

SPEECH

## Negative Nominal Central Bank Policy Rates: Where Is the Lower Bound?

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The Swiss National Bank (SNB), the European Central Bank (ECB), Danmarks Nationalbank (DNB), and the Swedish Riksbank recently have pushed short-term interest rates to levels below the “zero lower bound.” The current extent and depth of negative policy rates is unprecedented; previously only Denmark had a modestly negative policy rate in 2012 through 2014. The actions of the four central banks have led a number of commentators to ask, Is the concept of a zero lower bound on interest rates valid? If not, what might be the lower bound, if any, on nominal interest rates? Indeed, some economists have suggested that with changes to the monetary system, we could in fact eliminate the lower bound to interest rates altogether.

I’ll first review the reasons given by the central banks for setting negative policy rates—in all cases, the negative rates were seen as a means of advancing the banks’ macroeconomic objectives in the current environment. But much of my talk will focus on the unique complications associated with negative nominal interest rates and the extent to which these complications constrain how low the rates can be set.

After outlining these challenges, I’ll suggest that the zero lower bound on policy interest rates is much like the low tide mark on a beach: Standing at that border between the land and the ocean, you can continue to lower your elevation by walking into the water, but with each additional step, you will need to push against the increasing resistance of the water. There is a distinct qualitative difference between positive and negative nominal interest rates, just as there is a distinct qualitative difference between the beach and the ocean. The zero lower bound is marked by this same qualitative difference: zero is a rate below which a central bank encounters the distinctive and increasing costs of a negative nominal rate, relative to a nonnegative rate of interest.

### Purpose

In September 2014, the ECB lowered its deposit rate to its current level of negative 0.2 percent. More recently, in late 2014 and early 2015, the SNB, DNB, and Riksbank reduced their policy rates to levels below zero, with the SNB and DNB setting their rates at negative 0.75 percent.<sup>2</sup> These central banks established their negative rates for various reasons. Both the SNB and DNB established negative policy rates primarily to deter capital inflows and reduce the appreciation pressure on their currencies. In the case of the ECB and the Riksbank, negative policy rates were intended to provide additional monetary accommodation to ensure price stability over the medium term and a return of inflation to the central bank objective. Money market rates in the jurisdictions adopting negative deposit rates have also moved into negative territory, suggesting that the transmission of policy rates into market rates has continued.

The central banks implement their negative rate regimes in different ways, but in each case some of the bank reserves on deposit at the central bank are subject to negative rates. In other words, some commercial banks are charged periodically for (some of) their deposits at the central bank. In addition, some central banks conduct both overnight and term repo and reverse repo transactions at negative rates.

In addition to implementing the negative policy rates, each of these central banks has employed a variety of other tools to support its policy objectives, such as significant foreign exchange intervention for both the SNB and Danmarks Nationalbank and programs of asset purchases, or quantitative easing, for the ECB and, in a smaller-scale program, the Riksbank.

In an important sense, lowering interest rates to reduce capital inflows into a currency or to provide more accommodative financial conditions is a standard practice of central banking. Lower interest rates reduce the return to saving for households and reduce the “hurdle rate” to investment for businesses. Consequently, lower interest rates tend to support both consumption and investment, and thereby increased aggregate demand. If a central bank judges that demand is insufficient, and if the interest rate is already at zero, then lowering the interest rate necessarily means setting a negative rate.

A key dimension of these issues is the distinction between the nominal interest rate and the real interest rate. The nominal interest rate measures the gross interest rate at which debtors remunerate creditors. The real interest rate measures the *net* interest rate at which debtors remunerate creditors—that is, after subtracting the inflation that is expected to occur over the period during which the debt is outstanding. It is the real interest rate that is more important in stimulating or throttling consumption and investment decisions, as economic agents’ income and expenses are affected by inflation more or less equally.

