnetic strip could visibly record

when a bill was last withdrawn from the banking system. A carry tax could be deducted from each bill upon deposit according to how long the bill was in circulation since last withdrawn and how much carry tax was "past due." Likewise, a carry tax could be assessed on currency held as vault cash in banks.

In the United States the average period between acquisitions of cash is about two weeks, so currency stays in circulation for about a week at a time.[25] Therefore, a carry tax on the order of 5 percent per year would require a tiny 0.1 cents tax per dollar on the average deposit. Banks would be assessed a carry tax for the period that currency was in their vaults. There is little reason to think that the use of the monetary base would change much in response to the occasional imposition of a carry tax. Jefferson (1997) reports that the velocity of the monetary base has remained near 3.3 since 1980, a period in which the inflation tax averaged around 4 percent per year, and was over 10 percent in the early 1980s.

Most currency received in payment is immediately deposited in the banking system. For the vast majority of bills in circulation that were "current" or nearly so, people might very well ignore the tiny tax due at the next deposit date when accepting cash. Since merchants would make most of the currency deposits, they might take the trouble to collect the carry tax on currency from customers. Otherwise, the carry tax on currency would amount to a kind of sales tax paid by merchants. Either way, prices would adjust to determine the ultimate incidence of the carry tax.

The carry tax would serve as a powerful deterrent to hoarding currency. Currency that was hoarded and "past due" would only be accepted at a discount sufficient to cover the arrears. Since the carry tax on currency would equal or exceed the negative interest rate, the public would deposit or lend currency in excess of the transactions demand rather than hoard it.

3.5 The Carry Tax vs the Inflation Tax

Overcoming the zero bound on nominal interest rates is costly, whether accomplished by imposing a carry tax or an inflation tax. Ultimately one must compare the costs of imposing a carry tax with those of imposing an inflation tax to determine the most efficient means of dealing with the zero bound. This is not the place to assess quantitatively the respective costs.[26] It is useful, however, to compare the nature of the costs arising from the two alternatives. As is the case in public finance, we should consider both the distortionary and the administrative costs of the inflation tax and the carry tax alternatives.

The inflation tax would incur permanent distortionary costs to enable a central bank to create negative real interest rates on occasion. The carry tax would be imposed temporarily only on those occasions when a negative nominal interest rate was needed. Moreover, on those occasions no distortion would be introduced by the imposition of a carry tax. Imposing a carry tax temporarily to move the nominal interest rate below zero would have no effect on the opportunity cost of holding money. And imposing a carry tax at the zero bound to offset the effect of expected deflation on the real interest rate likewise would leave the opportunity cost of holding money unchanged.[27] Of course, if a carry tax on currency were fixed below the carry tax on electronic bank reserves, then currency demand would be distorted temporarily while the carry taxes were in effect.

The carry tax is costly mainly because systems have to be put in place to enable a central bank to impose it. There would be permanent administrative costs involved in operating and maintaining such systems. Currency would be more sophisticated and more costly to produce. Systems would have to be put in place at banks and automatic teller machines to read bills, assess the carry tax, and visibly record the bills "current." Substantial development and installation costs would have to be paid to put these systems into practice.

Such considerations notwithstanding, the case for the carry tax solution to the zero

bound problem is a compelling one for a number of reasons. First, an occasional imposition of the carry tax could guarantee that the zero bound would never be a problem for monetary policy. The permanent inflation tax could not guarantee that, unless inflation was targeted at a relatively high and costly rate. Second, varying the carry tax would enable interest rate policy to be made exactly as it is today. Third, long bond rates could be made to move closer to or below zero. Fourth, the carry tax would allow a central bank to deal directly with deflation expectations by making nominal interest rates negative.[28] Fifth, ongoing progress in payments technology is reducing the cost of putting systems in place to impose a carry tax. Sixth, systems to impose a carry tax could be introduced to pay interest on bank reserves and currency when nominal interest rates exceed zero, reducing the distortions that arise in that case.

4. Open Market Operations and Monetary Transfers

In Section 3 I considered lowering the floor on nominal interest rates by imposing a carry tax on money. In this section I explore the power of open market purchases and monetary transfers to stimulate the economy when nominal interest rates are at the zero (or lower) bound given by the cost of carry on money. The quantitative and carry tax policies could complement each other. Temporarily negative real interest rates are a powerful stimulant to spending, but they are costly for people holding liquid assets and for those heavily dependent on interest income. Quantitative policy could stimulate spending even if the nominal interest rate were fixed at the cost-of-carry floor. A central bank should pursue quantitative policy at the zero bound to make sure that a contraction of monetary assets in the economy or an excess demand for money does not cause or contribute to an economic downturn, or prevent a recovery.

Ordinarily open market operations support a central bank's interest rate policy by accommodating the demand for money at the opportunity cost given by the spread between the interest rate instrument and the zero cost of carry on reserves and currency.[29] In effect, open

market operations support the opportunity cost spread; they do not determine the level of interest rates. For a constant spread maintained by open market operations, we could just as well imagine that a carry tax (or carry interest) could be varied to manage the level of interest rates.[30]

When nominal rates are pressed against the cost-of-carry floor, whether that cost is zero or not, open market purchases become an independent policy instrument free to pursue targets for the monetary base or broader monetary aggregates. When such is the case, a central bank can use the carry tax to manage interest rate policy and open market operations to manage quantitative monetary policy.[31]

In Section 4.1 I begin to think about quantitative monetary policy at the interest rate floor by distinguishing between what I define as narrow and broad notions of liquidity services. In Section 4.2 I evaluate two potential impediments to the effectiveness of open market operations: banks and restrictions that limit open market purchases to short-term bonds. In Section 4.3 I set the stage for the analysis that follows by describing how the economy would adjust to an adverse aggregate demand shock without either a reduction in interest rates or an expansion of the monetary base.

