The Case for Implementing Effective Negative Interest Rate Policy[,]

by Andrew Lilley and Kenneth Rogoff,

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Abstract

This paper explores the case for gradually instituting changes necessary to implement unconstrained negative interest rate policy as a long-term solution to the effective lower bound on policy interest rates. If small depositors can be excluded, then passthrough of negative rates to large and wholesale bank depositors should be straightforward with administrative and pecuniary obstacles to large-scale hoarding. We argue that pure quantitative easing will be an insufficient tool to raise inflation expectations in the next recession using evidence that market participants have updated their beliefs of its potency. We present a systematic categorization of alternative policies and their constraints.

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I. Introduction

This paper explores the case for gradually instituting the changes necessary to implement unconstrained negative interest rate policy as a long-term solution to the zero-lower bound on interest rates (or more precisely the effective lower bound.) To be clear, we distinguish between the very limited negative interest rate policy that has already been tried in Europe and Japan, and the unconstrained negative interest rate policy we consider here. Effective unconstrained negative interest rate policy requires, at a minimum, that policymakers take administrative measures to forestall wholesale hoarding of physical currency by financial firms, insurance companies and pension funds.[1] We shall argue that if unconstrained negative interest rate policy can be implemented, it would be by far the most elegant and stable long-term solution to the severe limits on monetary tools that have emerged since the financial crisis. Admittedly, the question of how to resuscitate monetary policy effectiveness is of more immediate relevance in Europe and Japan, where interest rates remain at the effective lower bound (in many cases mildly negative) more than a decade after the global financial crisis, and more than two decades after Japan's financial crisis. But even the United States is likely to face severe constraints in the event of another financial crisis, possibly even in a deep recession.

No one should expect the United States to be an early adopter of unconstrained negative interest rate policy, especially given the central role of the dollar in the global financial system. But we would strongly disagree with those who say it is unthinkable and it will lead to widespread market dysfunction. As of May 2019, over ten trillion dollars' worth of bonds traded at negative interest rates internationally, without market breakdown. There are ample historical

[1] A variety of approaches for implementing negative rates ranging from administrative measures to precluding large-scale hoarding to a dual electronic/physical currency system are discussed in Rogoff (2016, 2017). See Bordo and Levin (2019) for an approach that involves a combination of administrative measures and a digital retail currency. Aggarwal and Kimball (2019) give a nuanced discussion of transition issues, see also Aggarwal and Kimball (2015).

precedents for cases where monetary policy innovation was resisted on the grounds that markets would collapse, including the move from fixed to floating exchange rates in the 1970s. Perhaps the closest analogy is during the 1951 episode where the Federal Reserve abandoned its bond price pegging program. As Milton Friedman commented:

"Before the Federal Reserve gave up the pegging of the bond price, we heard all over the lot that a free market in bonds was going to be chaotic, that the interest rate might go heaven-high or down, there might be capital losses, savings institutions might well be wiped out by their capital losses, and that we needed some basic peg price on which the market could form its anticipation. We abandoned the pegged price. None of these things happened…" (Friedman and Roosa, 1967, p. 173)

To be sure, implementing effective unconstrained negative interest rate policy will require a host of legal, regulatory and tax changes, and not all of these can be instituted by the central bank alone.[2] The obstacles in different countries will vary. It is notable, however, that in countries that have implemented mild negative rate policy, none has tackled the main challenge, which is how to prevent paper currency hoarding and, as a corollary, how to protect bank profitability if rates go deeply negative. Of course, if one believes that it is impossible to have negative deposit rates, then the capacity for instituting negative rate policy is very limited. But in our view, once wholesale hoarding is dealt with (the vast majority of retail depositors can straightforwardly be exempted from negative rates (Rogoff, 2016, 2017)), then the pass-through of negative rates to wholesale bank customers should be straightforward, just as the passthrough of negative policy rates has been to mortgages and other wholesale private debt obligations in many countries in Europe. In general, all of the various approaches to instituting unconstrained negative rate policy should be increasingly easy to navigate as paper currency becomes further

[2] Rogoff (2016) discusses a number of the issues, Agarwal and Kimball (2019) provides an extremely useful handbook on transitioning to unconstrained negative rate policy.

marginalized in legal, tax-compliant transactions (outside low-value transactions), and as countries deal with financial inclusion.

So how might the monetary authorities discourage wholesale hoarding of currency in the event of deeply negative interest rates? There are a broad number of approaches that do not require going cashless. These include raising the cost of hoarding by phasing out large-denomination notes,[3] imposing fees on wholesale re-deposits of currency at the central bank, and instituting regulatory limitations on legal hoarding facilities (Rogoff, 2016, 207). Bordo and Levin (2019) offer a more fully articulated administrative approach involving instituting a retail central bank digital currency.

It should be noted that there is a way to eliminate the hoarding problem without any change to the issuance or regulation of paper currency. It involves taking steps so that electronic currency (currently bank reserves at the central bank) becomes the unit of account, and creating a crawling peg between electronic currency and paper currency (analogous the proposal of Eisler, 1933). Admittedly, there are complications to the Eisler plan having to do with the fact that paper currency and electronic currency are not perfect substitutes.

Until now, central banks up against the effective zero lower bound have been relying mainly on various forms of quasi-fiscal policy, but the weight of evidence suggests these are far less effective than normal interest rate policy. Often lost in the popular discussion, or at best hidden behind dubious political economy arguments, is the fact that central banks are wholly-owned subsidiaries of the central government. For example, when central banks purchase long-term government bonds by issuing bank reserves that match the short-term treasury bill rate, this

[3] Rogoff (1998) argues that phasing large denomination notes would be helpful in combatting tax evasion and crime, even independent of interest rate setting issues.

amounts to no more than shortening the maturity structure of the consolidated government balance sheet. Treasuries do this routinely, and are perfectly capable of handling it on their own and on scale. In general, the fiscal authorities have ample tools to accomplish (or undo) any quasi-fiscal actions that central banks might take. They have access to greater resources and certainly have greater political legitimacy. The quasi-fiscal powers of the central bank are essential only in crisis situations where the ability to move quickly trumps other considerations.

Aside from quasi-fiscal policies, alternatives such as forward guidance have proved to be of very limited effectiveness as well. The main problem is that zero bound episodes last for years if not decades, making the credibility and commitment problems to promising elevated future inflation (after escape from the zero bound) exceedingly challenging. Raising inflation targets is a serious alternative to negative rate policy, but it, too, comes with severe limitations. A modest rise in the inflation target (including proposals on keeping 2% whilst adopting an inflation averaging target) would not create the kind of policy space needed for dealing with deep recessions, much less systemic financial crises. A more significant rise in inflation targets, on top of greatly distorting relative prices even in normal times, would eventually lead to shorter nominal contract lengths and an increase in indexing. Both factors would limit the effectiveness of monetary policy, possibly even to the point of making an increase in the target inflation rate counterproductive. Another important drawback is that higher inflation targets would undermine central bank credibility after decades of committing to inflation targets of 2% or less. Last but by no means least, it is not clear how to make a higher target credible without having the tools (such as negative interest rate policy) to achieve it. The experience of Japan in raising its inflation target to 2% in 2013, accompanied by a large fiscal stimulus, and still failing to raise medium-term inflation expectations, is emblematic.

In the first section of the paper, we discuss other options for dealing with monetary paralysis at the zero bound. The second part of the paper highlights the credibility struggles that major central banks have had in keeping inflation expectations at target over the medium term, arguably greatly exacerbated by investor skepticism that central banks have the tools to create inflation, even when the situation warrants it. This seems to be even more true today than during early rounds of quantitative easing when, as we show, markets viewed there as being a small but measurable possibility that QE could lead to very high inflation for a decade. The third section of the paper discusses a range of issues related to implementing effective negative interest policy, including both economic and political economy problems. We conclude by arguing that the obstacles to unconstrained negative rate policy all seem fairly minor compared to some of the radical alternatives that have been proposed (for example, the inherent difficulties implementing precisely-calibrated, well- timed and highly-credible countercyclical fiscal policy on steroids). In a technical appendix, we show that even in the United States today, markets have at times attached a significant probability to having interest rates become at least mildly negative.