The relationship between the nominal interest rate ( $r_N$ ), the real interest rate ( $r_r$ ) and the rate of expected inflation ( $\Pi_e$ ) is concisely expressed in the Fisher equation, or  $r_N = \pi_e + r_r$ . This relationship reveals that a negative real interest rate does not necessarily require fixing the nominal interest rate at negative levels. Instead, if expected inflation is positive, then for a sufficiently low but positive nominal interest rate, the real rate of interest will be negative.

One way to think of this is to liken prices and interest rates to the speed of travel for a person attempting to ascend a downward-moving escalator. The nominal interest rate can be thought of as the person's own effort to climb the steps; the rate of inflation can be thought of as the rate of speed of the escalator itself, descending against the stair climber. If the climber is ascending as fast as the escalator descends, she makes no vertical progress. This outcome can be likened to a real interest rate of zero—the nominal rate of interest just offsets the inflation eroding the value of money. If the climber ascends more slowly than the escalator descends, the outcome is analogous to a negative real interest rate. If the escalator stops for some reason, then the only way to have a negative real interest rate is for the climber to descend by climbing down the escalator—a negative nominal rate of interest.

It is not uncommon for countries to experience negative real interest rates. When nominal interest rates are positive, but real rates are negative, conditions are “conventional” in the sense that the debtor still pays positive gross amounts of interest to creditors. So the innovation in the negative nominal policy rates we see at Danmarks Nationalbank, the ECB, the Riksbank and the SNB is in the “nominal” aspect of their policy. It is unusual to set nominal policy rates at negative levels. When nominal rates are negative, creditors pay debtors interest, and debtors earn interest on their debt. That is, instead of your money working for you, you have to work for your money.

To explain why we are seeing these negative nominal rates, we can invoke the Fisher equation. In Denmark, Sweden, Switzerland and the euro area, rates of inflation, and expected inflation, had been falling and were near zero. Other things equal, the resulting real interest rates were too high for comfort. In an environment of low inflation, one policy to reduce real interest rates would be to boost expected inflation. However, there may be few or no easy ways to raise those expectations quickly; policies such as quantitative easing may take time to implement and have complications of their own. An alternative approach to reducing the real interest rate, the Fisher equation suggests, is for the central bank to set a negative nominal rate.

In addition to this straightforward influence of negative nominal rates on real rates, setting negative nominal rates may stimulate the economy in less predictable and clear ways. For example, setting a negative nominal policy rate—a move that is, by nature, unconventional—may surprise people and thereby send a strong signal of the central bank's intent to pursue its policy objective. Such a signaling channel may reinforce the effect of the negative rate and have an independent effect on boosting inflation expectations.

Lowering the policy rate into negative territory can also be useful in reducing the pressure on an appreciating currency. If a country's currency is facing such appreciation pressures at a time when “substitute” currencies have policy rates at or near zero, then the country's central bank may choose to move its policy rates into negative territory to reduce the yields available to market participants who are holding the currency in anticipation of a gain on sale.

## Complications

I'll now outline seven categories of complications associated with negative nominal policy rates. While some of these complications are already relevant in an environment of low real rates of interest, most arise only when nominal rates turn negative.

### 1. Avoidance

Why do people say there is a lower bound on interest rates at zero? Our simple proposition is that people would not invest a dollar in an account or bond from which they they could expect to recoup only an amount less than a dollar so long as they could alternatively and costlessly put their money in currency—an investment in which a dollar remains a dollar. If everyone could costlessly invest in currency rather than in activities bearing negative rates, then there wouldn't be any negative rate activity in which people would invest. Consequently, the negative interest rates in many European countries indicate that it is costly to invest in currency to earn a zero nominal rate of interest.