In Section 4.4 I describe the channels by which expansionary open market operations could counteract the effect of an adverse demand shock when interest rates are at the cost-of-carry floor. The mechanism by which increases in the monetary base are transmitted to spending involves the portfolio rebalancing channel emphasized by monetarists such as Friedman (1969) and Meltzer (1995) and the credit channel emphasized by macroeconomists such as Bernanke and Gertler (1995).[32]

In Section 4.5 I evaluate the role that monetary transfers might play in supporting quantitative monetary policy. To the extent that a central bank reverses monetary injections to stabilize the price level after the economy recovers, quantitative policy may result in an increase

in public debt. I identify the perceived burden of the public debt as a potential cost of using quantitative policy to stimulate the economy.

4.1 Narrow and Broadly Defined Liquidity Services

For the purpose of thinking about quantitative monetary policy when the interest rate is at the cost-of-carry floor, I distinguish between narrow and broad notions of liquidity services. Narrow liquidity services are those provided by the medium of exchange allowing the public to economize on "shopping time" in transactions. Once the short nominal interest rate has fallen to the cost of storing money, an expansionary open market operation cannot relax the transaction constraint any further to free shopping time for more productive uses.[33] At that point the economy may be said to be satiated in narrow liquidity services provided by the medium of exchange.[34]

I define liquidity broadly as a service yield provided by assets according to how easily they can be turned into cash, either by sale or by serving as collateral for external financing. Liquidity services defined broadly are valued because they can be used to minimize one's exposure to the external finance premium in the sense of Bernanke and Gertler (1995).

Bernanke and Gertler explain that imperfect information and costly enforcement of contracts create a wedge between the cost of funds raised externally (through the issuance of imperfectly collateralized debt) and internal funds.[35] They call the wedge the external finance premium. The premium reflects the deadweight costs associated with the principal-agent problem that typically exists between lenders and borrowers.[36] Among the factors reflected in the premium are the lender's expected costs of evaluation, monitoring, and collection. Bernanke and Gertler emphasize that the external finance premium fluctuates with conditions in the economy. The premium is negatively related to the net worth, ie, the balance sheet health of firms and household borrowers.[37] The cost of funds to bank dependent borrowers is inversely

related to the capital cushion of banks themselves.

I regard liquidity services broadly defined as an attribute of an asset that allows its owner to minimize his exposure to the cost of external finance. From this perspective, all assets provide broadly defined liquidity services to one degree or another. Generally speaking, liquidity services contribute to an asset's value together with the asset's direct utility or productive services.[38] Monetary assets such as currency and bank deposits are valued primarily for their implicit liquidity services yield. The implicit liquidity services yield accounts for a smaller share of the total return to holding short-term bonds, and a smaller share still of the return to longer-term bonds and nonfinancial assets.[39]

Consider unimproved land. With a haircut off market value to shield a lender from price fluctuations, unimproved land makes good collateral for a loan because it is inexpensive to monitor. For large parcels, the price risk can be considerable because it takes time and effort to find a buyer. But since a large fraction of the market value of unimproved land can be borrowed against with a relatively small external finance premium, implicit liquidity services provided by unimproved land can be substantial.

In what follows, I assume that the implicit marginal broad liquidity services yield declines (given income, consumption, and wealth) as the aggregate stock of monetary assets increases. Generally speaking, this would be so because the greater abundance of liquidity reduces the exposure of households and firms to the external finance premium. Liquidity broadly defined is at the heart of the leverage that quantitative monetary policy can exert when the nominal interest rate is at the cost-of-carry floor.[40]

4.2 Banks, Long Bonds, and Open Market Purchases

Could banks short-circuit open market purchases by simply holding newly created reserves instead of lending them? Ordinarily, the answer would be no. Banks could be expected to

maintain a minimum reserve to deposit ratio. At the interest rate floor, however, banks could be slower to rebalance their portfolios. Without an accompanying decline in interest rates it might be more difficult to attract new borrowers. If the economy were depressed, the external finance premium could be elevated and acceptable borrowers harder to find. Moreover, at the interest rate floor there is little advantage to buying securities. Thus, an open market acquisition of reserves by banks might not stimulate lending very much, at least initially. Large-scale open market purchases, however, could deplete banks of their securities and put cash in the hands of the nonbank public.

If the public were satiated with liquidity services narrowly defined at the interest rate floor, the public would simply replace short-term securities sold to the central bank with nontransactions bank deposits. Since the two assets are very close substitutes in terms of the broadly defined liquidity services that they provide, open market operations in short-term securities wouldn't matter much. To be effective at the interest rate floor, open market purchases must be undertaken in longer-term securities.[41]

Long bonds would provide relatively little liquidity services per dollar of market value if interest rates were temporarily zero or negative. Bondholders would be exposed to an elevated risk of capital loss due to uncertainty about the timing and magnitude of the rise in short-term interest rates that would accompany an economic recovery. Consequently, long bonds would get a more than usual haircut off market value when used as collateral for external finance. Moreover, the increased risk of capital loss would raise the cost of making a market in long bonds and increase their cost of sale. Thus, open market purchases that "monetize" longer-term bonds when interest rates are low could increase substantially broadly defined monetary liquidity.

4.3 An Adverse Aggregate Demand Shock

This section sets the stage for the analysis in Section 4.4 of quantitative monetary transmission at the zero bound. The preliminary analysis here assumes that the public expects no change in the real rate of interest, both because the price level is expected to remain constant and because the central bank is not expected to change its short-term interest rate instrument. Such a situation could arise in an economy characterized by credible price stability with the short-term nominal rate at the zero bound.[42] Assume that an adverse aggregate demand shock takes the form of an expected temporary decline in future income prospects.[43]

Since expected permanent income has fallen, households cut current consumption to a level that they expect to sustain through the hard times. Specifically, households wish to save a greater share of current income. Likewise, firms cut current investment, expecting less demand for output. Assuming that the macroeconomy is characterized by monopolistic competition and sticky money output prices, the cut in aggregate demand translates into a decline in firm demand for labor. In this Keynesian world, the perceived decline in income prospects causes real income to fall.