II: ALTERNATIVES TO NEGATIVE INTEREST RATE POLICY

One has to acknowledge that invoking significant negative nominal interest rates (say at least -2% to -3%) in a deep recession or a financial crisis would be, at this stage, an experimental policy. Even after making any necessary legal, tax and regulatory modifications -- above all having a mechanism for discouraging wholesale cash hoarding by financial institutions, pension funds and insurance companies – there is always a possibility for unintended consequences. To put this risk in perspective, we first discuss in this section alternatives that have been proposed. We divide these into four broad classes (1) "Pure quantitative easing" policies that (we argue) do little more than change the maturity structure of government debt in a way the Treasury can do at

least as effectively (2) "Fiscal quantitative easing" policies where the central bank buys private assets: the same equivalent policy can be achieved by having the Treasury trade government debt for private debt at face value, then having the central bank buy up the government debt via quantitative easing. (3) Having the central bank engage in pure fiscal policy via (market interest bearing) helicopter money and (4) policies that genuinely relate to monetary policy including forward guidance and changing the inflation target. [4]

1. Pure Quantitative Easing and Maturity Management of the Consolidated Government Balance Sheet

We begin with pure quantitative easing (pure QE), where the central bank issues bank reserves to purchase medium and long-term debt. The degree of confusion surrounding these pure QE policies is remarkable, in part because many overlook the equivalence between money and debt at the zero bound, and even more so because central banks have not wanted to acknowledge the inadequacy of their instruments. Point number one is that central banks do not have their own independent balance sheet. Any profits or losses the central bank earns pass through directly to the central government. (There is an important nuance in the case of the European Central Bank's balance sheet, that we shall come to shortly.)

True, one way a central bank's independence can be compromised is if the market value of its assets has a negative net value. As is well known, this is somewhat meaningless since the central bank's monopoly over currency creation means it can never go bankrupt if its liabilities

[4] The discussion here is necessarily brief, for a more thorough discussion, see Rogoff (2016). For excellent recent discussions of how alternative monetary instruments have worked to date, see Bordo and Levin (2019), or Eberly, Stock and Wright (2019).

are in its own currency. The central bank can be reprimanded, it can be absorbed back into the Treasury it grew out of. But it cannot be disowned.

We now turn to the question of whether quantitative easing involves creating a new class of government liabilities that might fundamentally alter debt management. The short answer is a resounding no, as established by Greenwood et. al (2015a,b,c). Consider first the current situation in the United States (as of May 2019), where both required and excess bank reserves have a virtually identical yield to the one-week Treasury bill rate. Consider a quantitative easing exercise where the Treasury issues 100 billion dollars in 30-year debt, which the Fed soaks up by issuing a 100 billion dollars in bank reserves to buy up the debt. The net effect is that privately-held floating rate debt has risen by 100 billion dollars and privately-held long-term debt has fallen by the same amount. The same could be achieved by having the Treasury just issue 100-billion-dollar debt at a one-week maturity (instead of long-term) and having the Fed do nothing.

Nor does the Fed have greater capacity to perform this maturity transformation. In any given year, the US Treasury typically has to roll over debt roughly equal to the Fed's four trillion-dollar post-crisis balance sheet, and should it desire to move faster, it buys up long-term debt before it matures, issuing very short-term debt to do so. The central bank is very much a junior partner when it comes to debt maturity management. Indeed, over-reliance on quasi-fiscal policy deeply compromises central bank independence, since the fiscal authorities can undo all its actions if they do not accord with the government's objectives. Whether inadvertently or not, the United States Treasury's post-financial-crisis actions to extend the maturity structure of debt worked at cross-purposes to the central banks quantitative easing policies to shorten maturity (Greenwood, Hanson, Rudolph, and Summers, 2015a).

Some may disagree and argue that changing the maturity structure of government debt on its own is enough, since the implementation of interest rate targeting has always involved the Fed purchasing securities, i.e. merely changing the maturity structure of government debt. This critique overlooks the fundamental difference between reserves and government debt under conventional monetary policy. Away from the zero-lower bound, swapping government securities for excess reserves (or the promise to) will serve to change the prevailing interest rate since banks would rather lend the excess reserves at a positive rate than hold them. It is only at the zero lower bound that swapping government debt for reserve balances is merely a maturity transformation.

A final question is whether maturity management is a substitute for monetary policy. Although early evidence suggested some effect from pure quantitative easing in the United States (again, this means central bank buying of government bonds), most recent academic authors have argued that the effects were extremely limited and in no way comparable to conventional interest rate policy (See Greenlaw et al, 2018 and Chung et al, 2019.) Eberly, Stock and Wright (2019) are somewhat more positive and suggest that QE might have been more effective if the Fed had gone bigger and earlier. However, we argue here one must also take into account that the first time around, markets expected much more of a long-run inflation effect than actually transpired. Specifically, in section III, we show that while inflation expectations remained robust during QE1 and QE2, this was mostly attributable to a belief that inflation may accelerate to be well above target in the coming decade - a belief which rapidly disappeared after the Fed exited the zero-lower bound without seeing a boom in money demand. This expectation of high inflation, or perhaps the misunderstanding of whether it is caused by pure quantitative easing, is unlikely to be repeated in any future iterations.

It must be noted that the European Central Bank is something of an exception, as there is no fiscal counterpart to its actions. In essence, when the European Central Bank engages in QE, it is effectively issuing a short-term synthetic Eurobond to buy up the national debts of individual countries. There is no central government yet willing and able to perform the same function, and ECB quantitative easing certainly appears to have been very effective as a crisis management tool. That said, the difficulties that Europe has had in reaching its inflation target underscores that even in Europe, QE is no substitute for normal interest rate policy.

2. Fiscal Quantitative Easing

We next turn to fiscal quantitative easing, in which the central bank purchases private sector assets. There is no real debate about the fact that fiscal QE played a critical role during the financial crisis in preventing markets from freezing up and collapsing with potentially dire consequences. Nor should there be any debate that emergency credit policy is a perfectly valid function of the central bank; in a crisis, swift effective action can sharply reduce costs to the real economy and (likely) the government balance sheet. Although this may involve having the central bank absorb a lot of junk debt on to its balance sheet, in most countries the usual presumption is that within a relatively short period, the central government will create a special purpose vehicle to transfer the risk.

Outside of emergency situations, fiscal QE can perfectly well be executed by the central government through a variety of mechanisms, most commonly by having the central government issue debt guarantees. Fiscal QE certainly has an effect, but outside crisis situations, it once again is much less powerful than normal interest rate policy, as the Bank of Japan's experience has clearly illustrated. On top of that, buying private debt in normal times involves picking

winners and losers and is effectively a type of industrial or development policy. One can debate the extent to which the government should intervene directly into private credit markets. In principle, the real effects can be very large if the intervention is massive enough, but the distortions can be large, too. In general, most advanced economies regard unelected central banker as ill-suited to making these fundamentally political decisions. Regardless, the conclusion has to be the fiscal QE is ill-suited as a substitute for conventional monetary policy in normal times.

3. Helicopter Money, Debt Destruction and Hyperactive Fiscal Policy

This takes us to helicopter money, where the central bank takes the lead in initiating fiscal transfers, which Buiter (2003), Turner (2015) and Bernanke (2016) have advocated, with the idea being enormously popular among the commentariat. In its crudest form, helicopter money involves having the central bank print money to issue pro-rata transfers to the public. This is, of course, equivalent to having the central government using debt finance to issue the same transfers to the public, then having the Federal Reserve engage in open market operations to buy up the debt. It is true that there is a strong theoretical presumption that temporary fiscal policy stimulus is more effective at the zero bound (mainly because the fiscal multiplier is not muted by a rise in interest rates). If executed forcefully enough, fiscal policy can lift the economy out of the liquidity trap (provided its temporary nature is credible, otherwise it is much less effective, as for example, Christiano, Eichenbaum and Rebelo, 2011, show.)

The issue is not whether well-calibrated debt-financed transfer policies can be an effective means of stimulus; this is always true whether monetary policy is allowed to fully operate or not.