Why is this the case? First, currency is bulky and weighty. For example, a million U.S. dollars, made up solely of \$100 bills, would form a stack measuring approximately 43 inches or 109 centimeters in height and weighing 22 pounds or about 10 kilos. Consequently, currency is inconvenient to use, especially for those who seek to make large investments or payments. Second, currency is subject to theft, requiring a big investment in security and insurance. Third, recounting currency every time it is moved or transferred between people entails time and expense. Finally, currency is subject to degradation, accident, fire, counterfeiting, and other mishaps.

Because currency is costly to invest in, then we could refine the proposition we stated earlier to say that a person *would* invest a dollar in an account or bond that promises to pay back less than a dollar so long as the person could not preserve more of his or her initial wealth by investing in currency, net of its costs. So one might suggest that it is the negative net return on currency that establishes the lower bound to interest rates—zero is only a rough approximation. This formulation is sharper, certainly, but it may

also be too blunt for the following reason. Notice that the costs of handling currency vary by the size of the investment one is considering. An ordinary person, with a few hundred or a few thousand dollars to invest, may find it perfectly convenient to invest in currency, and to store most of it in a safety-deposit box, one that the person may well have already rented to store important papers or other valuables. A large corporation, in contrast, likely would find dealing in currency extremely costly. So the proposition may be refined further to state that different economic agents will be more or less willing to invest in negative rate investments to the extent that diseconomies of scale make their costs of handling currency higher or lower than others'.

Vaults introduce some additional considerations affecting the costs of holding currency. Often, the costs of holding currency securely, by having a safety deposit box or a vault, are fixed costs. Once one has a vault, or has rented a safety deposit box, the costs of storing additional currency in it, up to its capacity, is nil. This suggests that there is a dynamic element to the economics of avoiding negative interest rates: the longer the negative rates are expected to persist, and the lower they are, the more favorable are the returns to investing in a vault. Once the vault investment has been made, maintaining negative rates would likely become more difficult.

An even more far-reaching change that many have suggested would be the creation of a new institution to handle and store currency on behalf of others; this could dramatically reduce the costs of holding currency. The institution contemplated would have a single, highly trusted, party start a currency warehouse, which would consist of a large secure vault and excellent record-keeping and shipping facilities. Individuals could then deposit currency in the currency warehouse, receive receipts for their deposit, and then make payments with the warehouse receipts. Such an innovation could conceivably lower the cost of holding currency as an investment, and yield investors a return close to zero, but still slightly negative.

Because of these dynamic considerations involving innovative actions to avoid negative rates, we could add a corollary to our proposition. Specifically, we posit that different economic agents will be less willing to invest in negative rate investments over time to the extent that innovations reduce the costs of handling currency or make available other zero, or near-zero, interest rate economic arrangements.

Some economists since Silvio Gesell—notably, Willem Buiter, Marvin Goodfriend, Miles Kimball, and Ken Rogoff—have suggested that currency be eliminated, taxed, made non-redeemable for deposits in banks, or made redeemable only in units that reflect an exchange rate that varies over time.<sup>3</sup> These are all other ways of imposing negative nominal rates universally across the alternative means of payment people use. If such steps were implemented and widely adopted, these proponents claim, there would no longer be a zero bound on interest rates, primarily because currency would not offer a zero interest rate alternative investment as a way to avoid negative rates on electronic bank balances.

These ideas are clever, but complicated and permanent in their effects. Without going through the details of each proposal, let me discuss two of them: first, the proposal to eliminate currency, and second, the proposal to have currency taxed or to have interest collected from currency holders. By eliminating currency, the problem of avoiding the zero lower bound would be greatly diminished. In his paper, Ken Rogoff suggests that the use of currency, by allowing anonymity in trading, facilitates tax evasion and other criminal activity. He points out many benefits of currency, including seignorage, lack of reliance on electronic networks, transaction cost savings, and expanded civil liberties associated with additional privacy. If these aren't enough however, let me suggest another, very important benefit of currency that I explored in a paper with Charles Kahn and William Roberds.<sup>4</sup>

The anonymity afforded by currency transactions prevents a buyer from suffering from any actions taken after the transactions that could exploit the knowledge gained by the seller of the buyer's identity. For example, identity theft, or theft of credit or debit card information, is avoided through the use of currency. This is an economic benefit that is distinct from valuing privacy from a civil liberties point of view. If currency cannot be used in transactions, buyers are at a disadvantage, and many otherwise beneficial transactions (not related to buyers seeking to engage in tax evasion or otherwise illicit activity) would not take place.