Households and firms react to the actual decline in income by cutting consumption and investment further. The contraction reaches bottom when the rate at which households wish to save out of current income just equals the investment that firms are willing to do. The bottom is reached because as current income looks worse relative to future income, households wish to save less out of current income. If gross investment demand holds up reasonably well, income stabilizes at not too low a level.[44]

Turning to the asset markets, consider first consumer durables such as cars and houses. The rise in the marginal utility of current consumption due to the cut in consumption spending makes the initial price of durables too high. Hence, the consumption price of durables falls to the point where the expected return makes owning durables worthwhile.[45] Firm profits and the

marginal product of capital are adversely affected by the decline in demand and employment. Consequently, the prices of physical capital and claims to intellectual and organizational capital fall as well.

The fall in asset prices, in turn, negatively influences consumption and investment. The fall in the prices of consumer durables and physical capital relative to their cost of production induces a cutback in investment and a further contraction in aggregate demand, income, and production.[46] The collapse in asset values reduces net worth, the capital of banks, and the value of collateral available for loans. This raises the external finance premium and depresses current spending further. The rise in the external finance premium amplifies the asset price declines and deepens and prolongs the downturn.

To complete the picture, consider the potential that exists for deflation in this depressed economy. If the output gap were large and expected to persist, then firms would try to cut their relative product prices in an effort to increase market share and offset the decline in profits. In aggregate, of course, attempts to cut relative prices would only cause the general price level to fall. That said, an output gap expected to be temporary could result in relatively little price cutting and little deflation. The outcome for deflation would depend critically on the public's confidence in the central bank's power to bring the economy back to full employment reasonably quickly.[47]

Consider the depressed economy from a monetary perspective. On net, the contraction increases the demand for liquidity services broadly defined. Yet a decline in bank lending and an increase in the desired ratio of reserves to deposits probably reduces the stock of monetary assets. Ordinarily, an increase in the implicit marginal liquidity services yield would precipitate an equivalent reduction of explicit returns on liquid assets, eg, short-term securities, relative to expected explicit returns on illiquid assets. But with nominal short-term interest rates at the cost-of-carry floor, the required increase in the expected explicit yield spread between illiquid and

liquid assets must show up as an increase in the expected explicit yield on relatively illiquid assets. Thus, the prices of illiquid assets fall relative to the prices of liquid assets to produce the required expected explicit return differential. Lower net worth elevates the external finance premium and raises the value of broad monetary liquidity further. At a minimum, a central bank should use quantitative monetary policy to offset any tendency for a contraction in monetary assets or a rise in the value of broad liquidity services to depress aggregate demand and employment.

4.4 Monetary Transmission at the Interest Rate Floor

Starting from the depressed state described above, consider what would happen if a central bank increased the monetary base by purchasing long bonds from the nonbank public. The object is to describe the transmission mechanism by which open market purchases help to offset the adverse aggregate demand shock independently of the nominal and real interest rate on bonds. The mechanism involves the portfolio rebalancing channel identified by monetarists and the credit channel by which a monetary expansion reduces the external finance premium. Even though I describe the two channels sequentially, it should be emphasized that I regard them as thoroughly intertwined, since broad liquidity services are closely related to the external finance premium.

Consider the portfolio rebalancing channel of monetary transmission. By expanding the monetary base in exchange for long bonds, open market purchases reduce somewhat the high implicit marginal liquidity services yield on monetary assets. As a result, holders of monetary assets seek to rebalance their portfolios by acquiring less liquid assets including consumer durables, physical capital, and claims to intellectual and organizational capital. The public cannot rid itself of the excess aggregate monetary liquidity. But the attempt to rebalance portfolios reverses somewhat the fall in asset prices that accompanied the adverse demand

shock. Portfolio balance is achieved when the prices of less liquid assets have regained enough of their lost ground that their expected return has fallen in line with the reduced implicit liquidity yield on monetary assets.[48]

The higher price of assets induces households to consume more out of current income. At the same time the rise in asset prices relative to their cost of production revives investment. The reduced saving rate, and the increase in investment reverse somewhat the contraction in income, consumption, and employment. The rise in the marginal product of physical and organizational capital and in firm profits, and the fall in the marginal utility of consumption, raise asset prices still further.

Now consider the credit channel of monetary transmission. A reduction in the external finance premium is achieved both by the increase in monetary assets and by the rise in asset prices. Balance sheets of households and firms are repaired to a degree. Collateral values reflate, net worth increases, and banks see an increase in capital. Bank lending revives with a decline in the premium on external finance. Credit spreads narrow. Spending increases because the cost of borrowing against future income prospects falls. Greater spending, in turn, has multiplier effects on current income and accelerator effects on investment.[49] Thus, we see that determined open market operations have the power to stimulate spending independently of any effect operating through the real interest rate on bonds.

There are complications, however. One involves the role of expectations and the credibility of open market policy. Open market purchases raise asset prices today by creating expectations that asset prices will be higher tomorrow and so on until the economy recovers fully. Open market operations must create a kind of bridge for asset prices. In order to value assets, the public works backward from the future expected recovery. Working backward from such a future period, the public will construct the path of sustainable asset prices based on its view of the way monetary assets influence nonmonetary asset prices, and its view of the central

bank's future intentions for open market purchases.

Such reasoning suggests that open market operations are not likely to exert a simple contemporaneous influence on asset prices and spending. The effect of open market operations will depend on expectations for future operations, much as the effect of a current interest rate policy action depends on expectations for future short rates. Quantitative monetary policy is not inherently more difficult to pursue than interest rate policy; but central banks have much more experience pursuing the latter.[50]

There will have to be some experimentation. Ordinarily, relatively small changes in aggregate bank reserves are sufficient to support interest rate policy actions. At the interest rate floor, however, open market purchases must influence liquidity broadly defined in order to be effective. That may require large-scale injections of monetary base, perhaps orders of magnitude larger than usual. Economists will have to develop and estimate models of how the monetary base influences the economy independently of interest rate policy. Costly portfolio adjustment will have to be a feature of such models.[51] Divisia indexes designed to track the liquidity services yield of broad monetary aggregates could help guide quantitative policy.[52] A central bank will have to rely more heavily on information in asset price movements than it does today.