We need not get into the details of just how large the multiplier is.[5] (There is a growing body of evidence suggesting that fiscal multipliers are lower at high levels of debt, partly through a Ricardian channel, partly through an interest rate channel; for a recent discussion see Huidrom, Kose, Lim and Ohsorge, 2019.) The important question is what, if any, should be the role of the central bank in fiscal transfers? In our view, the argument for any variant of helicopter money in which the central bank plays an active role is weak. The case for having an independent central bank stems first and foremost from the need to keep down long-term inflation expectations by delegating money creation to an independent authority with clear but narrowly-defined remit to stabilize output and inflation (Rogoff, 1985).[6] However, no central bank has been given the power to decide on either the level or the allocation of politically contentious direct transfers to the general public.

Even Bernanke's suggestion that the central bank might take the lead in determining the aggregate size of a transfer by funding a dedicated account that could be used at the government's discretion, would be far beyond anything that the "unelected power" of the Fed was ever intended to do (in Tucker's 2018 terminology.) One might perhaps rely on the Congress and public being fooled by the claim that when the Federal Reserve takes the lead, then what Bernanke terms a "money financed fiscal program" is perhaps a free lunch, relying on the public's ignorance. At the zero bound, a "money financed fiscal program" is no better or worse than "very short-term Treasury debt financed fiscal policy." That is because, at the zero bound, the Treasury can issue zero interest debt on its own. And as Bernanke recognizes, if the central

[5] In her thorough survey of the academic literature, Ramey (2019) gives a more guarded estimate of fiscal multipliers that some advocates of fiscal stimulus would suggest, even at the zero bound,

[6] Rogoff (1985) introduced the idea of having independent central bank with a high weight on inflation stabilization (including through inflation-targeting), and showed how this institutional device can substantially resolve the credibility problems first modeled by Kydland and Prescott, 1977 and Barro and Gordon, 1983.

bank does not change its inflation target, the public will expect the "money" to be soaked up as soon as interest rates start rising.

Equivalently, the central bank will have to start paying interest on reserves (as it is now doing), which is in essence equivalent to the Treasury issuing floating rate debt. Of course, the Fed can instead promise this injection to be a permanent increase in the money supply, and reduce its own equity in the process. But it is still owned by the government - either it reduces its remittances to the Treasury in the future, it eventually receives an equity injection, or it operates with perpetually reduced equity. Both of the former two options are still increases in taxes, making the operation merely an opaque form of debt. One can go in circles on this, but it is unlikely that money-financed deficits are the panacea many would wish them to be. It is possible that in some unique circumstances, the central bank might choose to mortgage its credibility and independence, but surely it cannot be considered the best long-run solution.

There is, of course, an important literature on having an independent fiscal authority (see for example, Halac and Yared, 2018). A number of countries including the UK and Sweden have instituted fiscal councils, albeit with a limited remit. Creating a way to have stronger and more powerful fiscal institutions remains an important policy topic, but for now this remains a distant vision. Helicopter money is at best a distraction from finding a serious solution to the zero bound, at worst a fast track to ending central bank independence.

Of course, one can argue that there is no reason for the central bank to do anything at the zero bound since fiscal policy becomes more potent, in theory at least. One only has to observe that in the United States, and in many other countries, neither the right nor the left have a clear long-term control of power, and the different parties almost invariably have extremely different

interpretations what "active" fiscal policy implies. In the United States, the Democrats might view active fiscal policy as running bigger deficits by increasing government spending towards its larger optimal size. For Republicans, on the other hand, active fiscal policy might entail running deficits by cutting taxes and constraining the long-run footprint of government to be smaller. Such conflict is hardly a recipe for creating a credible long-term path for government taxes and expenditures, underscoring why even if fiscal policy is to be used more in recessions, it is important to restore the efficacy of monetary policy.

4. Forward guidance and Raising Inflation Targets

So far, we have considered only quasi-fiscal policies where the central bank is very much the junior partner in its relationships with the Treasury, outside of crisis situations where the ability to act expeditiously is everything. We now turn to more policies that might more genuinely be thought of as monetary policy. One such policy is "forward guidance," a la Eggertsson and Woodford (2003), where the central bank recognizes that it is unable to lower the current interest rate (below zero), but by promising that when interest rate policy is restored, it will allow inflation to overshoot in the future. As Eggertsson and Woodford show, it is possible to achieve an equivalent optimal path for real interest rates, and thus the same effects on the real economy as if negative interest rate policy were possible. This is a completely reasonable idea from a theoretical perspective; Canzoneri, Henderson and Rogoff (1983) make a very closely related point, showing that if the central bank is unable to use the current interest rate to react, a lagged interest rate rule can have an exactly equivalent effect on the real interest rate through expected inflation.

However, in both cases, but particularly in the zero-bound example, there is a severe credibility problem. The public needs to trust that the central bank will honor its promise to allow inflation to drift higher in the future. But the typical zero bound episode can last years (decades as in Japan and soon Europe), making it extremely difficult to trust commitments that are not time consistent, and will likely have to be honored by future policymakers backed by future politicians.[7] Forward guidance is an excellent idea, but difficult to make credible, especially in deep recessions where the zero bound may be in place for a very long time, precisely the cases where having an effective monetary policy is most important.

This leaves only amending the path of the inflation target as a serious alternative. There are a number of alternative approaches, ranging from allowing a temporary overshoot after a period a low inflation (though this suffers some of the same credibility problems as forward guidance) to simply raising the inflation target, with the most common suggestion, originally analyzed by Fuhrer and Madigan (1994, 1997), to be to raise the target from 2% to 4%. Many others since, including Blanchard, Krugman, and Ball have also suggested 4%. There are many possible objections, including (1) potential damage to the credibility of central banks who have long promised to target 2%, (2) the fact that higher inflation would lead to greater price dispersion in normal times if contracting frequency does not adjust, (3) that if contracting frequency did eventually adjust (as theory would predict), monetary policy would be blunted. This could indeed imply that it would take larger policy rate changes to achieve the same stimulus, perhaps using up much of the extra 2% slack that higher inflation targets were supposed to buy and (4) that absent a powerful instrument such a negative rate policy, markets might not take the new higher target as credible given the difficulties central banks have had with hitting a 2% target.

[7] Chung (2019) emphasize this point, see also Rogoff (2016).

One only has to look at the experience of the Bank of Japan, which set an inflation target of 2% in January 2013 – which by any interpretation constituted a hike in market perceptions of its inflation target, and yet long-term inflation expectation barely moved from its level of 0.5%.

Perhaps the biggest problem though is that even if raising the inflation target from 2% to 4% did help, it might not help nearly enough in the event of a sufficiently deep recession where the optimal interest rate change might still take interest rates well into negative territory if feasible.

Despite such reservations, Federal Reserve officials have still tried to reassure the public that the Fed's tools are sufficient (for example Yellen, 2016). The fact that the top economics journals are replete with out-of-the-box alternatives to normal monetary policy at the zero bound is a testimony to general skepticism among economists. As we shall see in the next section, there is a serious skepticism in markets as well, with options pricing suggesting that markets seriously doubt the ability of even the US Fed to keep normal inflation rates at 2%. And of course, in the eurozone and Japan, there is really no one, even central bank officials, arguing that the existing toolkit is sufficient.

III. INFLATION EXPECTATIONS

The United States is not yet facing the paralysis of Japan, where the central bank has not been successful in pushing long-term inflation expectations up to 1%, much less 2%, or Europe where inflation expectations have anchored below 2% since 2013. Nevertheless, there appears to have been a steady decline in long-term inflation expectations (at least as measured by the TIPS market).[8] The 10-year breakeven inflation rate in the US has declined from around 2.4% before

[8] Throughout this section we will treat inflation-linked bonds as risk-neutrally priced, such that the breakeven is an unbiased measure of inflation expectations. If the price level were expected to jump in very low consumption states, as documented by Barro and Ursua (2008), then inflation break-evens would be an upwardly biased measure of

the crisis to 1.8% today. This decline cannot be dismissed as merely a reflection of the current state of the economy – break-evens which begin in 10 years' time, looking beyond the contemporaneous cycle, have declined by a larger amount. Indeed, even the 30-year break-even inflation rate from TIPS has fallen from over 2.5% in 2011 to under 2% as of April 2019.