It is important to consider whether the move to eliminate currency, or to alter radically how currency works, represents a degradation or an improvement in technology. Should society voluntarily abandon a widely used technology that has enormous benefits and features that are currently irreplaceable, such as the privacy that comes with an untraceable transaction? While some of those features are used by criminals to facilitate socially destructive activities, the vast majority of currency uses are legal and productive. Until there are equally secure electronic means of providing that anonymity, eliminating currency is not warranted.

Economists have proposed many clever ways to implement the taxation of currency, or, equivalently, the payment of interest on currency holdings. Some of the proposals entail decreasing the value of the currency by imposing a negative rate of interest. This can be likened to making currency out of ice. As you can imagine, such cold currency would slowly disappear as the ice turns into liquid water. (Other proposals would, in effect, attempt to raise or lower the temperature of the air surrounding the ice money.)

One might conjecture that the loss of purchasing power is the same whether a person holding a dollar for a period of a year sees the value of that dollar decline owing to inflation of 1 percent, or because he had to pay a penny of interest in an environment of stable prices. However, there is a subtle difference between a negative rate of interest charged on currency, and inflation decreasing the value of currency. With inflation, a dollar remains a dollar, but its purchasing power declines. In contrast, with negative interest rates, the dollar of currency is slowly whittled away as one makes interest payments, even though its purchasing

power can remain unchanged (this would be the case if prices fell by the same rate as the negative interest rate). In other words, the value of the unit of account is unchanged when a negative interest rate is charged on currency. In addition, dollars would no longer be fungible, because each dollar would have a different amount of interest accrued on it.

The difference in those two situations is the subject of money illusion—the behavioral tendency of people to think in nominal terms.<sup>5</sup> To the extent that money illusion is operative, then imposing negative nominal interest rates will be perceived as more costly to people than engineering an increase in inflation of the same amount—in both cases, the real wealth of the person’s money holdings is the same, but in the case of inflation, the person holds the same number of dollars at the end of the period, whereas with negative nominal interest rates, some of the person’s money holdings have been paid out as interest. Money illusion causes the payment of interest to be perceived as more costly, much as people resist nominal decreases in wages which manifests itself as downward wage rigidity.

## **2. Legal and operational frictions**

Legal and operational challenges will also arise as money and capital markets adjust to negative rates. Many debt contracts feature floating interest rates; that is, the interest rate on the debt is modified periodically to reflect prevailing market interest rates. But when the contractual language does not contemplate the possibility of negative rates, complications will ensue. In that event, the parties must renegotiate, which is difficult when the parties are highly dispersed, and adjust the contractual language to address what happens when market rates are negative. Another first-order operational problem is how to collect interest from creditors: often debtors have few means of calculating interest payments due from creditors, few easy ways to collect the payment, and a limited ability to enforce negative interest payments from creditors. Given these realities, designing interest-bearing securities at negative yields will require careful planning.