All this should not be seen as too discouraging for quantitative policy, however. With short-term interest rates already at the cost-of-carry floor, large-scale purchases of long bonds would present little risk to the economy. The main complications would involve relations between the central bank and the Treasury, and public debt policy more generally, as discussed in Sections 4.5 and 5.2 below.

4.5 Monetary Transfers

Monetary transfers could supplement open market purchases as a means of injecting liquidity

into a depressed economy. Transfers that raise permanent income have the potential to stimulate spending independently of an effect operating through either interest rates or asset prices. Hence, monetary transfers should be considered as part of a policy package to help offset an adverse shock to aggregate demand at the interest rate floor.

A central bank must be prepared to reverse monetary injections after the economy recovers in order to maintain price stability. Reversing transfers, or reversing open market purchases of long bonds with unexpected capital losses, could increase government debt in the hands of the public. I identify the perceived burden of public debt as a potential cost of using quantitative monetary policy to stimulate the economy at the interest rate floor.

4.5.1 Transfers and Spending

There are opportunities for a central bank to make transfers.[53] For example, monetary transfers would be delivered by financing with money creation a government budget deficit created by cutting taxes. Open market purchases are transfers to the extent that the public is Ricardian and government bonds are not net wealth.[54] And a central bank would transfer money to the public by buying long bonds at low or negative nominal interest and subsequently selling them back to the public with unexpected capital losses.

According to the permanent income hypothesis, money transfers would directly and substantially affect spending on non-durables and services only to the extent that they are expected to be repeated and permanent. Transfers expected to be non-recurring or reversed in the future would tend to be saved. There are two possibilities. The first is that the economic recovery raises income and real wealth enough to absorb the monetary transfers as permanent additions to the public's desired stock of monetary assets. The public would save the monetary transfers to the extent that it expected this outcome.

The second possibility is that the public's demand for money does not rise to absorb the

monetary transfers after the economy recovers. In this case, higher prices would dissipate the wealth effect of monetary transfers as the public attempted to spend its excess money balances. A central bank committed to price stability, however, would reverse any monetary transfers expected to create inflation. Thus, the public could expect any excess (inflationary) monetary transfers to be reversed by the central bank.

Monetary transfers could be reversed in one of two ways. The government could temporarily increase taxes relative to spending. In this case the public would pay the temporarily higher taxes with the transfers it had saved. Alternatively, the central bank could sell securities, in which case the public would receive a stream of interest payments matched by an offsetting stream of higher taxes.

The above argument suggests that monetary transfers should not be expected to exert an effect on spending by permanently relaxing budget constraints for the average household or firm. Nevertheless, transfers would exert the same portfolio rebalancing and credit channel effects on asset prices and spending as open market purchases.[55] Moreover, in severely depressed conditions it might be useful for a central bank temporarily to finance a tax cut with money creation in order to distribute money widely throughout the economy. Such transfers might be particularly effective in getting credit-constrained households and firms to spend. The effect on spending might be strengthened if it were known that any need to drain money in the future would be accomplished with open market sales rather than by running in reverse the tax cut by which the monetary transfers were initially distributed. Given a commitment to price stability that disciplines a central bank to reverse monetary injections to prevent inflation, monetary transfers could be used in conjunction with open market purchases to stimulate a depressed economy.

4.5.2 Reversing Monetary Injections, Capital Losses, and the Public Debt

The need to reverse monetary transfers by selling short-term bonds or by reversing open market purchases of long bonds with unexpected capital losses has consequences for the credibility of quantitative policy. Quantitative policy would lack credibility if a central bank were unable to take capital losses. Moreover, either of the above operations could result in a permanent increase of government debt in the hands of the public. Quantitative policy would also lack credibility if the country were unwilling to accept a resulting increase of government debt in the hands of the public, or unwilling to run a budget surplus in the future to retire the increased debt.

Consider open market operations. As pointed out above, monetary targeting is effective only if the public believes that sufficient monetary stimulus is forthcoming, and that the monetary stimulus will not be withdrawn before the economy recovers. Such a commitment exposes a central bank to considerable risk of capital loss on its long bonds due to uncertainty about the timing and magnitude of the rise in short-term interest rates that would accompany a recovery.[56] If the public thinks that the central bank is unwilling to take losses on its long bonds, then the central bank's monetary targeting policy will lack credibility.

To help assure the credibility of quantitative policy, the Treasury could agree to indemnify the central bank against capital losses on the market value of its portfolio. Recapitalization per se would be costless. It would just involve transferring Treasury securities to the central bank, which would return the interest to the Treasury. The problem is solved unless the central bank has to drain money initially injected by purchasing long bonds after those bonds have taken unexpected capital losses. In that case only a fraction of the money could be drained by selling the long bonds themselves. If the rest has to be drained by selling some of the additional public debt that was issued by the Treasury to recapitalize the central bank, then there would be an increase in the stock of government debt in the hands of the public after the economy recovers and interest rates return to normal.

Now consider monetary transfers. When a central bank transfers money to the public by monetizing a government tax cut, for example, the central bank acquires newly issued public debt as an asset. If the public debt is short term, then the monetary transfer can be reversed subsequently by selling that debt to the public with little risk of capital loss. There would be, nevertheless, an increase of government debt in the hands of the public.

Since a larger stock of public debt mainly increases transfer payments, it is costly in the aggregate only to the extent that it involves distorting taxes. Of course, a larger stock of outstanding public debt may be beneficial to the extent that it increases liquidity in the economy. Moreover, the additional debt would be forthcoming only if the economic recovery were secure. Yet the tax liabilities associated with interest payments on the debt could prove to be unpopular. In judging how much to encourage a central bank to use quantitative monetary policy at the interest rate floor, a society would have to evaluate any perceived burden of the public debt against the power of quantitative policy to act forcefully against economic downturns.