Table 1

Country	2005-2007	2016-2019	2005-2007	2016-2019
	Market Inflation Expectation (Average 10yr)		Market Inflation Expectation (Average 10yr, ***starting in 10yrs***)	
United States	2.51%	1.81%	2.87%	1.92%
Europe	2.35%	1.43%	2.51%	2.02%
Japan	0.54%	0.39%	0.58%	0.58%

Notes: Inflation expectations are calculated using the difference in yields of real and nominal Treasury bonds for the United States, with adjustments to estimate their yields for a constant maturity and without coupons. For Europe and Japan, inflation expectations are derived from zero coupon inflation swaps, due the infrequent issuance of inflation-indexed bonds. Bond data is from Gürkaynak et al (2007; 2010). Zero coupon swaps are from Bloomberg.

1. Are long-term inflation expectations of under 2% evidence of strong credibility or lack of confidence in alternative monetary instruments?

Inflation-targeting evangelists might herald this decline in medium-term inflation expectations as a triumph of central bank policy and communications, that proves that the markets have great confidence in existing "alternative monetary instruments". However, this interpretation seems overly sanguine. If a central bank's 2% inflation target is to be viewed as the target in normal times, with an escape clause for fiscal emergencies, then the breakeven

inflation expectations. Kitsul and Wright (2013) estimate that investors have high marginal utilities for both deflationary and high inflationary outcomes by comparing inflation option prices with model forecasts of inflation.

between real and nominal bonds should be distinctly higher than 2%, as it was in the early 2000s.[9]

After all, on a timespan of decades, the odds of a substantial fiscal shock at some point, sufficient to create strong pressures for inflation, are presumably non-trivial. Triggers could include an unprecedented catastrophic climate event, a cyberwar that spins out of control, a pandemic, a meltdown in the Chinese economy that leads to a deep global recession, or a new-age financial crisis, to name a few. These triggers are mainly abrupt events, but fiscal pressures to create higher inflation could also evolve very slowly over a long period of a decade or more. Although the United States may have ample fiscal space at present, excessive reliance on short-term debt finance to finance social programs, a greener society, or for that matter, further tax cuts, must ultimately have their limits. Another slow-moving fiscal shock would be a gradual reversal of the trend decline in global real interest rates that has allowed governments to manage high debt levels more easily than in the past. (Albeit it is still the case that countries with extremely high public debt levels such as Italy and Japan have also had very low growth.) While the risks may be small, it is naïve to assert that no matter what the shock, the United States (or Europe or Japan) will simply be able to borrow as much as needed at ultra-low interest rates without a hiccup. Even if outright default (as with US abrogation of the gold clause in the 1930s) is unlikely, the duress could still be sufficient to create pressures for a sustained rise in inflation, say to 4% or more for a decade.

[9] A secondary issue is that break-evens measure market expectations on inflation as measured by the CPI, which is not the Fed's price target. The Fed's official target is the index of Personal Consumption Expenditures, or PCE. The PCE includes a more comprehensive basket of goods, and averages annual inflation which is 30bps lower than the CPI (Bullard, 2013).

Some have argued that even if fiscal pressures erupt, there will be no need for very high inflation because governments can simply resort to financial repression (as discussed in Reinhart and Rogoff, 2009), using regulation and political pressure to force private agents to hold government debt at below-market interest rates. Financial repression can be useful in bringing down debt/GDP ratios gradually over time, but the process works much more quickly in an environment of moderate inflation. (Part of the reason Japan's debt/GDP ratio has continued to grow despite a moderate degree of financial repression is that inflation is so low, making it harder for growth in nominal GDP to outstrip the growth in debt.)

2. Measuring inflation expectations, removing the weight coming from the chance of sustained high inflation

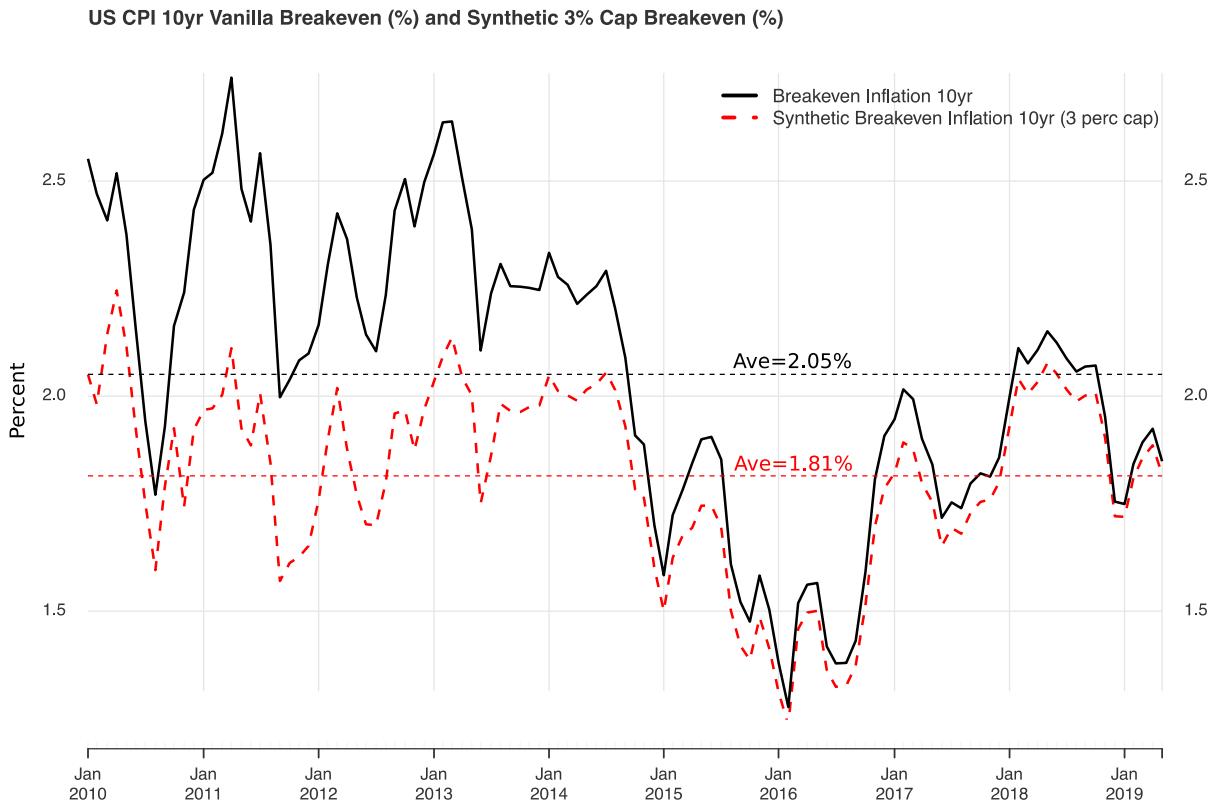
It is possible that markets have bought into the view that advanced economies have such massive fiscal space going far into the future, that advanced country governments will be able to navigate any adverse scenario just by borrowing more without any consequence. To explore the tail risk of high sustained inflation in more detail, we use a no-arbitrage argument to construct the price of a theoretical inflation-linked bond which features a cap, so that it provides insurance against moderate inflation, but does not insure against a regime change which carries very high inflation. Consider a 10-year real bond that would index to CPI with a ceiling – if inflation averaged more than 3% for 10 years, it would only pay up to a ceiling of a cumulative 3% annual increase.[10] This bond would allow the Treasury to inflate debt away in an inflation-based default, but it would still provide for a complete inflation hedge if the government allowed the Fed to maintain its ordinary inflation-targeting mandate. In essence, part of the difference between a nominal bond and an inflation-linked bond is in default risk. A nominal bond has some default

[10] It is worth noting that Treasury Indexed Bonds already include a floor of the opposite nature – if inflation is negative over the life of the bond, the principal indexation is capped at a cumulated 0%.

risk in real terms, while a real bond does not. By constructing this synthetic bond, we are making their inflation default risk equivalent. (Note that if inflation temporarily strayed outside the band to a high level, say 4% for a couple of years, it would not affect the cap – only a sustained deviation consistently over 3% would matter.) Such a bond would provide a better estimate of inflation expectations absent fiscal dominance.