This topic alone is worthy of a longer treatment. In fact, my colleague Ken Garbade and I wrote a piece on this topic, and I won’t repeat the many considerations that enter into the design of securities at negative rates.<sup>6</sup> I will point out that because it is so challenging to develop a practical way to collect periodic interest payments directly from holders, one possible work-around is for the issuer of a fixed-rate bond to set the coupon rate to zero, making the bond a single-payment security, and to sell the bond at a premium to its principal value. Alternatively, an issuer could sell a bond with a negative coupon rate by providing that, in the absence of timely payment of interest, the omitted interest payment will be deducted from the principal due at maturity. In this case the bond would be redeemed for less than par, depending on the number of unpaid coupons and the magnitude of the (negative) coupon rate. These alternatives have different tax implications, as discussed in a recent report by the Danish mortgage bankers.<sup>7</sup>

As one can imagine, these alternatives require a great deal of coordination and legal work to implement. One legal issue is whether, in the case in which bonds are to be redeemed for less than par, the bonds qualify to be used as collateral in various central bank or private arrangements that require collateral; another is whether the decrease in the par value of the bond might trigger a default that would require a writer of credit default swap protection to make payment to the holder of the swap. These and similar operational problems (including the difficulty of modifying security depositories and clearing and settlement systems to manage the calculations and transfers associated with negative rates) can presumably be solved in time. However, they represent expensive transition costs for those people and institutions that must deal with them as rates move from positive to negative.

## **3. Economic frictions**

There are many zero interest rate conventions in society: negative nominal rates, but not negative real rates, reverse the incentives to exploit these conventions. The problem is that the conventions evolved for a positive interest rate environment, and efforts to reverse the direction of these incentives can lead to bad economic outcomes for society. Furthermore, it is costly to change these conventions.

In many economic arrangements, including debt and tax payments, people can prepay debts or tax obligations, or make excessive payments on them, and earn a zero return during the prepayment period. For example, suppose that one holds a credit card under existing U.S. rules: one can withdraw funds from an account that is earning a negative rate, and pay one’s debt to the credit card company in advance of when it is due, earning a zero return during the prepayment period. Similarly, one can make excessive tax payments to the taxing authority, and earn nothing during the period before one receives a refund, thereby avoiding negative deposit rates at banks. Such “zero nominal rate” conventions abound in society, and the lower the negative rate, the more people will search for such ways to avoid the negative rates that might prevail elsewhere.<sup>8</sup> Consequently, our proposition could now include this consideration: Different economic agents will be more or less willing to invest in negative rate investments to the extent that their costs of handling currency are lower or higher than others’, and to the extent they have available to them zero interest rate economic arrangements. In addition, having talented individuals looking for these opportunities is a dead-weight loss to society. We would rather have them use their talents for more socially productive purposes.

In addition to the convention that all prepayments of debt carry a zero interest rate, creditors often have the option of deciding when to settle a debt, for example by choosing when to deposit a check once it is received. In an environment in which negative



nominal rates prevail, one would want to collect debts slowly (at least from creditworthy counterparties).<sup>9</sup> For example, if one were to receive a check from the U.S. government for a tax refund, one could simply put it in a safe place and earn zero interest on it during the time the check remained undeposited. (These practices could trigger further innovations, such as a check with a “deposit-by” date embedded in it.) How strong these incentives are depends on the level of the negative rates. The lower the negative rate and the more persistent it is expected to be, the more attractive these practices would be. Consequently, these zero rate economic arrangements form another constraint that would prevent rates from going too far into negative territory.

Notice that leaving the check undeposited, much like the hoarding of currency, is a negative outcome for society. In this case, the receiver of the check is able to impose the costs of earning negative deposit rates on the check writer. But this outcome turns on its head the reason that the convention of allowing the check receiver the option of deciding when to deposit a check was adopted in the first place. Under positive interest rates, the check receiver has an incentive to deposit the check at his or her earliest convenience. In other words, these conventions are incentive-compatible ways society has devised to enforce the payment of debt, taxes, and other obligations. By reversing those incentives, negative rates encourage the check receiver to deposit a check from a creditworthy source at his or her latest convenience. This may impose unexpected costs on the check writer, triggering unplanned overdrafts and associated charges, and, in this case, just as in the case of currency, encouraging investment in undeposited checks, rather than in some productive investment.