5. Practical Considerations

This section addresses practical issues that arise in connection with the proposed policies. The discussion is in two parts. I consider the carry tax first. Then I take up quantitative policy and issues connected with open market operations and monetary transfers.

5.1 The Carry Tax

Keynes (1936) endorsed a carry tax on money in principle.[57] But he objected that the tax would be impractical on the grounds that money was not unique in having liquidity services attached to it. He appears to have been thinking in terms of a permanent tax on currency, and he argued that substitutes for currency such as bank money, call debts, foreign money, and jewelry would take the place of currency if the latter were taxed.[58]

Keynes's objections would appear to have little force. Currency and noninterest bearing deposits have been taxed by inflation and reserve requirements for decades. The financial services industry responded by paying interest on deposits, offering new monetary assets such as money market mutual funds, economizing on reserves, and finding ways to avoid reserve requirements. But there was no move away from the monetary base as the medium of exchange.[59] Moreover, a carry tax only would be imposed if the zero bound became a constraint on monetary policy. Impositions of the carry tax would be relatively infrequent and of relatively short duration, and less onerous than the inflation tax and the reserve requirement tax.

Hart (1948), too, endorsed a carry tax on money in principle but thought it impractical.[60] He reasoned that a negative nominal interest rate might be hard for the public to accept. Hart agreed, however, that imposing "melting money," as he called it, should be reconsidered if other methods for dealing with a deficiency of aggregate demand proved unworkable. The problem with Hart's position is that systems for imposing a carry tax would have to be put in place well ahead of time. The public might find such systems and the occasional imposition of a carry tax acceptable, however, if the government agreed to use the systems to pay interest on bank reserves and currency when short-term interest rates exceed zero.

Dahlberg (1938), a proponent of the carry tax idea, worried about its legality.[61] But he noted that even the conservative Supreme Court of 1933-36 supported Congress's constitutional power over the nation's money in abrogating contractual gold clauses.[62] Dahlberg pointed out that several states taxed bank deposits as personal property, and that in the last century the Federal government taxed state banks 10 percent on all bank notes outstanding.

The Federal Reserve and the Treasury would need legislation to impose a carry tax, but one would not expect that power to be unconstitutional. In fact, one could make a case that the power to impose a "user fee" on money from time to time should be granted to the central bank in support of the nation’s commitment to maintain full employment with stable prices.

Buiter and Panigirtzoglou (1999) worry that "past due" bills might simply circulate like counterfeit currency. Given the nature of the public's use of currency discussed above, however, and the fact that most currency is deposited by merchants, this would not appear to be a problem. Merchants might object that the carry tax amounts to a sales tax. But merchants might be persuaded to go along by pointing out that the carry tax would encourage their customers to spend and make their own borrowing costs negative.

The regressivity of the carry tax is a concern. In response, a few hundred dollars of bank deposits per person could be exempt from the negative interest consequences of the tax, with a government rebate financed out of the carry tax proceeds.

The most serious impediment to imposing a carry tax on money involves the harm it could do if the public were not adequately positioned to withstand a period of negative interest rates. Individuals dependent on interest income such as the elderly would be hurt most. But anyone counting on interest income could be hurt.

An initiative to introduce systems to impose a carry tax should be accompanied by a program to encourage individuals to position their portfolios for the possibility of negative nominal interest rates. In particular, the public should be advised and strongly encouraged to arrange its financial affairs so as not to be excessively dependent on short-term interest income. The responsibility for educating the public could be assumed by the central bank as part of its economic education programs. The economic education part of the implementation of a carry tax would be as important as developing and installing systems to impose the tax itself.

Long bonds are a natural hedge against a period of low or negative interest rates. But the public is shy of the inflation risk in bonds. To reassure the public, and support the central bank's program to encourage the holding of long bonds, the legislature should mandate a price stability objective for the central bank. And the Treasury might help to supply the public with long bonds if need be.

5.2 Quantitative Policy

One of the main points of the paper is that quantitative monetary policy needs more fiscal support than usual in order to be effective at the interest rate floor. The relationship between the central bank and the Treasury must be more intimate. To help guide our sense of how that relationship should work, consider the following principle of independent central banking: "Monetary policy should be used to stabilize the macroeconomy regardless of the fiscal concerns of the Treasury. A fully independent central bank contributes importantly to economic stability. Independence insulates a central bank from short-run inflationary pressures to stimulate employment. It also frees a central bank from having to get legislative approval for its policy actions so that a central bank can react quickly and decisively to macroeconomic and financial market shocks. The legislature bestows independence only because it is necessary for a central bank to do its job effectively. Hence, the presumption is that a central bank ought to perform only those functions absolutely necessary to stabilize the macroeconomy."[63]

Independence requires accountability. An independent central bank should have its goals mandated to it by the legislature. The analysis in this paper suggests that the central bank should be directed to give priority to price level stability and to employ monetary policy to facilitate employment and economic growth.

The principle of independent central banking says that a central bank should not assume unnecessary fiscal burdens. A central bank should not purchase long bonds if it does not need to. Thus, if the short-term nominal interest rate is comfortably above zero, a central bank should do open market operations in short-term bonds. However, when the price level is stable and nominal interest rates are near zero, a central bank must be prepared to purchase long bonds in order to make quantitative policy effective at the interest rate floor. The problem is that a central bank can't do so without the fiscal support of the Treasury.