If the Treasury were to offer such a bond, its payoff would be identical to an investor buying the ordinary inflation-linked bond, but selling an inflation cap at a strike of 3% with the same principal as the inflation-linked bond. Under no-arbitrage, we can calculate the price paid for the theoretical bond in the time series by using the real bond price and the upfront payment received for selling this protection. We show the breakeven yield on this bond in figure 1. While the breakeven on the vanilla real bond has averaged 2.05% this decade, the breakeven on this synthetic bond has averaged only 1.81%. Notably, the difference between the ordinary and synthetic capped bond has shrunk in recent years, reflecting that markets appear to attach a much smaller probability to sustained inflation above 3%. In the first half of this decade, the breakeven on this synthetic capped bond was 38bps lower than the actual breakeven. Since the Fed's first hike in December 2015, has averaged only 7bps lower. This vanishingly small premium must reflect evolving beliefs amongst market participants about the propensity for the Fed's enlarged balance sheet to create inflation.

Figure 1



Notes: Breakeven Inflation 10yr is calculated using the difference in yields of real and nominal Treasury bonds for the United States, with adjustments to estimate their yields for a constant maturity and without coupons, using bond yield data from Gürkaynak et al (2007; 2010). The synthetic 10-year breakeven is calculated with inflation option pricing from Bloomberg. To remove the impact of outliers, we use the median value within each month to construct each monthly observation. Further detail on the pricing of the synthetic inflation-linked bond is provided in the appendix.

3. Are breakevens the best measure of inflation expectations?

A valid concern with measuring inflation expectations using breakevens is that the yield difference between nominal and real bonds may be changing due to other factors which we would then comingle with changes in inflation expectations. Since we use the constructed yield curves of Gürkaynak et al (2007; 2010), we do not need to be concerned with differences in coupons or maturities. The two most significant remaining factors are changes in inflation risk

premia and liquidity risk premia. In particular, if inflation-linked bonds are less liquid than nominal bonds, the breakeven will be compressed due to the market premium required to hold inflation-linked bonds. While our synthetic bond construction above mitigates the impact of inflation risk premia by capping inflation payoffs below 0% and above 3% – precisely in the regions where investors pay a premium for inflation protection (Kitsul and Wright, 2013) – it does not correct for liquidity premia.

The liquidity difference in our measure is abated by the fact that the yields we use exclude both on-the-run and first off-the-run nominal Treasury securities (which command a liquidity premium relative to most other bonds) but include the on-the-run Treasury indexed bonds, which are the most liquid of the curve (Andreasen et al, 2018). Daily trading volumes in on-the-run TIPS now average ~2bn per security, whereas off-the-run nominal Treasury bonds average <1bn (Brain et al, 2018). As such, it is unlikely that our measure of current inflation expectations is materially underestimated by the illiquidity of TIPS. We note that we may be *under*estimating the decline in inflation expectations, given the increased liquidity of inflation-indexed bonds, relative to nominal bonds. D'Amico et al (2018) estimate breakevens underestimated inflation expectations by up to 100bps in the early 2000s due to liquidity differences, though this premium had disappeared by 2012.

Zero coupon CPI swaps for the United States highlight a similar decline in market prices, though with a higher level (from an average 2.8% in 2005-2007 to an average 2.1% for 2016-2019). Inflation swaps are a much smaller market than TIPS and are likely consistently upwardly biased due to the prevalence of agents who are natural buyers of inflation protection derivatives (pension funds), and a paucity of natural sellers.

Survey measures provide an alternative benchmark to market pricing. Broadly, survey measures all show a material decline in inflation expectations across both households and professional forecasters, though not necessarily to below-target levels (Table 2). Notwithstanding this, these surveys are consistently positively biased in levels.[11]

Table 2

Country	2005-2007	2016-2019	2005-2007	2016-2019
	Surveys of Professional Forecasters (Average Long-Term)		Household forecast (Average Long-term)	
United States	2.46%	2.22%	3.0%	2.5%
Europe	1.91%	1.83%	N.A.	N.A.
Japan	N.A.	N.A.	2.9%	2.0%

Notes: For the United States, the long-term inflation forecast comes from the Survey of Professional Forecasters (Philadelphia Federal Reserve) for which we report the 10-year inflation forecast; household data is from the Michigan Survey of Consumer Finances, for which we report the average 5-year inflation forecast. For Europe, we use the Survey of Professional Forecasters (European Central Bank), for which we report the longer-term (5 year) forecast. Japanese household data is from the Opinion Survey on the General Public's Views and Behavior (Bank of Japan), available from 2006, for which we use the median household's 5-year inflation expectation.

IV. UNCONSTRAINED NEGATIVE RATE POLICY

We have argued previously (Rogoff, 2014, 2016, 2017) that the elegant and effective tool to restore monetary policy effectiveness at the zero bound would be unconstrained negative interest rate policy, assuming all necessary legal, institutional and regulatory changes were first

[11] For the United States, the long-term surveys of professional and household inflation expectations were on average 0.25% and 0.75% higher respectively than realized outcomes since 1997. For Europe, the 5 year ahead survey of professional forecasters' inflation expectations was on average 0.125% higher than realized since the survey began in 1997. For Japan, the median survey of 5-year inflation expectations from was on average 2.5% higher than the realized level since the survey began in 2006. All forecast errors are rounded to the nearest eighth of a percentage point.

instituted. Above all, this requires taking steps to preclude wholesale arbitrage into paper currency by insurance companies, pension funds and financial firms. Preventing such arbitrage by no means requires changing the currency system, as we shall see. However, the more paper currency becomes marginalized in tax-compliant, legal transactions, the more straightforward things become both institutionally and politically. Importantly from a political and perhaps equity perspective, it would not be difficult to shield small retail bank depositors from negative policy rates.[12]

1. Early Experience with Mildly Negative Rate Policy in Europe and Japan

The early experiences with very mild negative policy rates in Europe and Japan have been very helpful in revealing issues that need to be navigated and, by and large, this has proven straightforward (Dell'Ariccia et. al., IMF 2017). It is important to stress, however, that no country yet has taken the steps necessary to have the kind of deeply negative rates we are discussing here (say minus 2 percent or more).

Much of the pushback on mildly negative rates that has arisen from the claim that they strain bank profit margins, due to depositor resistance to negative rates. This leads a number of authors including Brunnermeier and Koby (2017), as well as Eggertsson, Juelsrud, Summers and Wold (2019) to argue that in theory, negative interest rates (at least past a certain point) will not be expansionary because as bank capital is depleted, banks will contract lending. In practice, bank performance does not seem to have suffered except at small banks (Lopez, Rose, Spiegel, 2018). Many large banks actually benefit because a significant share of their borrowing comes from wholesale markets where interest rates have followed government rates into negative

[12] See Rogoff (2016, 2017) and Agarwal and Kimball (2019) for discussions of how to small deposits.

territory. Large banks have also been better positioned to mark up other services and bundle these with deposits. Switzerland and Japan have moved to protect bank profits by "layering" reserves so that legacy levels are shielded from negative rates; the ECB has recently adopted this approach. A drawback though is that layering considerably weakens the transmission mechanism to the real economy, and rates go deeply negative, does nothing to prevent a run out of negative-interest bearing debt, including both public and private.

2. Implementing Negative Rate Policy in the Cashless Limit

Moving to a completely cashless system is neither necessary nor desirable into the foreseeable future. However, in thinking about negative rates, it is helpful to start with this case, in order to separate out issues that have only to do with cash. If there were no way to arbitrage into paper currency, of course, there would be nothing to stop investors from pulling out their savings to buy stocks, real estate, art and gold coins. This is hardly an objection; the incentives go in the same direction whenever the central bank lowers interest rates. Indeed, since the main driver of these investments are changes in real interest rates, as opposed to nominal interest rates, there are already many examples of central banks implementing deep negative real interest rates, with short-term policy rates well below inflation. And it must be noted that negative rate of 3% when inflation is zero is no more a tax on deposits in real terms than when the deposit rate is zero, and the inflation rate is 3%.

What about bank profits? It is very hard to see why in a cashless world, banks could not easily pass negative reserve charges on to wholesale depositors. There would be nowhere to hide. Of course, deposits would fall as money flows into other assets (and into consumption); large banks could easily substitute by borrowing more in wholesale markets. All banks would

benefit to the extent the economy is stimulated, thanks to greater demand for loans, and a lower default rate. Discouraging cash hoarding would help free banks from finding indirect ways to charge depositors negative rates (as they do now), and thereby reduce distortions.