Once again, in these situations we should consider how innovations might alter the possibilities to avoid negative rates over time. For example, faced with potentially large repayments, many private contracts, such of those that allow prepayment or delayed deposit, might be renegotiated, introducing additional legal and operational frictions.

#### **4. Pass-through to market rates, and retail v. wholesale**

Another practical challenge is that most if not all parties involved in negative interest rate policies—central banks and commercial banks alike—may wish to immunize ordinary retail bank depositors against experiencing negative interest rates. This is, in large part, a practical concern. As I pointed out earlier, the costs of avoiding negative interest rates by substituting currency for deposits is probably lower for retail depositors than for larger, business and institutional, depositors. Because retail depositors can avoid negative rates on deposits relatively easily, it makes sense not to impose negative rates on their deposits. In addition, many retail depositors may have a visceral negative reaction to being charged negative rates, and may lack a clear understanding of whether their bank is minimizing the costs of storing their deposits.

Recognizing these difficulties, the central banks that have negative policy rates offer zero rates on many of their deposits from banks, imposing negative rates on the “marginal” deposits. In this way, commercial banks can, in general, charge their retail depositors deposit rates of zero and earn zero at the central bank on at least a large portion of their reserve holdings.

Observers report that retail depositors in Switzerland, Denmark, and Sweden do not face negative deposit rates. At the same time, many large business and institutional depositors do earn negative rates on their bank deposits. This state of affairs opens up new avenues, at least in theory, by which some can avoid negative rates: large business depositors could attempt to impersonate a host of retail depositors. While generally unrealistic, the possibility of such a ploy requires that some effort be expended to prevent that avoidance activity. One such effort might include frequent adjustments of the institutions or deposits subject to negative rates (as we have seen recently in Denmark and Switzerland). The complications of the negative rate policy only become greater once one realizes that it is a policy that is intended to be passed through to most deposit and market interest rates, but not to retail depositors.

#### **5. Effects of negative rates on the health of financial intermediaries**

A robust financial sector is important for many reasons: to direct savings into productive uses; to assist households to smooth consumption; to facilitate trading, payment, clearing, and settlement of financial assets; and to deliver insurance and pensions to people. The health of banks and many other financial institutions depends on earning a spread between what the institutions earn on their assets and what they pay on their liabilities. Negative rates can squeeze bank profits. If banks are earning negative rates on their loans while charging a zero rate to retail depositors, they lose money. If the goal of negative rates is to ease financial conditions and provide stimulus to the economy, then the effects of the policy on the health of financial intermediaries must be carefully assessed. Pension and insurance funds too have potential difficulties in operating successfully in a negative interest rate environment. They often provide liabilities—that is, promises of future pension payments or insurance payments—at nominally fixed rates. If they can only invest in negative yield instruments, their profits could be imperiled. Such possible profit squeezes could also prompt financial institutions to take on inappropriately risky assets to earn an apparently positive return. These concerns are present to some extent at very low rates, but they are magnified at negative rates of interest, a point made by Ben Bernanke in his 2004 speech on the topic.<sup>10</sup>

A special case in the United States concerns the 2a-7 money market mutual funds, which are more prevalent in the United States than in Europe. Money market mutual funds are institutions that offer a floating rate of interest to shareholders that is intended to maintain the value of a share in the fund equal to par, or very close to par, at all times. With negative interest rates, and in the absence of a sponsor that is willing to subsidize shareholders in the fund, such a financial institution would not be able to return a

dollar invested today to a shareholder the next day. In such circumstances, the fund must disband, as it has “broken the buck.” Recent SEC reforms specify that prime institutional funds be offered only shares expressed as floating Net Asset Values in 2016, but retail and Treasury-only money funds will retain a fixed NAV share structure, and therefore will still be subject to this complication in an environment of negative nominal rates.<sup>11</sup>

## 6. Signal of deflation

Another complication centers on the signaling effects I mentioned earlier. When implementing negative rates, central banks recognize that the signaling effects of their action may be unpredictable. The inference drawn by people could be a negative one. For instance, people could infer that the central bank itself has low expectations for inflation and is lowering nominal rates into negative territory as a way to “ratify” the low expected inflation environment. Such an inference would complicate the central bank’s effort to achieve its objective because it could encourage and entrench the public’s expectations for deflation.<sup>12</sup> That could complicate the potential exit from the negative rate regime.