A second part of the fundamental principle is that the Treasury should support monetary

policy with fiscal policy.[64] Accordingly, the Treasury should do two things. First, the Treasury should maintain a sufficiently large stock of outstanding long bonds for the central bank to purchase, if it needs to, at the interest rate floor. In this regard the legislature might consider authorizing the central bank to purchase long-term assets other than government bonds in case there is an insufficient supply of the latter.[65]

Second, the Treasury ought to indemnify the central bank against capital losses on long bonds so that the central bank could aggressively pursue quantitative policy to stimulate a depressed economy.[66] To facilitate the indemnification, the Treasury should allow the central bank to accumulate, in a capital account, coupons earned on long bonds purchased to stimulate the economy. Moreover, the central bank should be empowered to enlarge its surplus capital to provide additional protection for its financial independence. Completely fortifying the central bank against capital losses would commit the Treasury to expand the public debt, perhaps substantially, in support of monetary policy. Such enhanced fiscal support of monetary policy might require legislation.

To further protect its financial independence, the central bank should routinely hold a share of its portfolio in long bonds to hedge its interest income against the possibility that short rates may go to zero or become negative. In return for a legislative commitment to price stability and the fiscal support of the Treasury, the central bank should be willing to consider monetizing a tax cut with money creation as long as monetization is consistent with price stability. As mentioned above, in severely depressed conditions temporarily transferring money widely and in large quantity to the public might be a valuable policy option.

6. Conclusion

I proposed and developed three options for overcoming the zero bound on interest rate policy: a carry tax on money, open market operations in long bonds, and monetary transfers. In the first

half of the paper I explained how a variable carry tax on electronic bank reserves could allow a central bank to target negative nominal interest rates. When short-term interest rates are pressed against the cost-of-carry floor, the carry tax would anchor the short end of the yield curve much as the intended federal funds rate does today in the United States. A carry tax on currency could supplement the carry tax on electronic reserves by creating more leeway to make interest rates negative.

In the second half of the paper I discussed how quantitative policy--open market purchases and monetary transfers--could stimulate spending at the interest rate floor by creating liquidity broadly defined. I described in some detail how quantitative policy could act independently of interest rate policy through a portfolio rebalancing channel and a credit channel of monetary transmission. The need for a central bank to drain money (by reversing monetary transfers or by selling long bonds with unexpected capital losses) to stabilize the price level after an economy recovers could greatly increase government debt in the hands of the public. I identified the perceived burden of this additional public debt as a potential cost of using quantitative policy to stimulate spending. I also pointed out that a central bank would need more fiscal support than usual from the Treasury to effectively pursue quantitative monetary policy at the interest rate floor.

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Endnotes

1. Ex post real Treasury bill rates from 1926 to 1997, excluding the wartime peg years, average about 1 percent per year. See Ibbotson (1998).

2. See pages 186-94.

3. Because the inconvenience and physical costs of storing currency are not literally zero at the margin, nominal interest rates can be slightly negative. In fact, the nominal yield on Japanese Treasury bills became slightly negative during the Asian financial crisis last autumn when nominal rates were already very low. Investors were willing to pay for the safety and convenience of government bonds rather than incur the cost of storing currency. Mogi and Zuckerman (1998).

Nominal yields on US Treasury bonds and notes calculated in the standard way became negative in the 1930s. However, Cecchetti (1988) shows that nominal rates only appeared to be negative by correcting the apparent negative yields for an institutional "exchange privilege" on bonds.

The behavior of nominal rates near the zero bound is discussed in detail in Sections 3.1 and 3.2 below.

4. See Chapter 17. Lerner (1952) clarifies some of the analysis in that chapter. See, in particular, Lerner's concluding section.

5. See Keynes (1936, Chapter 17 page 234 and Chapter 23 pages 353-8), Dahlberg (1938, Chapters 7 and 8), Fisher (1933, Chapter 3), and Hart (1948, Chapter 20, pp. 443-7). Keynes (1936, Chapter 23) credits Silvio Gesell with idea for imposing carrying costs on money in order to lower the floor on nominal interest rates. In a recent paper, Buiter and Panigirtzoglou (1999)

revive Gesell's idea for imposing a periodic stamp tax on currency. They show in a dynamic macromodel, how Gesell's tax on money allows the model economy to escape a liquidity trap.

6. Meltzer (1999) and Romer (1992) present interesting discussions of the role of money in various historical episodes of recession and recovery.

7. The "shopping time" model of money demand is discussed in McCallum and Goodfriend (1987).

8. Clouse et al (1999) report that real short-term interest rates were negative in most of the 12 recessions in the US since the early 1930s. The major exceptions occurred in the two recessions of the 1930s and in the post-World War 2 recession, when deflation actually pushed real rates up as the economy turned down.

Fisher (1930) points out on page 192 that "there is no absolutely necessary reason inherent in the nature of man or things why the rate of interest in terms of any commodity should be positive rather than negative." The interest rate is a relative price reflecting the cost of using a commodity today in terms of future units of that commodity. Barro (1987) explains the role of the real interest rate in macroeconomics as the central intertemporal relative price.

9. See Benhabib, Schmitt-Grohe, and Uribe (1999), Mints (1950) Chapter 3, and Reifschneider and Williams (1999).

10. See Hayami (1999) and Okina (1999) for discussions of monetary policy from the Bank of Japan's perspective.

11. See Abelson (1998), "Could It Happen Again?" (1999), "Deflation and All That," (1997), Faison (1999), Uchitelle (1999). See also Krugman (1999).

12. See Fuhrer and Madigan (1997), Orphanides and Wieland (1998), Reifschneider and Williams (2000), Svensson (1999), and Tetlow and Williams (1998).

13. If for some reason the economy had already undergone a severe deflation, then reflation would be called for to reverse the decline in the price level in order to reverse debt deflation effects. See Bernanke and Gertler (1995).

14. The work of Rotemberg and Woodford (1999) and Woodford (1999b) emphasizes the idea that credibility can be exploited to minimize the chances that the short-term nominal rate will hit zero. However, their work does not focus on what a central bank could or should do if the zero bound is actually encountered.

15. See Lebow (1993) for an early analysis of practical options.

16. The statement in the text follows from a fundamental principle of independent central banking given in Section 5.

17. See Goodfriend and Lacker (1999).

18. If there is a small marginal cost of storing bonds, then the nominal interest rate asymptotes to a small positive value so that the net nominal return to holding bonds is also zero.