Assuming cash is dealt with (or in a cashless world) what other obstacles might have to be cleared to make negative interest rate policy as effective as normal interest rate cuts? What steps can be taken to reduce attendant financial risks?[13]

Although much further study is warranted (perhaps by an independent commission), for the most part all of the issues seem to involve relatively straightforward plumbing fixes, and nothing on the order of the much more radical interventions that have been widely analyzed in major economic journals, ranging from engaging in fiscal policy on steroids to avoiding policies that might increase economic efficiency (thereby lowering prices and exacerbating deflation; see Eggertsson, Ferrero, and Raffo (2014), or Eichengreen (2016) on how increased protectionism can fight deflation.)

All the countries that introduced negative rates of -0.75% or less have managed to deal with financial plumbing fixes and in a reasonably short time period. For example, the idea that millionaires can arbitrage the system by overpaying estimates taxes and then claiming large refunds (thereby lending money to the government at a zero rate) is easily dealt with by paying a negative interest rate on large overpayments.[14] One important point that must be emphasized is

[13] These issues are detailed in Rogoff (2016), and Agarwal and Kimball (2019) have recently produced an extensive handbook.

[14] See Rogoff (2016), Agarwal and Kimball (2019) for further discussion of issues that would need to be addressed.

that many of the necessary plumbing fixes, while relatively minor, require the cooperation of the government, and cannot be instituted by the central bank alone.

Many of the objections to negative nominal rates are mainly political or philosophical and similar to objections presented against moderate inflation. For example, some might argue that negative interest rates are an unfair tax on savers in much the same way as inflation. Averaged over the cycle, however, an inflation-targeting central will not have a first-order effect on the average value of real interest rates. As long as central banks are using negative rate policy to hit their inflation targets, or more generally, to implement Taylor-rule type monetary policies, there will be no effect on the average real tax rate paid over the cycle (when most of the time nominal rates will be above zero anyway). It must also be kept in mind that long-term nominal rates would likely rise, not fall, if the zero bound were fully eliminated, as Yellen (2016) has argued.

Savers would also benefit to the extent negative-rate policy boosts the value real assets such as housing and equity. To shield small savers, governments can allow every citizen to register one debit (or savings) as account as eligible for zero interest rate protection, with banks being subsidized accordingly. In today's digital world, such a system would be straightforward and inexpensive to implement; let's remember that the government would earn large profits on its short-term debt in a negative interest rate world; some countries such as Germany already do so today.

Perhaps the single most fundamental objection to deep negative interest rate policy is that has not been tried before, and there would be risks. We absolutely acknowledge this; there were similar objections to the transition to floating exchange rates in the 1970s, but it had, at least,

been tried before by a few countries on a limited basis. To some extent, this is how mild negative interest rate policy has evolved until now. It is a reasonable forecast that there will be early experiments with open-ended negative rate policy in smaller countries before it is tried in larger countries, although Japan is still a very strong candidate for early adoption.

In any event, deep recessions and financial crises already entail large risks and considerable unknowns, and all directions policy might take entail risks. The early experimentation with negative rates suggests that these risks are manageable. The experience will likely evolve in coming years as more and more countries experiment with deeper and deeper interest rates.

3. Approaches to Dealing With Legacy Paper Currency

So far we have set aside the elephant in the room, which is paper currency. Ample experience has shown that paper currency does not get in the way of mildly negative interest rates. It is by no means easy to store whole quantities of cash (billions of dollars). Any registered institution (bank, pension fund, insurance company) would need insurance costing at least ½ percent of stored funds, if available. There are large fixed costs to building storage vaults, which must include humidity and temperature controls. Yet there are no guarantees of how long negative interest rate policy will last, and therefore over what period the fixed costs may be amortized. Even porting the money from the central bank to the storage site (and eventually back) would be an expensive operation. Although it will differ by country, existing obstacles to physical currency transportation and storage likely are sufficient to allow central banks to take rates to minus 2 percent without having the economy crippled by runs into cash; again, it is simplest to think of small retail depositors as being excluded. If large bills (say equivalent to $50 and

above) were eliminated, the transportation and storage costs would be considerably amplified, most likely allowing negative policy rates of up to 2.5 to 3 percent without major cash runs. As Rogoff (1998) argues, getting rid of large denomination notes likely makes sense anyway from a public finance perspective; it would only take a relatively small decrease in tax evasion and crime to more than pay back any lost seigniorage revenues. However, to allow the larger negative rates of -5 to -6% or more that might be needed in the event of a deep recession of a financial crisis, and to set aside bank concerns about passthrough of negative rates to large depositors, it is likely that administrative measures would also be needed, for example taxing large re-deposits of cash into the central bank and other regulatory impediments to cash hoarding (Rogoff, 2016), see also Bordo and Levin (2019). Again, small depositors would be excluded, and the political economy of negative rates could be strengthened by providing universal basic debt accounts per Rogoff (2016), which might also in principle be at the central bank.

As noted in the introduction, there are approaches to placing a negative (or positive) interest rate on physical cash that are more nuanced. Setting aside impractical ideas such as a Gesselian stamp tax or Goodfriend's (2000) magnetic stripe in currencies, both of which are clever but flawed (mainly because cash becomes illiquid), by far the most important idea is the Eisler (1932) dual-currency system. Eisler's approach was first resuscitated in the modern context by Davies (2004a,b) and Buiter (2005), and has been strongly advocated by economist Miles Kimball including in Agarwal and Kimball (2019). Conceptually, the idea is to have a dual currency system, where the central bank sets a moving exchange rate between paper and electronic currency. In the current regime, the exchange rate between electronic and paper currency is one. However, what the central bank can do when it wants to institute a negative rate on bank reserves is to announce that the exchange rate between paper currency and electronic

currency will depreciate at the same negative rate being applied to electronic deposits. Concretely, if the central bank maintains a negative interest rate of 4 percent, then anyone turning in paper currency after 3 months will receive 99 cents, after six months 98 cents, after nine months 97 cents, etc.) Assuming that prices are set in electronic currency, then the zero bound will be eliminated but there will be no run into paper currency.[15]

Formally, if S(t) is the rate at which the central bank trade one dollar in paper currency for electronic currency (in dollars), and -i(t) is the negative nominal interest rate at time t, then the central bank needs to set the rate of depreciation of electronic currency as

$$dS/dt = i(t)$$

The central bank would enforce this exchange change rate by setting it as the rate at which it redeemed paper money for electronic currency at its cash window. Eisler's ingenious device solves the problem of charging a negative rate on paper currency without making users carefully look at each individual bill to determine its exact value, and without any extra input or devices.

Unfortunately, the Eisler approach is not quite as neat as its advocates sometimes portray it. One problem is that paper currency and electronic currency are not actually perfect substitutes, which is of course why some central banks have been able to charge negative rates without first dealing with cash. Setting the rate of depreciation at the same level as the negative interest rate (as in the above formula) could set off a run out of cash (as opposed to into cash). Accelerating the move towards a "lower cash" society is a worthwhile goal for public finance

[15] As Buiter (2005) notes, there would still be a problem if prices continued to be set in paper currency, in which case the zero bound problem would persist, but the government can probably ensure that electronic prices are the focal point by setting taxes and all government contracts in electronic currency.

and safety reasons. However, too abrupt a move, without dealing with financial inclusion or legacy payment systems, would not be desirable. Another tricky issue is that when the period of negative rates ends, the exchange rate between electronic and paper currency will be stuck at a nonunitary value, which could be an inconvenience in normal times. It is feasible to restore it as the central bank begins to pay a positive rate of interest on reserves by having the exchange rate appreciate instead of depreciating, though there can be some tricky expectations issues to navigate (for example, if the public expects that the central bank will immediately restore paper currency to par as soon as the negative rate episodes ends), it will defeat the effort to prevent hoarding.[16]

Another (less compelling) concern sometimes expressed is that if investors had to worry about negative interest rates, there would be "no safe asset." But government short to medium term government debt already pays negative rates in countries such as Germany and Japan, and it has not seemed to make investors regard them as any less safe. As already noted in the introduction, Friedman (1967) argues that fears of monetary Armageddon in the event of monetary regime changes have often been overblown in the past.