## 7. Public acceptance

As with all public policies, negative nominal rates must be acceptable to the public if they are to be a useful tool for central banks. Certainly, avoiding severely negative rates, especially for retail depositors, would tend to reduce perceived adverse effects on households. There is some anecdotal evidence that people in Switzerland, for example, on balance are not in favor of negative rates.<sup>13</sup> But businesses and households may feel that they have been treated unfairly as they see others take advantage of various avoidance activities to which they don’t have access. Others may suffer the theft or loss of a currency hoard, possibly resulting in feelings of regret after the fact, and place the blame on the negative rates. The hoarding of cash itself is an unproductive investment that drains resources from the financial sector of the economy, and consequently, may result in less efficient payments, difficulties in obtaining loans, and other problems.

## Conclusion

Even though nominal rates can become negative, zero is still an important benchmark: below that level of rates, society faces a distinctive set of complications and costs that can blunt the intended good effects of a negative nominal rate policy.

So given that, once one has waded into the ocean and implemented a negative nominal rate, how low can rates realistically go? Unfortunately, there is no simple answer. As I have noted in this talk, negative nominal rates introduce a number of legal, operational, and economic frictions associated with. These complications limit the pass-through of negative nominal policy rates to households and businesses. In addition, because the negative rates are costly in terms of resources, they limit the potential stimulus to aggregate demand. Negative nominal rates may also adversely affect the profitability of financial institutions and thus make financial conditions less accommodative than they would be otherwise.

Addressing the complications of negative nominal interest rates includes redesigning debt securities; in some cases, redesigning financial institutions; adopting new social conventions for the timeliness of repayment of debt and payment of taxes; and adapting existing financial institutions for the calculation and payment of interest, the transfer and valuation of debt securities, and many other operations. These innovations will require considerable time, resources, and effort. A benefit-cost analysis thus must weigh the potential advantages of negative rates against the costs of pushing back the tide of all of these conventions and institutions that have proven useful under positive nominal interest rates. That calculation likely will differ across countries, across institutional environments, and across the expected levels and duration of negative rates.

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<sup>1</sup> The views expressed in this speech are those of the author and do not necessarily reflect the views of the Federal Reserve Bank of New York or of the Federal Reserve System.

<sup>2</sup> The press releases announcing the interest rate decisions by the SNB, the ECB, and the Riksbank can be found at the links that follow: [http://www.snb.ch/en/mmr/reference/pre\\_20150115/source/pre\\_20150115.en.pdf](http://www.snb.ch/en/mmr/reference/pre_20150115/source/pre_20150115.en.pdf), <http://www.ecb.europa.eu/press/pr/date/2014/html/pr140904.en.html>, <http://www.riksbank.se/en/Press-and-published/Press-Releases/2015/Riksbank-cuts-repo-rate-to-025-per-cent-and-buys-government-bonds-for-SEK-30-billion/>

<sup>3</sup> Willem H. Buiter and Nikolaos Panigirtzoglou, “Overcoming the Zero Bound on Nominal Interest Rates with Negative Interest on Currency: Gesell’s Solution,” *Economic Journal* 113, no. 490 (October 2003): 723–46; Kenneth Rogoff, “Costs and Benefits of Phasing Out Paper Currency,” paper presented at NBER Macroeconomics Annual Conference, April 11, 2014, Harvard University; Silvio Gesell, *Die Natuerliche Wirtschaftsordnung* (Rudolf Zitzman Verlag, 1916), available in English as *The Natural Economic Order* (London: Peter Owen Ltd., 1958); Marvin Goodfriend, “Overcoming the Zero Bound on Interest Rate Policy,” *Journal of Money, Credit, and Banking* 32, no. 4, part 2 (November 2000): 1007–35; Miles Kimball, “How and Why to Eliminate the Zero Lower Bound: A Reader’s Guide,” *Confessions of a Supply-Side Liberal* blog, September 20, 2013.