19. If bonds are also costly to store, then the nominal interest rate asymptotes to a value equal to the marginal cost of storing bonds minus the marginal cost of storing currency.

20. Stavins (1999), pp. 6-8, discusses the pricing of transactions services.

21. Wolman (1997) shows that the welfare consequences of low or negative rates of inflation turn importantly on whether currency is actually satiated or not at zero interest.

22. Physical costs of storing coin are probably large enough at the margin that storing large values of cash as coin would not be a cost-effective means of avoiding negative nominal interest rates.

23. In principle, as an alternative to imposing a carry tax on currency, banks could agree to suspend the payment of currency for deposits whenever a carry tax was imposed on electronic reserves at the central bank. Currency and deposits each have a comparative advantage in making payments. Currency is more efficient for small transactions made in person, and checkable deposits are useful for making larger payments at a distance. The respective demands for the two monies would be well-defined. The imposition of a negative nominal interest rate coupled with a suspension would cause the deposit price of currency to jump to the point that the expected negative deposit return to holding currency matched the negative nominal rate on deposits.

This mechanism is reminiscent of the temporary suspensions that occurred in the US prior to the establishment of the Federal Reserve. For instance, currency went to a few percent premium over deposits for a few months during the suspension that occurred in the aftermath of the banking panic of 1907.

Suspending the payment of currency for deposits would avoid the cost of imposing a carry tax on currency. After the initial capital gain, however, currency would bear the same expected negative return as deposits. Moreover, the proposal would involve the inconvenience of dealing with a fluctuating deposit price of currency. Furthermore, the possibility of making a capital gain on currency relative to deposits when a suspension occurs would create destabilizing speculative runs on the banking system. Such attacks would be annoying and costly for banks. Effort invested in attacking banks would be a waste of resources from society's point of view.

24. John Taylor's (1993) interest rate rule could be adapted to situations when the nominal rate was made negative.

25. See Porter and Judson (1996), Table 1, page 887.

26. The costs of inflation are well known and have been documented and measured extensively elsewhere. See, for instance, Feldstein (1997), Fischer (1996), Goodfriend (1997), Lucas (2000), Summers (1991, 1996), Wolman (1997), and references therein.

27. An exogenously imposed carry tax would be distortionary. Consider a permanent carry tax on money. In balanced growth, the real interest rate is governed by time preference, intertemporal substitutability, and the growth rate. A carry tax on money would not affect the real interest rate in balanced growth. It would, however, raise the consumption interest opportunity cost of holding money and cause people to economize on real money balances.

28. The deflation trap in Benhabib et al (1999) arises because of the assumed zero bound on nominal interest rates. Benhabib et al show that as long as there is a zero bound, deflation expectations can put the economy on a trajectory to the deflationary equilibrium. Using the carry tax to overcome the lower bound on nominal rates eliminates the deflationary equilibrium in their model and the possibility of a deflationary spiral.

29. For the purpose of this discussion, one may take the price level and the real transactions variable in the money demand function as given. The general point holds in slightly different form in a fully dynamic, flexible price model.

30. Hall (1999) proposes that a central bank pay interest on reserves, and vary the spread between the market rate and the own rate on reserves as the policy instrument. If one interprets

his interest on reserves as a negative cost of carry, then his analysis can be seen to be related to the discussion here.

31. McCallum's (1988) monetary base policy rule could be adapted to this situation.

32. See Friedman (1969), pages 229-234, and pages 255-6.

33. Woodford (1999a), page 87, makes this point forcefully.

34. Note that the reduction of the opportunity cost of holding the medium of exchange to zero and the reduction of the purchasing power of money to zero are two different things. The real demand for the medium of exchange is satiated at the point that the marginal services yield net of the cost of carry becomes zero. At that point the average value, ie, purchasing power of the medium of exchange, is still positive. See Johnson (1969).

35. This paragraph is taken directly from Bernanke and Gertler (1995), pages 34-5, with minor changes and omissions.

36. "Among the factors reflected in the premium are the lender's expected costs of evaluation, monitoring, and collection; the lemons premium that results from the fact that the borrower inevitably has better information about its prospects than does the lender; and the costs of distortions in the borrower's behavior that stem from moral hazard or from restrictions in the contract intended to contain moral hazard (for example, restrictive covenants or collateral requirements)." Bernanke and Gertler (1995), page 35.

37. See Mishkin (1978) for an analysis of the household balance sheet in the Great Depression.

38. Keynes (1936) argued this way in Chapter 17.

39. Heaton and Lucas (1996) find that transactions costs in the stock market can produce an equity premium of about half of the observed value. Fifty percent of the equity premium in their model is accounted for by the marginal implicit liquidity services yield on short-term bonds.

40. Diamond (1997), Freeman (1985), and Holmstrom and Tirole (1998) may be interpreted as analyzing broad liquidity services provided by bank deposits, currency, and government bonds, respectively, in models with an external finance premium.

Heaton and Lucas (1996) show quantitatively that the equity premium is very sensitive to the stock of short-term government bonds available and is reduced when an outside supply of bonds is increased. Bond holdings provide liquidity services broadly defined by allowing borrowing constrained individuals to smooth consumption without paying transactions costs.

We can interpret the findings as follows. When the stock of outside bonds is small and the marginal implicit liquidity services yield is high, the explicit premium on equity relative to bonds is large because the implicit marginal liquidity yield on bonds is large. As the per capita inventory of bond holdings increases, individuals are better protected against having to smooth consumption by paying large transactions costs to sell other assets. The required explicit bond return rises as the marginal implicit liquidity services yield falls, ie, the explicit equity premium falls.

See Barro (1974) for an early discussion of liquidity services provided by government bonds.

41. In principle, a central bank could buy long-term assets besides bonds. Government bonds or highly-rated private bonds are preferable because they are the most convenient assets to monitor and manage. If the stock of bonds proved inadequate, then assets such as land or gold might be purchased as well. Purchases of foreign currency denominated bonds would also be

an option.