Indeed, far from impeding market clearing, allowing for negative policy interest rates arguably can preclude much more dangerous dynamics when price (the interest rate) is stuck at the effective zero lower bound cannot clear the market for safe assets. For example, (Cabellero and Farhi, 2017) argue excess demand for safe assets can potentially induce a fall in real output to bring demand into line with supply. Allowing for negative interest rate policy allows the price

[16] Aggarwal and Kimball (2015, 2019).

of the bonds to clear the market, thereby preventing the distortion of the zero bound from creating new sources of monetary non-neutrality.

Are negative rates "unfair" not only to depositors but to holders of currency? No more so than inflation which is already a tax on paper currency. Indeed, proposals to raise the inflation target to 4% would be a significant increase in the tax on cash. Compared to negative rate policy that is likely to be mainly invoked in deep recessions, the tax from a higher inflation target would in place all the time, not just in exceptional circumstances.

One of the reasons why, among large countries, Japan is a more obvious candidate as an early adapter of negative interest rates is that unlike the dollar, only a very small share of yen paper currency appears to be held outside of Japan. Indeed, the issue of foreign currency holdings makes the United States quite distinct from any other country, albeit the Eurozone and Switzerland face some of the same issues. Exactly how much of US currency is held abroad is a matter of considerable debate, as is the question of whether foreign use is a positive or negative externality to the rest of the world on net.[17] Independent of whether the externality is positive or negative, foreign use of the dollar is a profit center for the United States, though the benefits must be weighed against the fact that paper currency significantly facilitates tax evasion and crime in the United States, not just abroad. Rogoff (1998, 2016) argues that even assuming only a very modest effect on tax evasion and crime, the gains from (gradually) withdrawing large denomination notes from circulation likely outweigh the benefits.

Another distinction between the US and other advanced countries is that demographics are not yet quite so grim as in the Eurozone and Japan, and overall growth is more dynamic.

[17] Rogoff (2016) argues that the negative externalities for the rest of the world are significant.

Again, this makes the case for Europe and Japan to consider preparing for unconstrained negative interest rate policy much stronger than for the US, but it hardly eliminates it from the US. Kiley and Roberts (2017) find that the zero bound could be a problem for the United States as much as 30-40% of the time (albeit Chung et al, 2019 argue that these estimates are likely high-side.)

4. Financial Stability Concerns

Last but not least, is the question of financial stability concerns. Dell'Ariccia et.al. (IMF 2017) find that negative rate policy to date has not raised particularly acute financial stability concerns, but this is always a question whenever real interest rates are low. Dealing with financial stability is always an important issue, and it not obvious that negative nominal rate policy would introduce substantially new concerns from those studies in the long history of negative real rate policy; this is certainly an issue meriting further study.

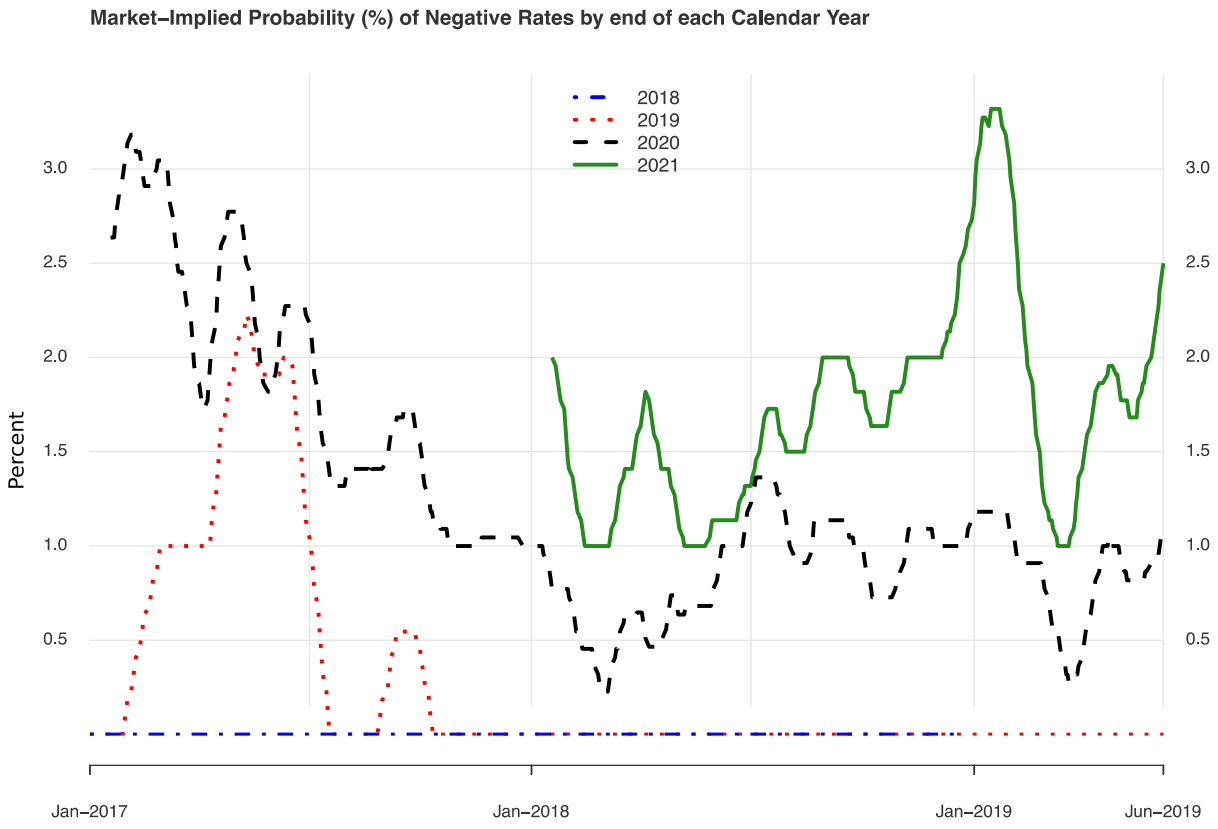
The financial stability argument can be flipped on its head. If central banks had been able to invoke effective negative nominal rate policy after the financial crisis, it is possible that the recovery period would have been much faster, and the period of ultra-low interest rates much much shorter, thereby reducing financial risks rather than exacerbating them. Being able to create moderate inflation in the aftermath of a financial crisis might actually be extremely helpful, letting the steam out of private debt problems (and in Europe, periphery country debt problems.) Whether or not central banks wanted to elevate inflation, quantitative easing proved relatively ineffective, unconstrained negative interest rate policy would have provided the tool needed if it had been available.

5. Expectations of negative rates being implemented in the near future

Though many may disagree with our prescriptions, it is worth noting that even in the United States, both market pricing and survey data attribute material probabilities to nominal interest rates moving into negative territory in the near future – and yet they hold these beliefs without an agreed framework for how they would be implemented.

Firstly, we show that markets attribute a material probability to this event, using option prices. In Figure 2, we show an estimate of the lower bound for the risk-neutral probability that markets ascribe to the short-term borrowing rates of high credit banks (USD 3m LIBOR) being below -0.25% at the end of each calendar year. Markets have consistently assigned a positive probability that these borrowing rates will be materially below zero within the next three years, at times as high as 3%, implying Federal reserve rates which are even lower.

Figure 2



Notes: Market-implied probabilities of 3-month LIBOR (USD) rates setting below -0.25% at December 15th of 2018 through 2021. Market implied probabilities are derived from options prices on the Eurodollar futures with strikes of 100.25 and 100.5, which correspond to LIBOR rates of -25bps and -50bps respectively. Probabilities are lower bounds and are estimated assuming risk neutrality, averaged over the preceding month. See appendix for details.

Surveys of the relevant parties yield similar conclusions. In the New York Fed's most recent market surveys (March-19), participants were asked for the percent chance that they attached to the target federal funds rate being in certain ranges by year-end 2021, conditional on moving to the zero lower bound at some point before this date. Primary dealers and investment managers assigned average probabilities of 12% and 17% respectively of ending 2021 with a negative target federal funds rate.