<sup>4</sup> Charles M. Kahn, James McAndrews, and William Roberds, “Money Is Privacy,” *International Economic Review* 46, no. 2 (May 2005): 377–99.

<sup>5</sup> See Eldar Shafir, Peter Diamond, and Amos Tversky, "Money Illusion," *Quarterly Journal of Economics* 112, no. 2 (1997): 341-74, for evidence on money illusion.

<sup>6</sup> Kenneth Garbade and Jamie McAndrews, "Interest-Bearing Securities When Interest Rates are Below Zero," *Liberty Street Economics* blog, May 4, 2015.

<sup>7</sup> "NEGATIVE INTEREST RATES ON MORTGAGES" Working Group on negative interest rates on mortgages, Business and Growth Ministry, Denmark <https://www.evm.dk/~media/oem/pdf/2015/15-04-28-negative-renter.ashx>

<sup>8</sup> Many of these were reviewed in Kenneth Garbade and Jamie McAndrews, "If Interest Rates Go Negative . . . Or, Be Careful What You Wish For," *Liberty Street Economics* blog, August 29, 2012, and in John Cochrane, "Cancel Currency?" *The Grumpy Economist* blog, December 30, 2014. A particularly interesting case is given in one of the models discussed in the Danish working group on mortgages referenced above. In one of the models for dealing with negative interest rates, a borrower who would be due, for example, \$20 in interest payments today, has his principal balance reduced by \$20, reducing the need for a later repayment of \$20. But that presumes a 0 interest rate between now and the repayment date; an alternative would be to calculate the future value of \$20 today compounded at the negative rate of interest.

<sup>9</sup> Because the strength of this incentive depends on creditworthiness, it is unlikely that the business of loan-sharking would change very much in a negative interest rate world. However, among trusted loan-sharks and their customers, one could imagine the comic possibilities of seeing loan-sharks' goons roughing up borrowers when the borrowers attempt to prepay their loans.

<sup>10</sup> Ben S. Bernanke and Vincent R. Reinhart, "Conducting Monetary Policy at Very Low Short-Term Interest Rates," paper presented at the International Center for Monetary and Banking Studies Lecture, Geneva, Switzerland. January 14, 2004

<sup>11</sup> See the Securities and Exchange Commission, "SEC Adopts Money Market Fund Reform Rules: Rules Provide Structural and Operational Reform to Address Run Risks in Money Market Funds" July 23, 2014 <http://www.sec.gov/News/PressRelease/Detail/PressRelease/1370542347679> for a discussion of reforms that limited fixed NAV designs for money market mutual funds to retail and Treasury-only funds.

<sup>12</sup> A theoretical model that captures this idea is described in Jess Benhabib, Stephanie Schmitt-Grohe, and Martin Uribe, "The Perils of Taylor Rules," *Journal of Economic Theory* 96, (January/February 2001): 40-69.

<sup>13</sup> There have been a couple of informal polls by Swiss newspapers. For instance, in December 2014, after the SNB first announced negative rates (25 bps), the *Tagesanzeiger* (one of the biggest Swiss newspapers) asked readers whether the decision was a good one. Of the respondents, 47.7 percent said, "Yes, it's necessary to maintain the exchange rate" [the floor was still in place then], while 52.3 percent said, "No, this policy punishes savers." <http://www.tagesanzeiger.ch/wirtschaft/geld/Geldpolitik-Nationalbank-fuehrt-Negativzinsen-ein/story/26525077>)

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