Long bonds, land, gold, and foreign exchange all expose the central bank to unexpected capital losses due to rising interest rates. A central bank could purchase medium-term bonds to minimize its exposure to higher interest rates. However, to achieve the same increase in net broad liquidity, open market operations might have to be carried out on a correspondingly greater scale with little change in exposure to interest rate risk.

A central bank could buy relatively short-lived producer or consumer durables and lease these to the public. Such transactions would amount to a substitution of central bank credit for private short-term financing of the durables. The net liquidity effect would reflect the injection of base money minus the loss of private short-term securities. And purchasing durables for the central bank portfolio would involve non-negligible administrative and management costs. This option looks like a more costly version of the previous one.

A central bank could also inject liquidity into the economy by overpaying for assets. Overpaying amounts to making monetary transfers. Transfers are considered in Sections 4.5 and 5.2 below.

42. Assume that long-term interest rates are anchored by the expected path of future short rates up to a term premium and a liquidity spread according to the expectations theory of the term structure.

43. Since I am holding the real interest rate fixed, I am really focusing on what happens inside the disturbance term in the popular "forward looking IS function" that plays an important role in modern models of monetary policy. See, for example, Kerr and King (1996). The aggregate demand shock, the quantitative monetary policy response, and the effect of quantitative policy on the economy all reside in the disturbance term.

44. By making real interest rates negative, a central bank could encourage investment and lower the saving rate at any level of income. Income would stabilize at a higher level than with no reduction in the real interest rate.

45. In principle, if the central bank made real interest rates sufficiently negative, the price of durables could rise enough to create an expected depreciation.

46. Adjustment costs may be involved in the production and installation of consumer and producer capital goods so that aggregate investment responds relatively smoothly to a change in asset prices relative to their costs of production. If the contraction is not too long, we can ignore the effect of investment on stocks, on the marginal service yield of consumer durables, and on the marginal product of capital.

47. See Goodfriend and King (1997) for a discussion of the relationship between the output gap, the markup, and inflation in the modern New Synthesis style macromodel. From the perspective of the New Synthesis, the stickiness of real interest rates and the price level in the face of the adverse demand shock causes the markup to rise as employment and nominal wages fall. Real business cycle reasoning in the New Synthesis context sees the decline in employment as resulting from the temporarily elevated markup tax.

48. If the real interest rate on bonds is negative, then a decrease in expected future appreciation creates a partially offsetting benefit to holding the asset related to the negative real interest rate on bonds.

49. King (1993), page 77, describes simulations of the effect of a persistent change in the money stock in a quantitative sticky-price macromodel with a rational expectations investment function. He reports that persistent changes in the demand for final output lead to quantitatively

major shifts in the investment demand schedule at given real interest rates. The effects are generally sufficiently important that real interest rates actually rise with a persistent monetary expansion rather than fall. His findings support the idea advanced here that a determined, persistent monetary expansion would stimulate spending without a fall in the interest rate.

50. One can understand interest rate policies commonly pursued by central banks today without considering money supply or money demand. See, for example, Kerr and King (1996) and Woodford (1999a), part 2.2. Models that ignore money presume that a central bank has full credibility for a future price level target or a path for the price level. It should not be forgotten, however, that the credibility for a price path objective devolves from a central bank's power to manage the monetary base to enforce it, if necessary. It was the collapse of credibility for low inflation that caused the Federal Reserve to move temporarily from interest rate to monetary targeting in 1979 to bring inflation down.

51. Christiano and Eichenbaum's (1992) work on the liquidity effect of open market operations highlights the important role played by portfolio adjustment costs.

52. See Barnett and Spindt (1982).

53. Mints (1946, 1950, pp. 205-12) considers and recommends various methods of delivering monetary transfers to the public.

54. The application of the Ricardian view of public debt to open market operations is discussed in Barro (1987, pp. 395-6) and Mundell (1971, Chapter 1). See also Barro (1974).

55. Monetary injections may be said to exert a wealth effect in the sense that they reduce the external finance premium. This seems analogous to a wealth effect exerted when the short-term

nominal rate moves closer to zero. In both cases wealth is created by reducing a distortion. Interest rate and asset price substitution effects seem to be more important for the transmission of monetary policy than the wealth effect.

56. There would seem to be little scope for minimizing capital losses due to higher interest rates by buying assets other than long-term bonds. See note 41.

57. Keynes (1936), page 234.

58. Keynes (1936), page 357.

59. As mentioned in Section 3.4 above, Jefferson (1997) shows that St. Louis home base velocity has remained near 3.3 since 1980, a period in which the inflation tax averaged around 4 per cent and was over 10 percent in the early 1980s.

60. Hart (1948), pp. 443-7.

61. Dahlberg (1938) page 97.

62. See Kroszner (1999).

63. With minor changes, this paragraph comes from Goodfriend (1994), page 573.

64. Fiscal accommodation ordinarily occurs because the Treasury accepts whatever interest earnings transfers it gets from the central bank arising from changes in a central bank's portfolio as a result of its monetary policy actions.

65. The Federal Reserve Act would have to be amended to allow the Fed to do so. See Small and Clouse (1999).

66. There is a well-known instance in which the US Treasury protected its long bond holders from capital losses. The 1951 Treasury--Federal Reserve Accord freed the Federal Reserve from pegging long bond rates at 2.5 percent. As part of the processes of allowing long-term interest rates to move higher, the Treasury agreed to exchange at par some long bonds with a 2.5 percent coupon for long bonds with a 2.75 percent coupon. Long-term rates moved up to about 2.75 percent soon after the Accord. And bondholders that participated in the conversion managed to avoid capital losses. The Fed had been accumulating long bonds prior to the Accord as a result of its support of bond prices. The Treasury's exchange offer allowed the Fed to escape capital losses on its substantial holdings of long bonds. See Eichengreen and Garber (1990).