V. CONCLUSIONS

The strong case for having a rule-based international monetary system (Taylor, 2016), implemented by independent central banks (Rogoff, 1985), is well established. The quasi-fiscal tools presently available to monetary authorities at the zero bound make it difficult to conform to rules in part because they are of such limited and unpredictable effectiveness, and in part because they can just as easily be implemented – indeed even reversed – by the fiscal authorities. Other ideas such as forward guidance on interest rates do fall within the realm of monetary policy, but during long zero-bound episodes are extremely difficult to make credible. Modifying inflation targets is a plausible option, but comes with many problems of its own, one of which is that it is difficult to make a higher inflation target credible when markets doubt that the central bank has the instrument to achieve it; the case of Japan well illustrates this point.

Borrowing the phrase of former US Treasury Secretary Hank Paulson, the central bank needs a "bazooka" at the zero bound that makes credible its commitment to achieving its policy rule. Negative interest rate policy is precisely the requisite instrument and can be achieved by making the legal, tax and regulatory changes needed to use unconstrained negative interest rate policy effectively in fighting a deep recession. Most of the necessary adaptations of the financial plumbing needed to make negative interest rate policy effective – potentially as effective as interest rate policy in positive territory – are straightforward. The most vexing issue is preventing large-scale cash hoarding by pension funds, insurance companies and financial institutions (small depositors can easily be exempted). If hoarding is decisively dealt with (for example, by allowing the trade-in value of paper currency at the central bank to depreciate over time during negative interest rate episodes a la Eisler 1933), it should solve the problem of bank profitability (to the extent there is one) by making it straightforward to pass on negative interest

rates on to large-scale depositors. This will ensure that the normal stimulus effects of lower interest rates on consumption and investment will transmit to the real economy. Of course, as is usually the case, lower interest rates will likely also push up the prices of housing, equities and other assets, while at the same time pushing up nominal interest rates on longer-term bonds due to higher long-term expected inflation as well stronger medium term growth.

Monetary policy design should be forward looking and not backward looking. The increasing marginalization of cash (in legal, tax-compliant transactions) will make it ever easier to effectively implement negative interest rate policy in the coming years. The process could be constructively accelerated by phasing out large-denomination notes which still play a significant role in tax evasion and crime, but are largely vestigial in the legal economy. Indeed, thanks to the fact that hoarding cash is actually quite expensive for financial institutions, insurance companies and pension funds, it is already possible to have mildly negative rates (perhaps as low as minus 2%) without any tax on cash, and eliminating large bills would likely increase the scope for negative rates somewhat further. In any event, as cash steadily becomes marginalized in the legal economy, as countries take more steps to deal with financial inclusion, and assuming small depositors are excluded, political pushback on negative rate policy should evaporate, much as political pushback on flexible exchange rates evaporated over time.

The biggest drawback to unconstrained negative rate policy is that it has not really been tried anywhere, and unintended consequences are possible. But in a deep financial crisis, countries must often choose from a menu of difficult options, and a decade after the financial crisis, it is clear that none of the other options for restoring monetary policy effectiveness are particularly attractive or sustainable. As we have noted at the outset, the case for considering how to make unconstrained negative rate policy effective is stronger at present in Europe than

the United States, and stronger still in Japan. In our view, it is quite likely that some advanced country central banks will experiment with unconstrained negative rate policy during a deep recession within the next decade. The United States is not the obvious first mover. However, given the steady downward drift in global real interest rates, the difficulties in raising expected inflation, the apparent ineffectiveness of quasi-fiscal instruments at the zero bound, and ultimately the importance to central bank independence of having an instrument that the Fed "owns", creates a strong imperative for proactively preparing now for a negative interest rate world that is perhaps inevitable.

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Appendix

A.1: BOUNDING RISK-NEUTRAL PROBABILITIES FROM THE MARKET PRICES OF OPTIONS

We outline the process we use to infer risk-neutral probabilities from the market prices of various options. We first describe the process in general, since all probabilities in the paper are constructed in this manner. For parsimony we assume a discount rate of zero in this explanation.

Consider the payoff of a call option over an asset with an underlying price of x, where the option has a strike of k. The payoff of the option at the exercise date has the following profile, where α is a general scaling parameter:

$$\Pi(x) = \alpha \cdot \begin{cases} x - k \text{ if } k < x \\ 0 \text{ if } x \leq k \end{cases}$$

We can then construct a synthetic option which combines buying a call with a strike of k_2 and selling a call with a strike of k_1 on the same underlying asset, where $k_1 > k_2$. The payoff function of such a synthetic option follows:

$$\Pi(x) = \alpha(k_1 - k_2) \cdot \begin{cases} 1 & \text{if } k_1 \leq x \\ \dfrac{x - k_2}{k_1 - k_2} & \text{if } k_2 < x < k_1 \\ 0 & \text{if } x \leq k_2 \end{cases}$$

The risk-neutral valuation (V) of this synthetic option is therefore given by

$V = \int pdf(x)\Pi(x)dx$. We do not observe the value of this synthetic option directly since it is not traded, but we can infer it from the market price of the call option with strike k_2 minus the price of the call option with strike k_1. We then use this valuation to provide a lower bound on the probability that $x > k_2$ under the assumption of risk-neutrality.

$$\begin{aligned} V &= \int pdf(x)\Pi(x)dx \\ &= \int_{k_2}^{\infty} pdf(x)\Pi(x)dx \\ &\leq \int_{k_2}^{\infty} pdf(x) \cdot \alpha\,(k_1 - k_2)dx \\ &\rightarrow \frac{V}{\alpha\,(k_1 - k_2)} \leq \underbrace{\int_{k_2}^{\infty} pdf(x)\,dx}_{Pr(x > k_2)} \end{aligned}$$

Therefore, we can use this general formula to provide a lower bounds on the probability of interest rates being below -0.25%, so long as we can observe the market price of an option with a strike for the relevant event, and a second option which has a higher strike. The second option is

necessary since there are an infinite number of combinations of outcomes and probabilities which would be consistent with one option price, but a second option price limits this space to at least a single lower bound.

Probability of negative rates: We provide a lower bound on the risk-neutral probability of 3 month borrowing rates falling below -0.25% using Eurodollar call options. Eurodollar futures are cash-settled derivatives on the 3 month-LIBOR rate, the interest rate that a bank borrows at in US dollars for 3 months, subject to satisfying certain credit requirements. The price of these derivatives are quoted as $100 - r$ where r is in percentage points (e.g. for an interest rate of 0.5% the price of the derivative would settle at 99.50). A call option on Eurodollar futures with a strike of 100.25 entitles the buyer the right to enter into the long side of a Eurodollar future at the price of 100.25 with the option seller.

In this case, we construct the value of the synthetic option from the price of buying another Eurodollar call option with a strike of $k_2 = 100.25$ ($P_t^{C,K=100.25}$) and selling another with a strike of $k_1 = 100.5$ ($P_t^{C,K=100.5}$), yielding a lower bound for the risk-neutral probability that rates are below -0.25%.

$$Pr_t\,(r < -0.25) \geq \frac{P_t^{C,k=100.25} - P_t^{C,k=100.5}}{100 \cdot\ (100.5 - 100.25)}$$

A.2: ESTIMATING A SYNTHETIC BREAKEVEN WITH A CPI INDEXATION CAP

Consider a 10-year real bond that would index to CPI with a ceiling on the indexation as follows. If inflation averaged more than 3% for 10 years, it would only pay up to a ceiling of a cumulative 3% annual increase. The payoff profile of this bond is identical to a compound payoff profile, one where the investor buys the ordinary inflation-linked bond, but selling an inflation cap at a strike of 3% with the same principal as the inflation-linked bond. Under no-arbitrage, we can calculate the price paid for theoretical bond in the time series by using the real bond price and the upfront payment received for selling this protection.

To convert this up-front payment into the equivalent yield on the inflation-linked bond, we must adjust the yield according to the modified duration of the inflation-linked bond. Since the bond we are pricing has no coupons, the Macaulay duration is the years to maturity, and since its compounding is continuous, the modified duration is exactly the Macaulay duration:

$$\mathrm{r}_t^{\text{synthetic}} = r_t - \frac{premium_t}{T}$$

The synthetic BEI is therefore the yield on the continuously compounding nominal bond minus the synthetic yield on the continuously compounding real bond.